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Original Article

Impact of jump rope and balance board training on ankle stability in athletes with chronic ankle sprains

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Abstract:
This study aimed to compare the effects of jump rope and balance board training on ankle stability in athletes with chronic ankle injuries. Thirty-two university athletes (aged 19–22 years) meeting screening criteria for chronic ankle injuries were randomly assigned to two groups: one undergoing jump rope training (n = 16, age 20.38 ± 1.15 years, height 164.63 ± 8.50 cm, weight 60.35 ± 10.26 kg, BMI 22.26 ± 3.40 kg/m^2) and the other performing balance board training (n = 16, age 20.63 ± 1.09 years, height 168.88 ± 11.18 cm, weight 62.91 ± 8.70 kg, BMI 22.24 ± 3.26 kg/m^2). Training sessions were conducted three days per week over 8 weeks. After weeks 4 and 8, the ankle stability test using the star excursion balance test (SEBT) in three directions (anterior, posterolateral, and posteromedial) and ankle angle proprioception showed significant improvements in the jump rope and balance board training groups ($p < 0.05$). In both groups, SEBT results indicated better ankle stability after weeks 4 and 8 compared to baseline. Additionally, in the balance training group using a BOSU ball, SEBT results revealed significantly greater ankle stability after week 8 than after week 4 ($p < 0.05$). The findings from this study indicate that both jump rope and balance board training can enhance ankle stability in athletes with chronic ankle sprains. However, coaches and athletic trainers should carefully consider the appropriate form of training. For athletes concerned about the risk of further ankle injury, balance training on a BOSU ball is recommended because it provides a safer option and is more effective in improving ankle stability compared to jump rope training.
Keywords: jump training; balance training; ankle injuries

Introduction

Advancements in sports science have significantly enhanced athletes' physical capabilities across various sports, often leading to the setting of new records in competitions. However, participation in any sport carries inherent risks, with ankle sprains being among the most prevalent injuries (Ferran & Maffulli, 2009). Ankle sprains typically occur when the body descends, causing the foot to impact the ground with a sudden inward ankle twist. This excessive twisting and stretching can lead to recurrent injuries, eventually resulting in chronic ankle instability, which impairs muscle control around the ankle from the initial sprain onward (Bastien et al., 2014). The primary cause of ankle instability and chronic ankle sprains is ligament laxity, specifically affecting the anterior talofibular ligament, calcaneofibular ligament, and posterior talofibular ligament in the ankle. Following injury, these ligaments can calcify internally, impacting the ankle's mechanoreceptors and impairing proprioception (Rendos et al., 2017). Additionally, muscle weakness is a contributing factor. If left untreated, ankle instability can also affect the knee joint.

Many athletes endure chronic ankle injuries leading to ankle instability. Recent studies indicate that 40% of seasoned athletes have experienced at least one ankle sprain, with 22% developing symptoms of chronic ankle instability following repeated sprains (Choisne et al., 2019). Left untreated, these injuries can significantly impair athletic performance (Gribble et al., 2016). Ankle sprains are the most prevalent sports injury, accounting for 68.3%, followed by knee injuries at 22.1% and other ankle injuries at 12.3% (Whitehead, 2017). Early and accurate diagnosis, proper treatment, and physical rehabilitation can facilitate athletes' return to normal sports activities. Conversely, inadequate or inconsistent treatment and incomplete diagnosis can exacerbate the root causes of chronic ankle sprains, leading athletes to suffer from persistent injury, diminished confidence, and premature cessation of sports participation (Ferran & Maffulli, 2009). Therefore, individuals with chronic ankle injuries should undergo symptomatic treatments such as using elastic bandages, ankle support devices, or even a cane for support during movement once swelling and initial injury have subsided and healed properly. Patients or athletes should engage in mobility exercises, particularly targeting the ankle area, to enhance ligament and muscle strength, improve flexibility, and restore normal body balance under the guidance of a physician

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(Maffulli & Ferran, 2008). Various approaches are available for treating and rehabilitating ankle instability (Domingo, 2015). Once inflammation and injury in athletes are controlled, rehabilitation can commence with methods including strength training, balance exercises, proprioceptive exercises, and muscle flexibility exercises.

