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Effect of balance exercises on balance, function, and performance in athletes with chronic ankle instability

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ABSTRACT

Background: Chronic Ankle Instability (CAI) is a common condition affecting athletes and characterized by repeated episodes of the ankle "giving way" and impaired balance, leading to functional limitations. Balance and proprioceptive exercises are one of common rehabilitation strategies used in the treatment of CAI.

Purpose: To study the effect of balance training exercises on, balance, function, and performance of athletes with chronic ankle instability.

Methods: Fourteen patients (ages 19–30) with unilateral chronic ankle instability (CAI), including both genders, underwent 12 balance training sessions over 4 weeks (3 sessions/week). Each session involved 3 sets of 10 repetitions per exercise, with each repetition lasting 5 seconds and a 30-second rest between sets. Dynamic postural control was evaluated using the Star Excursion Balance Test (SEBT), functional instability with the Arabic version of the Cumberland Ankle Instability Tool, and performance with the side hop and figure-of-eight hop tests.

Results: Results revealed a significant difference in the means of the anterior and posteromedial directions for the balance, ($p=0.05$) and ($p=0.013$) respectively, also showed improvement in the means of function ($p=0.009$) , no significant differences in the means of other directions of the SEBT (antero-medial ,antero-lateral, medial ,lateral Posterior and Postero-lateral) ,also in the means of side hop and figure of 8 hop testing($p>0.05$).

Conclusion: The results of this study confirmed the effective role of balance training exercises in improving balance and function, in athletes with CAI while, its effect on performance (side hop and figure of 8 hop tests) is still questionable.

Keywords: Chronic Ankle Instability-Star Excursion Balance Test-Cumberland Ankle Instability Tool-side hop test- a figure of 8 hop test.

INTRODUCTION

Ankle sprains represent one of the most frequently encountered musculoskeletal injuries, commonly occurring during high-impact athletic activities such as basketball and soccer, as well as during daily activities involving uneven terrain. Epidemiological data indicate that approximately 25% of all sports-related injuries are attributed to ankle sprains of varying severity (Bleakley et al.,2019). While minor ankle sprains are typically managed successfully through non-surgical conservative interventions, (Herzog et al.,2019), inadequate attention to rehabilitation and insufficient engagement in structured exercise therapy during the recovery phase often result in poor long-term outcomes. Notably, up to 70% of individuals may experience recurrent sprains and residual instability, with 40% to 50% progressing to chronic ankle instability (CAI) (Su et al., 2024).

Chronic ankle instability (CAI) is characterized by structural and/or functional impairments of the ankle joint and surrounding soft tissues, leading to persistent joint instability and restricted range of motion. Recurrent ankle sprains are a hallmark feature of this condition (Shi et al.,2019). Clinically, CAI presents with symptoms such as muscular weakness, ongoing pain, proprioceptive deficits, ligamentous laxity, functional impairment, and repeated episodes of giving way. Additionally, CAI is often associated with intra-articular pathologies such as cartilage degeneration and synovitis, which further exacerbate symptoms and significantly diminish an individual's quality of life (Zhang et al., 2019).

Chronic ankle instability (CAI) has a profound impact on athletic performance and significantly heightens the risk of subsequent injuries. Athletes with CAI often experience prolonged recovery periods, diminished performance, and, in some cases, shortened careers (Donovan et al.,2021). The condition can adversely affect on-field performance, as pain, swelling, and fear of reinjury may compromise an athlete's ability to compete at full capacity (Herzog et al.,2019).Over time, persistent instability may lead to more severe complications, including osteoarthritis, muscle weakness, and long-term functional disability. Beyond recurrent ankle sprains, other factors such as reduced flexibility and strength imbalances in the lower extremities may contribute to the development and exacerbation of CAI, further increasing the risk of long-term injury and dysfunction (Subramanian et al., 2021).

Current treatment strategies for chronic ankle instability (CAI) encompass both surgical and non-surgical approaches. While surgical interventions remain commonly utilized, there is ongoing debate regarding the selection of specific procedures and the efficacy of postoperative recovery outcomes. Exercise therapy plays a critical role in the rehabilitation of CAI (Schaefer & Sandrey2012), particularly during the later stages of recovery. Research has identified several key factors contributing to the persistence of CAI symptoms, including impaired dynamic balance, proprioception deficits, delayed fibular reaction time, and reduced valgus strength (Su et al., 2024).

