

The Relationship between Hip Function and Chronic Ankle Instability: Implications for Rehabilitation

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Abstract. Chronic ankle instability (CAI) is a common sequela of ankle sprain, characterized by a high recurrence rate and long-term functional impairment. Traditional rehabilitation methods mainly focus on local ankle training, often neglecting the role of proximal muscle groups in maintaining the overall stability of the lower limbs, which limits the therapeutic effect. Both clinical and experimental studies have shown that poor hip function can alter the pattern of movement coordination and increase the compensatory burden on the ankle, allowing CAI to persist. Evidence shows that hip strengthening training, including open and closed kinetic chain exercises, can improve balance, motor control, and joint stability, sometimes surpassing ankle training alone. Combining hip training with gait retraining, neuromuscular control training, and specialized exercise practice can further enhance the rehabilitation effect. The use of quantitative assessment tools and the formulation of individualized rehabilitation pathways have received increasing attention. Currently, research still faces some challenges, such as the lack of standardized training programs, insufficient large-scale randomized controlled trials, and unclear neurophysiological mechanisms. This review aims to explore the role of hip muscle function in ankle stability, providing practical suggestions for incorporating hip-focused intervention measures into CAI rehabilitation to improve long-term recovery.

Keywords: Chronic ankle instability, rehabilitation, hip muscle, kinetic chain.

1. Introduction

Ankle sprain refers to pain and limited range of motion caused by stretching or tearing of one or more ligaments in the ankle joint. Approximately 85% of ankle sprains are lateral ankle sprains (LAS), which are the most common lower limb injuries among both the general population and athletes [1, 2]. Research indicates that 16-40% of sports-related injuries are acute ankle sprains. If left untreated, it can lead to CAI, with a recurrence rate of 70% [3]. Current research mainly focuses on local anatomical features, injury processes, and ankle rehabilitation techniques. There is extensive research on the specific anatomical structures of the ankle and rehabilitation methods, but most studies overlook how the proximal muscles of the lower limb chain affect ankle stability, especially the little-known function of the hip muscles as core stabilizers. This is a significant gap.

Recent studies show that rehabilitation often focuses on local management techniques such as proprioceptive training, strength training, and the POLICE principle [4], with the aim of restoring ankle range of motion. Warm-up methods can prevent LAS during training but are insufficient to completely prevent injuries caused by abnormal lower limb alignment. The ankle, knee, and hip form an integrated kinetic chain. When the ankle is dysfunctional, it may cause proximal compensatory problems in the knee and hip. During single-leg tasks, the gluteus medius and gluteus minimus play a pivotal role in stabilizing the hip and pelvis, ensuring proper pelvic alignment and enabling controlled movement of the swing leg. Research on young, elite female basketball players shows that these muscles, not just abductors, contribute to more effective lower limb movement patterns and may reduce injury risk. The purpose of this review is to explore the relationship between ankle stability and hip muscle function, providing a theoretical basis for developing more comprehensive injury prevention and rehabilitation programs.