Jump rope is an isotonic training method that enhances strength and endurance. It is crucial in developing the neuromuscular system's ability to generate force during muscle extension and contraction. Effective isotonic contractions involve coordinated motor unit activity facilitated by mechanisms such as the myotatic reflex (stretch reflex) (Chu and Plummer, 1984; Chu, 1992). Jump training requires flexibility and reflex responsiveness, enabling skeletal muscle structures to contract numerous contractile muscle cells alongside connective tissues and elastic fibers that support these cells. These tissues, including elastic fibers with rubber-like properties that contract when stretched, cannot themselves contract. Jump rope training enhances motor skills and muscle strength overall (Srimark and Netprasert, 2015), stimulating the sensory system of the joints. It involves coordinated work on the leg's jointed skeleton, integrating the musculoskeletal and nervous systems with surrounding structures. Previous reviews in literature on therapy and exercise have demonstrated that repetitive training impacts neuromuscular stimulation, particularly activating anatomical structures in the hip, knee, and ankle joints, aligned with principles of biomechanics, facilitating efficient movement. The sensory nervous system mechanisms in joints contribute to physical movement and play a role in sensing changes in muscle tone and postural balance. Receptors from this sensory system, part of the peripheral nerve network, are present in body tissues, including muscles, muscle membranes, tendons, ligaments, and joint membranes.

Balance training using a BOSU ball involves muscle strength development through isometric contractions, where muscle length remains constant while experiencing high tension levels. Isometric training is widely used for maximizing strength and can increase maximum power by 10–15% more than other training methods (Kertanegara et al., 2017). Enhanced muscle strength is crucial in stabilizing the ankle through neuromuscular control, movement perception, postural control, and muscle strength. The central nervous system receives movement signals via sensory nerves in the ankle, processing these signals and sending nerve impulses to instruct muscles around the ankle to stabilize the joint and maintain overall body posture (Donovan et al., 2015). An ankle injury or deformity that changes the ankle's tissue properties can impair nerve impulse reception to the central nervous system. This impairment can lead to incorrect processing by the central nervous system, affecting the control of muscles responsible for joint stability and subsequently causing ankle instability and balance issues (Hassan et al., 2022; Rahim et al., 2022). Research into balance training for individuals with unstable ankles, utilizing feedback stimulators after training, has shown improved balance among participants. This approach is believed to aid in reducing ankle instability and promoting sensorimotor restoration (Mettler et al., 2015).

Studies such as those by Srimak & Netprasert (2015) have shown that jump rope training improves balance and motor skills in healthy subjects. In the context of soccer volunteers, Trecroci et al. (2015) found that athletes who underwent eight weeks of jump rope training exhibited enhanced ankle stability and dynamic lower limb balance. However, there is a significant gap in research comparing the effects of ankle stability training through jump rope versus balance training, especially for individuals with severe ankle instability. Both training methods are promising for increasing ankle stability. However, further comparative studies are needed to elucidate their specific impacts on this population. For these reasons, the authors proposed a training regimen to evaluate the impact of rope jumping versus balance training tools on ankle stability among chronically injured athletes. The study aims to utilize these findings to enhance the training of athletes with chronic injuries, thereby improving their sports performance. Specifically, the study analyzes the effects of jump rope and balance training on ankle stability in chronically injured athletes at three points: before training, after 4 weeks, and after 8 weeks. Additionally, it compares the effects of both training methods on ankle stability after 4 and 8 weeks.

Materials and methods

Participants

The study included 32 university athletes from Maha Sarakham Province, Thailand who passed screening for chronic ankle injuries. They were divided into two groups: a jump rope training group (n = 16, age 20.38 ± 1.15 years, height 164.63 ± 8.50 cm, weight 60.35 ± 10.26 kg, BMI 22.26 ± 3.40 kg/m^2) and a balance training group (n = 16, age 20.63 ± 1.09 years, height 168.88 ± 11.18 cm, weight 62.91 ± 8.70 kg, BMI 22.24 ± 3.26 kg/m^2) as shown in Table 1. Inclusion criteria required participants to have experienced at least one sprained ankle in the past three months, without a history of surgery or other musculoskeletal injuries, and with a Cumberland ankle instability tool (CAIT) score of 25 or less (Gribble, 2013), indicating ankle instability during physical activities or sports in the past six months. The exclusion criteria included participants who had experienced accidents resulting in musculoskeletal injuries to the spine, wrists, elbows, shoulders, knees, or ankles during the study period. The sample size for this study was determined based on a previous literature review by Cruz-Diaz et al. (2015) using G*Power V 3.1.9.4 statistical software, with a power of 0.8, effect size of 1.03 and alpha level of 0.05. Calculations indicated a sample size of 13 participants per group, with an additional 20% dropout rate considered, resulting in a final sample size of 16 participants per group, totaling 32 participants. Ethical approval was obtained from the Ethics Committees of Khonkaen University (Khonkaen, Thailand), and all procedures were conducted in accordance with the Declaration of Helsinki for research involving human subjects and the ICH Good Clinical Practice Guideline. Reference No. HE632050.