A variety of rehabilitation protocols have been explored to address the deficits associated with chronic ankle instability (CAI), ranging from simple progressive strength (Smith et al.,2012) (Docherty et al.,1998) and balance (Kidgell et al.,2007) (Mckeon et al.,2008) programs to more comprehensive multicomponent approaches that integrate strength, balance, and range of motion (ROM) exercises. These functional rehabilitation strategies have proven effective in enhancing strength, balance, and self-reported functional outcomes. However, few studies have specifically evaluated improvements in functional performance, particularly with respect to power and agility (Hall et al., 2018). Functional activity, as defined in the context of CAI, refers to dynamic, closed kinetic chain movements beyond simple static standing. Research assessing the impact of strength training alone on functional performance has failed to demonstrate clinically significant improvements (Webster &Gribble 2010). This suggests that strength training, in isolation, may not be sufficient to enhance functional outcomes that closely mimic the movements encountered in sports and physical activity. Balance training protocols (BTPs) and resistance-band protocols (RBPs) have been shown to improve strength and postural control, respectively. However, to date, no studies have simultaneously investigated the effects of these two modalities within the same research framework (Park et al., 2024).

This study aimed to study the effects of balance training exercises on dynamic postural control (SEBT), function (CAIT), and performance (side hop test and figure of 8 hop test).

MATERIALS AND METHODS

Study design: Experimental Study Design

Sample size calculation: The sample size was calculated using the G*Power software (version 3.1.9.4). Sample size calculation was done using Balance, as reported in **(Bahrami & Sabbagh 2023)** with 80% power at $\alpha = 0.05$ level. and revealed that the required sample size for this study would be 12 subjects plus 10% to avoid dropout. So, it would be 14 subjects. Calculation was made with α set at 0.05, power set at 0.95 and effect size set at 0.9.