2. The Impact of Hip Muscle Function on Ankle Stability

Ankle stability was once thought to depend primarily on local joint anatomy and neuromuscular control. Recent research, however, indicates that the hip muscles, particularly the gluteus medius and gluteus minimus, play a crucial role in regulating dynamic balance and lower limb movement patterns, thereby indirectly influencing ankle function and injury risk. A study measured the hip abduction and adduction muscle strength of female basketball players aged 13 to 18, and also examined the relationship between these muscle forces and balance ability, as well as the range of ankle dorsiflexion movement. The study reported a positive correlation between hip abductor strength and Y Balance Test (YBT) scores (right hip abduction and right YBT, $\beta = 0.592$, $p = 0.048$), suggesting that stronger hip abductors contribute substantially to maintaining dynamic balance [5]. Another study selected 10 healthy individuals and 10 patients with CAI and measured their coordination of the hip and ankle. The results revealed significant group differences across multiple gait phases, including the frontal plane during the weight-bearing response (healthy group 165.9 ± 18.4 , CAI group 127.6 ± 48.6 , $p = 0.04$), the sagittal plane during mid-stance (healthy group 307.2 ± 9.8 , CAI group 291.8 ± 11.4 , $p < 0.01$), terminal stance (healthy group 301.1 ± 13.0 , CAI group 313.4 ± 10.9 , $p = 0.04$), and early swing (healthy group 243.9 ± 35.2 , CAI group 329.9 ± 57.8 , $p < 0.01$) [6]. This study indicates that the coordination of the hip joint is closely related to the stability of the knee and ankle joints. The function of the hip muscle group for the stability of the lower limbs is not only the function of the hip joint itself, but also affects the dynamic balance of the entire lower limb through coordinated control of the movement of the knee and ankle, and training the function of the hip muscle group may become an important method to help stabilize the ankle joint and reduce sports injuries.

3. Impaired Hip Muscle Function in Chronic Ankle Instability

Ankle joint strength training has certain effects on patients with CAI. However, more and more studies have found that the hip muscle function of CAI patients is insufficient. This may be the cause of ankle instability and repeated sprains. The lack of strength in the proximal muscles can affect the overall stability of the lower limbs, reducing the effectiveness of ankle rehabilitation. At this time, it is necessary to shift from focusing only on the ankle joint to paying attention to the overall kinetic chain. The hip is the key stabilizing part. Studies have shown that the hip abduction, extension, and external rotation strength of CAI patients is significantly lower than that of healthy people, indicating that the lack of strength in the proximal muscle groups directly affects the stability of the lower limbs. A study involving 548 people, including 271 CAI patients and 277 healthy controls, showed that the isometric hip abduction strength (SMD: 0.56, $p < 0.001$), extension strength (SMD: 0.62, $p = 0.003$), and external rotation strength (SMD: 0.59, $p = 0.005$) of the CAI patient group were significantly lower [7]. This indicates that CAI patients have proximal neuromuscular dysfunction, which is a key part of the CAI pathological mechanics. Athletes with low hip strength have difficulty controlling movements in the frontal and transverse planes, which can lead to excessive internal or external ankle inversion or rotation, thereby causing re-injury.

The hip muscle function also deteriorates during activities. Another study found that CAI patients' hip muscles tend to fatigue and function deteriorate after prolonged activities. This change is closely related to the change in the way the legs move. The ankle movement situation of CAI patients changes during the standing stage when moving to the side. The proximal joints exhibit greater stiffness compared with those of healthy individuals [8]. This study shows that CAI patients have movement perception problems. The way they exert force on the ankle when moving to the side is different from that of healthy people. This changed movement pattern may cause the CAI patients to constantly sprain their ankles and make their hip muscles constantly tired and function deteriorate. Abnormal hip muscle function is an important factor for the instability of the ankle joint in CAI patients. Solving the deficiency near the hip suggests that hip exercises are useful. It emphasizes the value of multimodal rehabilitation combining movement control, neurophysiology, and biomechanics.

Strengthening the training of hip muscle function helps improve the stability of the patient's lower limbs and reduce the occurrence of injuries.

4. Effects of Hip Strengthening on Chronic Ankle Instability Rehabilitation

The common ankle exercises mainly focus on local stability. More and more evidence shows that exercising the muscles close to the center of the body brings more benefits. Multiple studies support incorporating hip strengthening in the rehabilitation treatment for CAI patients because the hip muscles play an important role in stabilizing the lower limbs [9]. Studies have shown that CAI patients who strengthen their hip abduction and external rotation muscles have significantly improved dynamic balance, static balance, hip abduction and external rotation muscle strength, and all these aspects have shown significant improvement [10]. These programs yield better dynamic balance, improved movement coordination, and greater joint stability. For example, hip strength training not only enhances proximal stability but also affects the movement chain to improve ankle joint function. The results of the 4-week hip strengthening training showed that the experimental group performed significantly better than the control group in their reported functions (FAAM-ADL/SPORT), dynamic and static balance, hip abduction and external rotation muscle strength ($p < 0.05$). This indicates that strengthening hip muscle strength through the movement chain effect not only improves proximal stability but also improves ankle joint function [11]. These results emphasize that for maximizing the performance of the distal joints, rehabilitation should combine proximal goal training rather than focusing solely on the ankle joint.