Table 1. Participant characteristics (mean ± SD)

Characteristics	Group	
	Jump rope training (n = 16; 6 males, 10 females)	Balance training (n = 16, 9 males, 7 females)
Age (yrs)	20.38 ± 1.15	20.63 ± 1.09
Height (cm)	164.63 ± 8.50	168.88 ± 11.18
Weight (kg)	60.35 ± 10.26	62.91 ± 8.70
Body mass index (kg/m^2)	22.26 ± 3.40	22.24 ± 3.26

Instruments and protocol

In this study, chronic ankle instability was assessed using the Cumberland ankle instability tool (CAIT) questionnaire (ICC = 0.92). The CAIT questionnaire consists of 9 questions, each assessing the subject's perceived level of ankle stability, with a maximum score of 30 points. Participants with a score of less than 25 points were classified as having chronic ankle instability (Gribble, 2013).

Ankle proprioception was assessed using an isokinetic test (ICC = 0.85). The assessment involved a physical therapist holding the participant's ankle in a dorsiflexed position of 45 degrees. The therapist then moved the ankle by pushing the foot towards the knee 5 times in the specified range of motion, measuring and recording the ankle angle after each movement (Whitehead, 2017). Additionally, ankle stability was evaluated using the star excursion balance test (SEBT) (Patel et al., 2018). The SEBT is a standardized assessment of dynamic balance and proprioception (Adiguzel, 2020; Cordun & Rosu, 2022). It involves the use of taped lines on the floor arranged in three directions: anterior, posteromedial, and posterolateral. The participant starts in the center and uses their non-dominant leg to reach out as far as possible along each taped line while maintaining balance. The furthest point reached in each direction is marked, and the test is performed three times, with the best-recorded value used for analysis (ICC = 0.89) (Dressler et al., 2018).

The jump rope training in this study was conducted three days per week, with each session lasting 30 minutes. The training protocol consisted of performing jump rope exercises for 20 s per session, with two sessions per set. There was a 30-s rest interval between sessions and a 3-min rest interval between sets, resulting in a total of three sets performed.

In this study, balance training occurred three days a week. Participants stood on a BOSU ball for training, with the following progression: Weeks 1–2, two-legged stance; Weeks 3–4, one-legged stance; Weeks 5–6, two-legged stance with eyes closed; Weeks 7–8, one-legged stance with eyes closed. Each training session consisted of three sets lasting 60 s each, with a 1-min rest between sets.

Statistical analysis

This research employed SPSS for statistical data analysis. It assessed differences in mean and standard deviation of ankle stability between the two groups after 4 and 8 weeks. Additionally, it analyzed in-group differences in mean ankle stability before training, after 4 weeks, and after 8 weeks using one-way analysis of variance with repeated measures. Between-group comparisons were conducted using a paired samples t-test at a significance level of 0.05.

Results

A comparison of ankle stability, assessed by SEBT, between the jump rope and balance training groups, where participants stood on a BOSU ball, revealed statistically significant differences ($p < 0.05$). Specifically, in the balance training group, there was a significant increase in mean ankle stability in the anterior direction after weeks 4 and 8 compared to baseline, and significant improvements were also observed in the posterolateral and posteromedial directions after weeks 4 and 8 ($p < 0.05$). However, no statistically significant differences were found in ankle stability between the two groups ($p < 0.05$), as indicated in Table 2.

Table 2. Ankle stability assessed by the SEBT

Variable	**Jump rope training (n = 16)**			**Balance training (n = 16)**		
	Before	4th week	8th week	Before	4th week	8th week
Anterior	85.29 ± 7.93	94.29 ± 8.04*	101.12 ± 10.12*,**	91.22 ± 8.77	101.43 ± 10.99*	107.80 ± 11.55*,**
Posterolateral	120.56 ± 9.67	129.43 ± 6.83*	133.50 ± 7.54*	112.97 ± 11.01	124.80 ± 8.79*	130.10 ± 8.06*,**
Posteromedial	108.19 ± 8.79	115.64 ± 7.49*	118.82 ± 8.79*	100.25 ± 12.03	109.95 ± 10.95*	115.63 ± 11.15*,**

Significant difference: before training, $^{*}p < 0.05$; week 4, $^{**}p < 0.05$; between groups, $^{\dagger}p < 0.05$

A comparison of CAIT scores between groups revealed no significant difference in the jump rope training group before training, after week 4, and after week 8. However, in the balance training group, which performed exercises on a BOSU ball, significant differences were observed after week 8 compared to before training and between weeks 4 and 8 ($p < 0.05$). Regarding ankle angle proprioception, significant differences were found in the jump rope group after week 8 compared to before training ($p < 0.05$). In contrast, significant differences were noted in the balance training group before and after weeks 4 and 8 ($p < 0.05$). Comparison of CAIT scores and ankle angle proprioception stability between groups indicated no statistically significant differences ($p < 0.05$), as shown in Table 3.