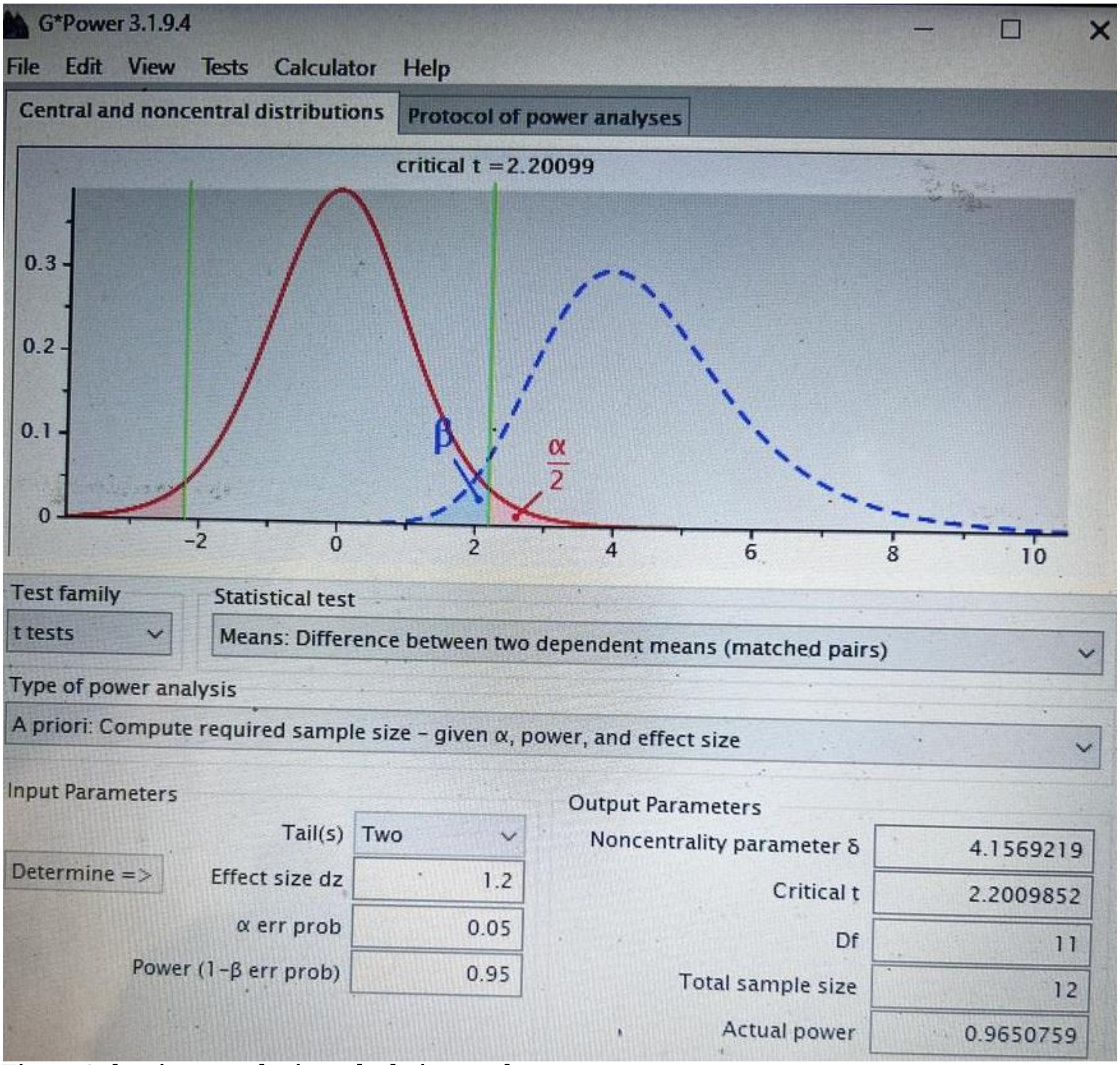

Figure 1 showing sample size calculation used for the study

Participants: 14 Athletes having a history of chronic lateral ankle sprain during the offseason period, with age range from **19-30 years,** with BMI ranging between (18.5-29.5kg/m2) **(Lin et al.,2021).** Each patient signed an informed consent before starting the study. All patients were referred by an orthopedic surgeon who diagnosed CAI based on clinical and radiological examination. Patients were eligible for inclusion in our study if they had a history of at least one ankle sprain (the initial sprain must have occurred at least more than 3 months before study enrollment, at least one interrupted day of desired physical activity, reporting at least 2 episodes of giving way and/or recurrent sprain and/or feelings of instability in the 6 months before study enrollment and self-reported ankle instability using a validated ankle instability questionnaire, CAIT>24**(Gribble et al., 2014)** .

Patients were excluded if they had a history of spine, pelvis, and lower extremity injury, fracture, or surgery **(Gribble et al.,**

2014), LBP that required medical or surgical intervention **(Tahoon et al., 2022)**, participation in supervised or unsupervised ankle rehabilitation within **3 months** before enrollment in the study **(Tahoon et al., 2022)**, history of an acute lower extremity injury in the 3 months before the study and history of lower extremity surgery or fracture that required alignment in the involved limb **(Hall et al.,2018).**

Ethical approval: Prior to the initiation of any physical therapy interventions, approval for this study was obtained from the Institutional Review Board of the Faculty of Physical Therapy, Cairo University (P.T.REC/012/005346).

Assessment Procedures:

All participants underwent the following assessments before and after physical therapy interventions and the treatment duration was 4 weeks.

A) Balance Using Star Balance excursion test:

is a series of single-limb squats using the non-stance limb to reach maximally to touch a point along 1 of 8 designated lines on the ground. The lines are arranged in a grid that extends from a center point and is 45° from one another **(Gribble et al.,2012)**. Each reaching direction offers different challenges and requires combinations of sagittal, frontal, and transverse movements. The reaching directions are named in orientation to the stance limb as anterior, anteromedial, anterolateral, medial, lateral, posterior, posteromedial, and posterolateral, The goal of the task is to have the individual establish a stable base of support on the stance limb in the middle of the testing grid and maintain it through a maximal reach excursion in 1 of the prescribed directions. While standing on a single limb, the participant reaches as far as possible with the reaching limb along each reaching line; lightly touches the line with the most distal portion of the reaching foot without shifting weight to or coming to rest on this foot of the reaching limb; and then returns the reaching limb to the beginning position in the center of the grid, reassuming a bilateral stance **(Zając et al.,2024)**. If the individual touches heavily or comes to rest at the touch-down point, has to make contact with the ground with the reaching foot to maintain balance, or lifts or shifts any part of the foot of the stance limb during the trial, the trial is not considered complete **(Picot et al.,2021).**

B) Function By Using The Arabic Version Of The Cumberland Ankle Instability Tool:

It is a 9-item questionnaire designed to evaluate both ankles, i.e., pain in each ankle during daily activities, ankle instability in different types of physical activities, ankle control when recurring sprains occur, and the recovery period after recurrent ankle sprains. The nine items generate a total score from 0 to 30 for each foot, where 0 is the worst possible score, meaning severe instability and 30 is the best possible score, meaning normal stability **(contri et al.,2023)**, The questionnaire collected personal information such as the name, age, height, weight, sports participation, history of ankle sprains on both ankles and the presence/absence of any associated painful symptoms. The CAIT investigates the perception of pain and ankle instability in relation to sports engagement, as well as the performance of daily activities such as going down stairs, running, walking, and overcoming uneven or flat surfaces **(Figlioli et al.,2024),** The scales served to differentiate between stable and unstable ankles and assess the severity of functional instability encountered with a threshold of 27.5 points **(Hiller et.,2006).** The Arabic version of the Cumberland Ankle Instability Tool appears to be Valid and reliable **(Korakakis et al.,2019).**

C) **Functional Performance assessment** By Using The

I-side-hop test:

The side-hop test was utilized to assess lateral functional performance and was performed by instructing participants to hop laterally on a single limb over a 30-centimeter distance and return to the starting position. One complete repetition was defined as a lateral hop followed by a return hop to the initial position. Participants were instructed to perform 10 consecutive repetitions as quickly as possible. Trials were considered invalid if the contralateral limb made contact with the ground or if the participant failed to clear the 30-centimeter distance. Timing was recorded using an electronic stopwatch to capture the fastest performance time. Each participant completed one to three practice trials each containing 10 repetitions, followed by three recorded test trials **(Halabchi & Hassabi, 2020).**

II-The figure of 8 hop test:

The figure-of-eight hop test was conducted using a 5-meter course delineated by cones. Participants were instructed to hop on a single limb, completing two full laps around the designated course as quickly as possible. All testing procedures were performed with participants barefoot to standardize foot-ground interaction. Trials were classified as unsuccessful if the participant placed the contralateral limb on the ground, lost balance and fell, failed to activate the stopwatch timing pad, or deviated from the prescribed course. In such cases, the trial was repeated. The total time to complete the course was recorded using a handheld stopwatch, with timing accuracy to the nearest 0.01 second Using 3 trials, **(Halabchi & Hassabi, 2020).**

Treatment Procedures:

Fourteen patients received the treatment in the form of stretching and resistance exercises for 5 minutes as a warm-up **(Huang et al.,2014)**.

Followed by balance exercises, the six types of exercises performed were:

The stretching exercise was the standing calf stretch done for 1 set of 10 Repetitions **(Loudo & Dolphino 2010)**

Exercise 1: Single-legged stance:(Hale et al.,2014)

(A) The patient stood on one leg with the other knee flexed.

(B) From this position, the patient is asked to maintain balance for 60 seconds for 3 repetitions.

(C) At first with eyes opened then with eyes closed.

(D) When the patient can do the exercise, it will progress to be with eyes closed on a dynadisc and increase in one repetition.

Exercise 2: Single-legged stance on the balance board:(Hale et al.,2014)

(A) The patient stood on one leg with the other knee flexed on a balance board.

(B) From this position, the patient is asked to maintain balance while moving the balance board in plantarflexion, dorsiflexion, inversion, and eversion without letting the board contact the floor for 10 repetitions in each direction.

(C) When the patient can do the exercise, it will progress to be without upper limb support and by adding rotational movements.

Exercise 3: Single-legged hop:(Hale et al.,2014)

(A) The patient stood on one leg with the other knee flexed.

(B) From this position, the patient is asked to hop as far as possible in the anterior direction 5 times and progress in the form of 5 reps when the participant can do it with minimal ankle and hip movements.

(C) When the patient can do the exercise, it will progress to medial, lateral, and posterior directions.

Exercise 4: Quadrant Hop: (Hale et al.,2014)

(A) The patient stood on one leg with the other knee flexed.

(B) From this position, the patient is asked to hop without loss of balance or fatigue for 2 sets of 5 hops in the clockwise and counterclockwise directions.

Exercise 5: Single-legged Ball Catch: (Hale et al.,2014)

(A) The patient stood on one leg with the other knee flexed.

(B) From this position, the patient is asked to catch the ball without loss of balance for 3 sets of 20 tosses.

(C) When the patient can do the exercise, it will progress in the form of tossing the ball outside the patient's base of support.

Exercise 6: Hop ups and downs: (Hale et al.,2014)

(A) The is instructed to hop off a step in a single-legged stance on the floor for 3 sets of 10 repetitions.

(B) When the patient can do the exercise without fatigue or loss of balance, the height of the step will be increased from 4 inches to 12 inches in 2 increments.

Statistical Analysis:

Statistical analysis was conducted using SPSS for Windows, version 26 (SPSS, Inc., Chicago, IL), data were screened for normality assumption, homogeneity of variance, and presence of extreme scores, and the p-value was set at < 0.05. Descriptive statistics would be used to describe the demographic subject characteristics; in the form of mean and standard deviation (SD) of patients' data (age, weight, height, BMI, side affected (left or right), and chronicity of LE. A paired test would be used for calculating significant differences.

RESULTS

The distribution of females and males was (5)35.7% and 9 (64.3%), The mean value of subjects' age was (22.14±2.48), The mean value of BMI was (22.69±3.2)

The mean ± SD of balance anterior direction pre-intervention was 82.7 ± 5, and post-intervention was 88.3 ± 5 cm. Independent sample t-test revealed significant differences for the post-intervention assessment of Balance (p=0.05*) compared to pre-intervention**(Table1,Figure1)** and the mean±SD of balance in the posteromedial direction pre-intervention was 87.7 ± 5.57 and post-intervention was 92.9 ± 6.6 cm, Independent sample t-test revealed significant differences for the post-intervention assessment of Balance (p=0.013*) compared to pre-intervention **(Table1,Figure2)** and the mean± SD of CAIT pre-intervention was 18.57 ± 2.02 and post-intervention was 20.6 ± 2.09, Independent sample t-test revealed significant differences for the post-intervention assessment of Balance (*p*=0.009*) compared to pre-intervention**(Table 2,Figure3)**, while there is no other improvements or change in the other directions of the SEBT(anterolateral, anteromedial, medial, lateral, posterior and posterolateral) (*p*>0.005) showing insignificancy also there is no significant change in the terms of side hop and figure of 8 hop testing between pre and post interventions (*p*>0.005).