Studies have shown that exercising to strengthen the hip muscles can improve the movement patterns of the knee and ankle joints and prevent injuries caused by poor force transmission. In this study, after 8 weeks of hip abduction muscle strengthening exercises, the static and dynamic balance, and the asymmetry of knee flexion and extension muscle strength of the patients in the experimental group improved significantly. Enhancing proximal stability and optimizing force transmission within the kinetic chain are central to restoring coordinated lower limb function in individuals with CAI. Strengthening key proximal muscles, particularly the hip abductors, contributes to reducing compensatory movement patterns and improving neuromuscular efficiency. These adaptations exert beneficial downstream effects on distal joint symmetry, balance control, and overall movement stability.

Evidence suggests that hip-centered interventions produce functional benefits beyond the local region, supporting their inclusion in comprehensive CAI rehabilitation programs. By improving the strength and coordination of the hip musculature, such training enhances lower limb stability and reduces the likelihood of recurrent sprains. Therefore, hip-focused exercises should be regarded as a fundamental component of CAI rehabilitation. In clinical settings, rehabilitation protocols should include regular assessment of hip muscle strength and targeted training, such as side-lying leg raises, clamshells, and closed-chain landing tasks, to promote integrated motor control and reduce the risk of re-injury [12].

5. Clinical Implications and Rehabilitation Recommendations

In clinical practice, a growing body of evidence supports the hip muscles training for CAI in patients with a rehabilitation scheme, in order to improve the rehabilitation effect. Studies have shown that patients with CAI often have insufficient gluteal muscle strength, especially weakened hip abduction, external rotation, and extension muscle strength, which may affect proximal stability and motor control [7, 10]. These proximal deficits not only reduce the ability to stabilize the pelvis during dynamic tasks but also impair kinetic chain efficiency, ultimately increasing the risk of recurrent ankle sprains. Therefore, it is recommended to incorporate the gluteal muscle isometric test into the routine assessment, such as quantitatively evaluating the above-mentioned muscle strength using a hand held dynamometer (HHD) or isometric equipment, and pay attention to bilateral symmetry to

identify potential defects. Establishing normative data for different populations, such as athletes and non-athletes, may further enhance the clinical utility of these assessments. Based on the assessment results, a comprehensive rehabilitation plan covering hip strengthening, balance training, and motor control strategies should be formulated [11].

Clinical evidence indicates that combining hip strengthening exercises (such as side-lying leg raises, clamshells, and fire hydrants) with closed-chain movements, balance training, and visual feedback can accelerate functional recovery and enhance rehabilitation outcomes in individuals with chronic ankle instability [8]. In addition, emphasis should be placed on single-leg standing on unstable planes, balance training under disturbed conditions, and hip-led landing strategies to optimize neuromuscular coordination and recruitment timing. It is worth noting that CAI is also associated with changes in hip-ankle coordination during gait and coordination variability during the standing period. Therefore, gait training should focus on improving the hip-ankle coordination pattern to reduce the risk of reinjury [6]. A study further pointed out that when designing and implementing lower extremity prevention strategies, the impact of hip abduction and adduction muscle strength on balance and ankle joint function should be emphasized [5]. Therefore, in clinical rehabilitation, the assessment and training of hip muscles should be strengthened to ensure that, through comprehensive, progressive, and function-oriented training methods, the overall motor control ability and proximal stability of patients can be improved, ultimately effectively reducing the occurrence of CAI and the risk of re-injury.