Table 2. The CAIT scores and ankle angle proprioception of the jump rope and balance training groups

Variable	**Jump rope training (n = 16)**			**Balance training (n = 16)**		
	Before	4 week	8 week	Before	4 week	8 week
CAIT	18.13 ± 1.50	18.88 ± 1.45	20.06 ± 1.65	18.06 ± 1.53	20.06 ± 1.29	$26.13 \pm 1.09^{*,**}$
Proprioception	38.81 ± 8.27	41.27 ± 6.61	$43.54 \pm 3.35^{*}$	37.85 ± 6.54	$40.70 \pm 3.75^{*}$	$43.48 \pm 3.12^{*,**}$

Significant difference: before training, $^{*}p < 0.05$; week 4, $^{**}p < 0.05$; between groups, $^{\dagger}p < 0.05$

Discussion

In this study, participants underwent 8 weeks of jump rope and balance training using a BOSU ball. All participants completed assessments of ankle stability using the CAIT (Gribble, 2013) and SEBT in three directions: anterior, posterolateral, and posteromedial. Ankle angle proprioception stability tests were also conducted to evaluate the effects of jump rope and balance training on ankle stability in athletes with chronic ankle sprains. Balance and jump rope training significantly improved ankle stability in chronic ankle sprain athletes after 4 and 8 weeks ($p < 0.05$). Both forms of training in this study improved muscle function, leading to cellular regeneration. Proper sensory stimulation from the joints enhances muscle contraction, thereby enhancing movement skills and strength (Srimark, 2015). The sensory nervous system plays a crucial role in perceiving changes in muscle tone and is vital for controlling motion balance or postural stability during training (Prakash et al., 2017). Enhanced muscle strength aids in maintaining ankle stability through control of the nervous system, neuromuscular function, proprioception, postural control, and overall muscle strength. A recent study demonstrated that after 8 weeks of jump rope training, both healthy individuals and athletes exhibited improved movement skills, ankle stability, and balance. The lower limbs exhibited greater improvement after training, and individuals with ankle instability who underwent training using a balance machine to stimulate reflexes experienced reduced balance issues and ankle instability (Mettler et al., 2015). Proper training enhances muscle strength and contributes to maintaining ankle stability through neuromuscular control, movement perception, postural control, and muscle strength (Hall et al., 2015). The central nervous system receives sensory signals from nerves in the ankle, processes these signals, and subsequently sends nerve impulses to instruct the muscles surrounding the ankle to stabilize the joint and maintain overall body posture for stability (Donovan et al., 2015).

However, the study reported that both jump rope and balance training on a BOSU ball significantly improved the stability of athletes with chronically sprained ankles ($p < 0.05$). Specifically, in the balance training on a BOSU ball group, the data comparing ankle stability on the SEBT showed significant improvements in the anterior, posterolateral, and posteromedial directions compared to before training, after week 4, and after week 8. The increase in ankle stability after week 8 was statistically significant compared to week 4, likely attributed to the isometric contraction used during the balance training on the BOSU ball. Isometric contraction, which maintains constant muscle length with high muscle tension, was the predominant method employed in this study. This type of training has been shown to enhance maximum power by 10–15% more than other training methods (Kertanegara et al., 2016). Additionally, it was observed that participants perceived improved ankle stability angles. The group that underwent balance training on a BOSU ball showed a notable increase in ankle stability perception according to CAIT scores after week 8 compared to baseline. Moreover, significant enhancements in ankle angle perception and movement were observed after weeks 4 and 8 compared to baseline, with week 8 showing a statistically significant improvement over week 4 ($p < 0.05$).

Conclusions

The study's findings demonstrate a significant impact of jump rope and balance board training programs on ankle stability in athletes with chronic ankle sprains. Both groups showed significantly improved ankle stability and angle proprioception compared to before training. However, when comparing the results between the two training groups, it is evident that the balance training program resulted in superior ankle stability and ankle angle proprioception compared to the jump rope training group. The results of this study underscore the importance of selecting the right training program for athletes to minimize ankle injuries and enhance ankle mobility efficiently. While jump rope and balance board training can improve ankle stability in athletes with chronic ankle sprains, coaches and athletic trainers should carefully consider and tailor their training programs. Specifically, for athletes concerned about exacerbating ankle injuries, incorporating balance training on a BOSU ball may offer a safer and more effective approach to enhancing ankle stability compared to jump rope training. This approach can help athletes feel more confident in their ankle stability while maximizing training effectiveness.

Conflicts of interest
The authors declare that there is no conflict of interest.

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