Table 1: balance in all directions

Balance	**Pre-test mean±SD**	**Post-test mean±SD**	**P-value**
Anterior	82.7± 5	88.3± 5	***p*=0.05***
Antero-medial	77.6 ± 5	81.7 ± 4.5	*p*=0.134
Antero-lateral	76 ± 5.57	81.4 ± 4.5	*p*=0.59
Medial	65.5 ± 8.1	75 ± 10	*p*=0.061
Lateral	66 ± 15	69.9 ± 15.6	*p*=0.251
Posterior	84.9 ± 10.5	88.1 ± 10.2	*p*=0.901
Postero-medial	87.7 ± 5.57	92.9 ± 6.6	***p*=0.013***
Postero-lateral	85.05 ± 2.38	91.5 ± 2.7	*p*=0.167

Table 2: Performance (side hop and Figure of 8 hop testing), Function (Pain and Instability).

Side Hop testing	10 ± 1.26	9.17 ± 1.2	*p*=0.655
The figure of 8 Hop testing	13.2 ± 1.01	11.9 ± 1	*p*=0.714
CAIT	18.57 ± 2.02	20.6 ± 2.09	***p*=0.009***

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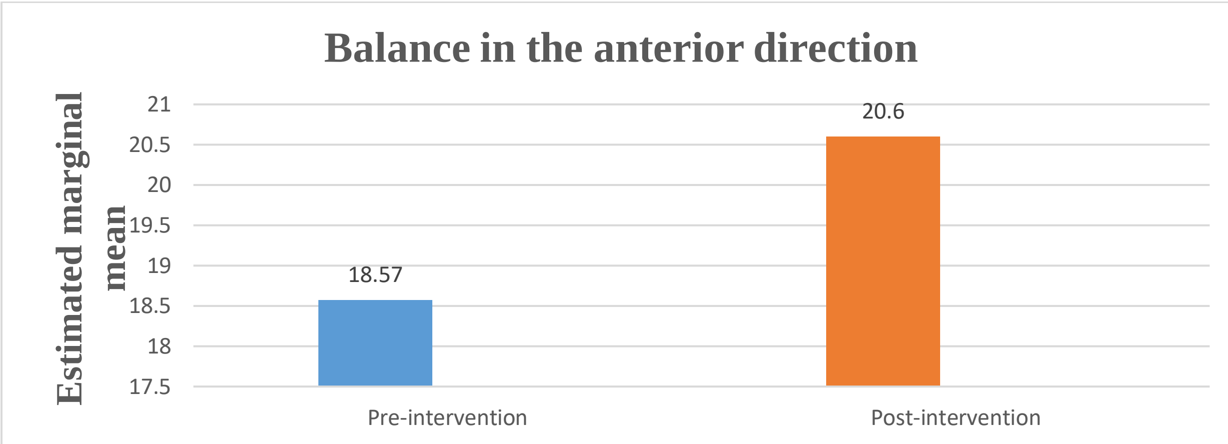