6. Conclusion

CAI is a common aftereffect following ankle sprains. Local rehabilitation of the ankle alone is often insufficient to cure the condition, indicating that traditional methods have limitations in addressing recurrence issues. Numerous studies have shown that poor hip muscle function significantly affects ankle stability. This aspect has received little attention. Currently, some materials emphasize the importance of hip strengthening in the rehabilitation of CAI. It can greatly reduce the recurrence rate, make the upper body more stable, restore the coordination of the kinetic chain, and from a clinical perspective, this is particularly important for high-risk groups such as athletes and manual workers.

There are still significant deficiencies in the current research on hip training for CAI treatment. There is a lack of ready-made solutions, significant individual differences among patients, and a scarcity of high-quality clinical evidence. Future research should focus on three main directions: developing objective assessment tools, using wearable devices and artificial intelligence to provide precise and real-time assessment of rehabilitation progress, formulating individualized rehabilitation plans, improving intervention accuracy, meeting the needs of each patient, and promoting multidisciplinary approaches, combining knowledge from sports medicine, neurophysiology, and biomechanics, to better understand how hip strengthening enhances ankle stability. Hip training in CAI rehabilitation has great potential.

Authors Contribution

All authors contributed equally to this study.

References

- [1] Luo L, Sun W D, Zhao X H, et al. Effect of strengthening training of hip muscles on functional ankle instability. *Chinese Journal of Rehabilitation Theory and Practice*, 2017, 23: 1195-1199.
- [2] Halabchi F, Hassabi M. Acute ankle sprain in athletes: Clinical aspects and algorithmic approach. *World Journal of Orthopedics*, 2020, 11: 534-558.

- [3] Roos K G, Kerr Z Y, Mauntel T C, et al. The epidemiology of lateral ligament complex ankle sprains in National Collegiate Athletic Association sports. *The American Journal of Sports Medicine*, 2017, 45: 201-209.
- [4] Bahr R, Cook J, Langberg H, et al. Treating sports injuries. In: *The IOC Manual of Sports Injuries: An Illustrated Guide to the Management of Injuries in Physical Activity*, 2012: 25-39.
- [5] Domínguez-Navarro F, Benitez-Martínez J C, Ricart-Luna B, et al. Impact of hip abductor and adductor strength on dynamic balance and ankle biomechanics in young elite female basketball players. *Scientific Reports*, 2022, 12: 3491.
- [6] Yen S C, Chui K K, Corkery M B, et al. Hip-ankle coordination during gait in individuals with chronic ankle instability. *Gait & Posture*, 2017, 53: 193-200.
- [7] Zheng J, Xu B, Xiong X, et al. Hip muscle strength in patients with chronic ankle instability: A systematic review and meta-analysis. *Physical Therapy in Sport*, 2025, 75: 48-57.
- [8] Simpson J D, Stewart E M, Turner A J, et al. Lower limb joint kinetics during a side-cutting task in participants with or without chronic ankle instability. *Journal of Athletic Training*, 2020, 55(2): 169-175.
- [9] Jaber H, Lohman E, Daher N, et al. Neuromuscular control of ankle and hip during performance of the star excursion balance test in subjects with and without chronic ankle instability. *PLoS ONE*, 2018, 13(8): e0201479.
- [10] Yeum W J, Lee M Y, Lee B H, et al. The influence of hip-strengthening program on patients with chronic ankle instability. *Medicina*, 2024, 60(8): 1199.
- [11] Zhang H W. Research on the application of movement chain theory in rehabilitation patients with functional ankle instability. *Chinese Journal of Convalescent Medicine*, 2024, 33(10): 68-72.
- [12] RostamiAnhar S, Roshani S, Dangharalou M M, et al. The effect of hip abductor strengthening exercises on lower limb strength asymmetry and balance in women with multiple sclerosis: A randomized controlled clinical trial. *Multiple Sclerosis and Related Disorders*, 2024, 84: 105505.