Figure 1: Mean Balance in the anterior direction pre and post

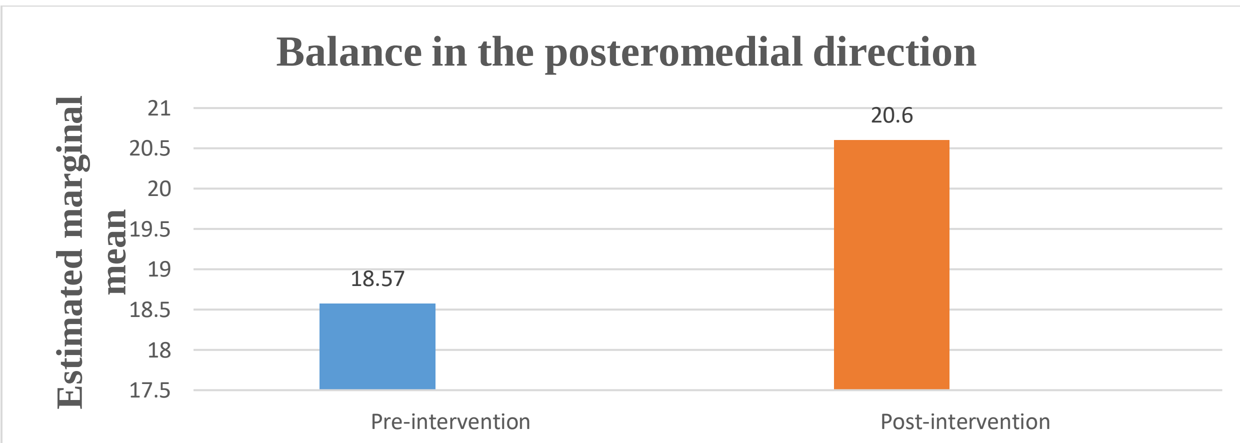

Figure 2: Mean Balance in the posteromedial direction pre and post

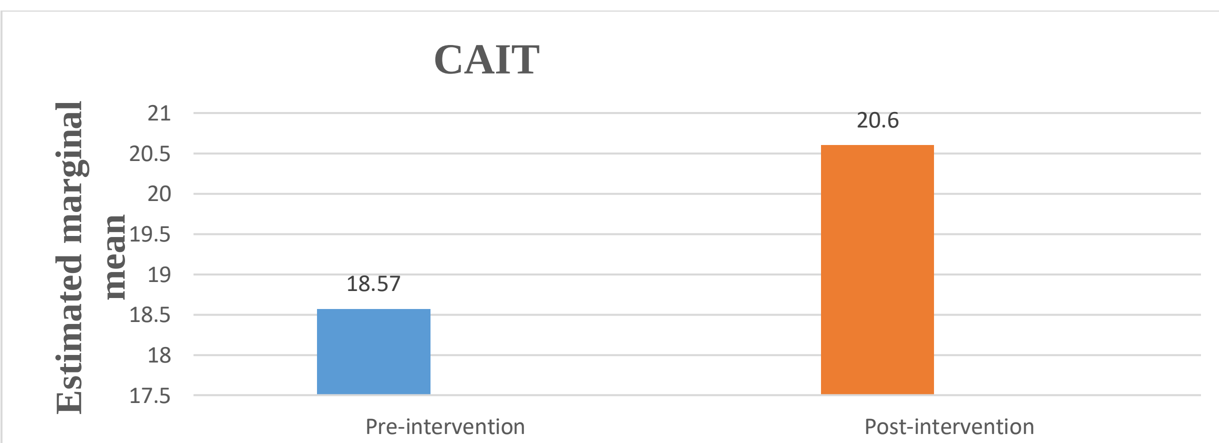

Figure 3: CAIT pre and post

DISCUSSION

The results of our study revealed significant differences between pre and post-assessment values of balance in the anterior and posteromedial directions and non-significant differences in other directions, also revealed significant differences between pre and post-assessment values of CAIT while there were no significant differences between pre and post assessment values of performance tests (side hop and figure of 8 hop testing).

I-Dynamic Balance (SEBT):

The findings of this study are consistent with those reported by Youssef et al. (2018) who found that both the Weight-bearing Exercise for Better Balance (WEBB) program and unilateral balance training significantly improved postural control which was assessed using the Biodex Balance System before and after a four-week intervention and showed significant improvements in the Overall and Anteroposterior Stability Indices, supporting the effectiveness of these balance training protocols.

These results are consistent with the findings of Hall et al. (2018), who found that both strength and balance training programs had a positive effect on balance assessed by Balance Error Scoring System (BESS), SEBT, after 6-week training program of both strength and balance exercises.

The results of this study came in line with that made by Cain et al., (2020) who found that four-week rehabilitation program combining balance and strength training had a positive effect on balance which was measured by time-in-balance test, foot-lift test, Star Excursion Balance Test.

II-Function:

The findings of our study are consistent with those made by Cruz-Díaz et al. (2015), who Found that a six-week balance training program had a significant effect on dynamic balance, perceived ankle instability, and pain in athletes with CAI measured by CAIT.

The results of our study came in line with that made by Jain et al., (2014) who found that a 4-week balance training program had a significant effect on self-reported ankle instability using CAIT and ankle joint position sense (JPS) using joint position-reposition test in patients with FAI.

The findings or our study came in line with that made by Nam et al., (2018) who found that 8 weeks of visual feedback balance training had a significant effect on CAIT score in adults with functional ankle instability.

III-Performance:

The results of our study did not come in line with those made by Park et al.,(2024) who found that a 6 week strength and balance training program on elite male soccer players had a significant effect on functional performance and may be this disagreement came from variations in participant demographics, including gender, athletic background, and intervention specifics, emphasizing the need for contextually tailored training protocols and further research into population-specific responses to rehabilitation programs.

The findings of our study did not come in agreement with those made by Wright et al., (2017) who found that 4-week balance training program had a significant effect on performance and this disagreement may come from differences between studies may be attributed to variations in participant characteristics such as gender, athletic background, and intervention specifics. These findings underscore the value of short-term, targeted interventions and highlight the importance of tailoring rehabilitation programs to specific populations.

CONCLUSION

The results of this study confirmed the effective role of balance training exercises in improving balance and function, in athletes with CAI while, its effect on performance is still questionable.

RECOMMENDATIONS

- Further studies should be performed with a longer follow-up period.
- Further studies are **needed to explore the correlation** between various measured variables and treatment interventions in CAI patients.
- Further studies are needed to compare the effects of different manual therapy techniques in the treatment of CAI.
- Further studies are needed on larger sample sizes
- Further studies are needed to compare different types of sports activity and their effect on the development and treatment of CAI.

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Conflict of interest:

The authors declare no conflicts of interest.

References

1. Bahrami, F., & Sabbagh Langeroudi, M. (2023). Comparison of the Effects of Core Stability and Trampoline Exercises on Static and Dynamic Balance, and Ankle Proprioception in Female Volleyball Players with Chronic Ankle Instability. Journal of Sport Biomechanics, 9(2), 140-154.
2. Bleakley, C. M., Taylor, J. B., Dischiavi, S. L., Doherty, C., &

Delahunt, E. (2019). Rehabilitation exercises reduce reinjury post ankle sprain, but the content and parameters of an optimal exercise program have yet to be established: a systematic review and meta-analysis. Archives of physical medicine and rehabilitation, 100(7), 1367-1375.

3. Cain, M. S., Ban, R. J., Chen, Y. P., Geil, M. D., Goerger, B. M., & Linens, S. W. (2020). Four-week ankle-rehabilitation programs in adolescent athletes with chronic ankle instability. Journal of athletic training, 55(8), 801-810.
4. Contri, A., Ballardin, F., De Marco, G., Gaucci, M., Scariato, A., Zanoni, V., ... & Pillastrini, P. (2023). Italian version of the cumberland ankle instability tool (CAIT-I). The Foot, 56, 102043.
5. Cruz-Diaz, D., Lomas-Vega, R., Osuna-Pérez, M. C., Contreras, F. H., & Martínez-Amat, A. (2015). Effects of 6 weeks of balance training on chronic ankle instability in athletes: a randomized controlled trial. International journal of sports medicine, 36(09), 754-760.
6. Docherty, C. L., Moore, J. H., & Arnold, B. L. (1998). Effects of strength training on strength development and joint position sense in functionally unstable ankles. Journal of athletic training, 33(4), 310.
7. Donovan, L., Hetzel, S., Laufenberg, C. R., & McGuine, T. A. (2020). Prevalence and impact of chronic ankle instability in adolescent athletes. Orthopaedic journal of sports medicine, 8(2), 2325967119900962.
8. Figlioli, F., Belmonte, G., Giustino, V., Canzone, A., Ferrantello, E., Gervasi, M., ... & Patti, A. (2024). Applicability of the Cumberland Ankle Instability Tool in Elite Volleyball Athletes: A Cross-Sectional Observational Study. Sports, 12(3), 71.
9. Gribble, P. A., Hertel, J., & Plisky, P. (2012). Using the Star Excursion Balance Test to assess dynamic postural-control deficits and outcomes in lower extremity injury: a literature and systematic review. Journal of athletic training, 47(3), 339-357.
10. Gribble, P. A., Bleakley, C. M., Caulfield, B. M., Docherty, C. L., Fourchet, F., Fong, D. T. P., ... & Delahunt, E. (2016). Evidence review for the 2016 International Ankle

Consortium consensus statement on the prevalence, impact and long-term consequences of lateral ankle sprains. British journal of sports medicine, 50(24), 1496-1505Halabchi, F., & Hassabi, M. (2020). Acute ankle sprain in athletes: Clinical aspects and algorithmic approach. World journal of orthopedics, 11(12), 534.

11. Hall, E. A. , Chomistek, A. K., Kingma, J. J., & Docherty, C. L. (2018). Balance-and strength-training protocols to improve chronic ankle instability deficits, part I: assessing clinical outcome measures. Journal of athletic training, 53(6), 568-577.
12. Herzog, M. M., Kerr, Z. Y., Marshall, S. W., & Wikstrom, E. A. (2019). Epidemiology of ankle sprains and chronic ankle instability. Journal of athletic training, 54(6), 603-610.
13. Hiller, C. E., Refshauge, K. M., Bundy, A. C., Herbert, R. D., & Kilbreath, S. L. (2006). The Cumberland ankle instability tool: a report of validity and reliability testing. Archives of physical medicine and rehabilitation, 87(9), 1235-1241.
14. Huang, P. Y., Chen, W. L., Lin, C. F., & Lee, H. J. (2014). Lower extremity biomechanics in athletes with ankle instability after a 6-week integrated training program. Journal of Athletic Training, 49(2), 163-172.
15. Jain, T. K., Wauneka, C. N., & Liu, W. (2014). The effect of balance training on ankle proprioception in patients with functional ankle instability. Journal of Foot and Ankle Research, 7(Suppl 1), A37.
16. Kidgell, D. J., Horvath, D. M., Jackson, B. M., & Seymour, P. J. (2007). Effect of six weeks of dura disc and mini-trampoline balance training on postural sway in athletes with functional ankle instability. The Journal of Strength & Conditioning Research, 21(2), 466-469.
17. Korakakis, V., Abassi, M., Kotsifak, A., Manai, H., & AbuEsba, A. (2019). Cross-cultural adaptation and psychometric properties' evaluation of the modern standard Arabic version of Cumberland Ankle Instability Tool (CAIT) in professional athletes. PLoS One, 14(6), e0217987.
18. Lin, C. I., Houtenbos, S., Lu, Y. H., Mayer, F., & Wippert, P. M. (2021). The epidemiology of chronic ankle

instability with perceived ankle instability-a systematic review. Journal of foot and ankle research, 14(1),41.

19. Loudon, J. K., & Dolphino, M. R. (2010). Use of foot orthoses and calf stretching for individuals with medial tibial stress syndrome. Foot & ankle specialist, 3(1), 15-20.
20. McKeon, P. O., Ingersoll, C. D., Kerrigan, D. C., Saliba, E. T. H. A. N., Bennett, B. C., & Hertel, J. A. Y. (2008). Balance training improves function and postural control in those with chronic ankle instability. Medicine & science in sports & exercise, 40(10), 1810-1819.
21. Nam, S. M., Kim, K., & Do, Y. L. (2018). Effects of visual feedback balance training on the balance and ankle instability in adult men with functional ankle instability. Journal of physical therapy science, 30(1), 113-115.
22. Park, Han Soo, Jae Keun Oh, Jun Young Kim, and Jin Ho Yoon. "The effect of strength and balance training on kinesiophobia, ankle instability, function, and performance in elite adolescent soccer players with functional ankle instability: a prospective cluster randomized controlled trial." Journal of Sports Science & Medicine 23, no. 3 (2024): 593.
23. Picot, B., Terrier, R., Forestier, N., Fourchet, F., & McKeon, P. O. (2021). The star excursion balance test: an update review and practical guidelines. International Journal of Athletic Therapy and Training, 26(6), 285-293.
24. Schaefer, J. L., & Sandrey, M. A. (2012). Effects of a 4-week dynamic-balance-training program supplemented with Graston instrument-assisted soft-tissue mobilization for chronic ankle instability. Journal of sport rehabilitation, 21(4), 313-326.
25. Shi, X. J., Han, J., & Liu, Y. (2019). Research progress on pathological mechanism, evaluation and diagnosis of chronic ankle instability [J]. Chin J Sports Med, 38(9), 816-824.
26. Smith, B. I., Docherty, C. L., Simon, J., Klossner, J., & Schrader, J. (2012). Ankle strength and force sense after a progressive, 6-week strength-training program in people with functional ankle instability. Journal of athletic training, 47(3), 282-288.

27. Su , Y., Li, W., Pan, C., & Shi, Y. (2024). Effects of combination of strength and balance training on postural control and functionality in people with chronic ankle instability: a systematic review and meta analysis. BMC Sports Science, Medicine and Rehabilitation, 16(1), 79.
28. Subramanian , S. S., Teng, S. Y., Senthil, P., Gaowgeh, R. A. M., Alfawaz, S. S., & Neamatallah, Z. (2021). Correlation between Level of Functional Ability and Sports Performance among Football Players with Chronic Ankle Instability (CAI). J. Pharm. Res. Int, 33, 415-424.
29. Tahoon, A. M., Abdelmageed, S. F., & Mosaad, D. M. (2022). The mechanical relation between chronic ankle instability and pelvic alignment: a matched case-control study. Annals of Applied Sport Science, 10(4), 0-0.
30. Webster, K. A., & Gribble, P. A. (2010). Functional rehabilitation interventions for chronic ankle instability: a systematic review. Journal of sport rehabilitation, 19(1), 98-114.
31. Wright , C. J., Linens, S. W., & Cain, M. S. (2017). A randomized controlled trial comparing rehabilitation efficacy in chronic ankle instability. Journal of sport rehabilitation, 26(4), 238-249.
32. Zając, B., Olszewski, M., & Mika, A. (2024). Influence of protocol variables on outcomes of the star excursion balance test group (SEBT, mSEBT, YBT-LQ) in healthy individuals: a systematic review. Frontiers in Physiology, 15, 1415887.
33. Zhang , L. L., & ZHENG, J. J. (2019). Advance in posture control for chronic ankle instability. Chinese Journal of Rehabilitation Theory and Practice, 908-912.