



The Effect of a Training Approach Using an Anti-Gravity Treadmill on Improving Strength and Balance in Athletes with Medial Ankle Ligament Tears

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Abstract

This study examined the effect of a rehabilitation program using exercises and an anti-gravity treadmill on athletes with partial medial ankle ligament tears. Five athletes underwent eight weeks of training three sessions per week, including walking heel and forefoot exercises and treadmill use with and without anti-gravity support. Pre- and post-tests measured dorsiflexion plantar flexion inversion strength, balance, and single-leg walking. Results showed significant improvements in all measures: dorsiflexion (0.8 → 3.32), plantar flexion (0.9 → 2.7) inversion (0.36 → 3.06) balance (155.2 → 198.6) and single-leg walking (5.94 → 8.5) ($p < 0.05$). The program effectively enhanced ankle strength stability balance and functional performance. The anti-gravity treadmill enabled safe progressive training, supporting recovery while reducing joint stress. Combining strength, flexibility and balance exercises accelerated rehabilitation, improved motor performance minimized reinjury risk, and emphasized the value of ongoing functional assessment for safe return to sport.

Keywords : Ankle Injuries, Ligament Injuries, Rehabilitation, Exercise Therapy, Treadmills.

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Introduction

Medial ankle ligament tears are common injuries that occur when the medial ligament on the inner side of the ankle is ruptured due to abnormal or sudden ankle movements. This injury affects the ligament's function, leading to impaired balance and stability, as well as swelling and pain in the affected area.

In particular, medial ankle ligament tears are frequent injuries resulting from sudden movements or ankle sprains that impact the medial ligaments. These injuries often occur in athletes or individuals engaging in high-intensity physical activities that place significant stress on the lower limbs. Sudden directional changes , rapid movements and high-impact actions as seen in football and basketball players, increase the likelihood of such injuries .

Currently , scientific and technological advancements in sports have contributed to higher levels of athletic performance in recent years. As a result , the differences in athletic achievement have become minimal. These factors also make sports injuries more prevalent due to the high physical demands placed on athletes during performance , particularly in sports such as football , basketball and track and field (Shlash, 2023) .

Sports injuries are a major cause of sidelining athletes and limiting their ability to participate in physical activities especially when injuries are recurrent in the same area or affect a vital part of the body . Medial ankle ligament tears are considered complex injuries that cause severe pain and require rest and rehabilitation . If not treated properly and promptly these injuries may take a long time to heal potentially worsening the condition and delaying the athlete's return to sport. Moreover , the ankle joint is one of the most important joints in the body as it supports the entire body and is essential for walking and daily activities. Therefore , various treatment approaches have been developed for this joint .

An injury is defined as the impact on a tissue or a group of tissues by an external , internal , or self-induced factor leading to impaired function of that tissue. Rehabilitation and exercise programs play a crucial and fundamental role in daily life . Injuries can also be described as the disruption or impairment of the integrity of body tissues due to external factors whether mechanical, physical or chemical. Such factors are usually sudden and severe causing anatomical changes such as restricted joint or muscle movement as well as physiological alterations in the functions of the affected area including tears , bleeding , skin discoloration and other effects (Qasim, 2015).

When any part of the body is injured, it may result in the inability to move that part or to perform activities correctly for a period of time, which can reduce the functional capacity of the injured area. Therefore, the most appropriate method to restore function is through rehabilitative exercises, following consultation with a specialized physician and obtaining X-ray imaging. Pain management and appropriate pharmacological treatment should be applied when exercises cannot

be performed due to discomfort. Consequently, targeted rehabilitation exercises, including the use of an anti-gravity treadmill, are essential for effectively restoring the injured area.

Through the researcher's review of previous studies and research in the field of ankle sprain rehabilitation as well as the expertise of specialized supervisors and through the researcher's constant presence on the field during most tournaments held in Iraq as a referee in the federation certain observations were made regarding injuries reported by athletes during competition periods and preparation phases. After conducting further investigation and research in the sports field and with the active involvement of the supervisors in monitoring injured athletes both on the field and in other sports the researcher's visits to physical therapy and sports rehabilitation centers in Baghdad revealed that many athletes were suffering from partial medial ankle ligament tears . These athletes required proper injury rehabilitation and treatment to prevent further aggravation and to enable a safe return to competition . Some athletes experienced recurrent injuries increasing the risk of permanent absence from the field or the need for surgical intervention .

Consequently , the researcher in collaboration with the supervisors , decided to employ exercise programs in conjunction with an anti-gravity treadmill for the rehabilitation of medial ankle ligament injuries. The primary goal is to prevent the progression of the injury to a severe condition that could only be treated surgically. Exercises will be applied both with and without the device, following a group-based system at the rehabilitation center located in Baghdad (Al-Bashir Center) .

Research Questions

1. Do the exercises used have an effect on the rehabilitation of medial ankle ligament tears?
2. Does the device (anti-gravity treadmill) have an effect on the rehabilitation of medial ankle ligament tears?
3. Can medial ankle ligament tears be fully treated and rehabilitated to restore normal function?

Research Objectives

1. To design rehabilitation exercises for medial ankle ligament tears.
2. To develop rehabilitation exercises in conjunction with an anti-gravity treadmill for medial ankle ligament tears.
3. To determine the effect of exercises and the anti-gravity treadmill on medial ankle ligament tear rehabilitation.



H1: There are statistically significant differences between the pre-test and post-test results of the study group of athletes with medial ankle ligament tears.

Recently, there has been an increase in medial ankle ligament injuries, making it a phenomenon with significant medical and technical implications. To improve medical examination, diagnosis, treatment, and rehabilitation methods for ankle injuries, the importance of the current study lies in determining how athletes with medial ankle ligament tears can return to their normal condition. This is achieved according to established scientific principles and using appropriate tests at each stage of rehabilitation. The study focuses on exercises aimed at rehabilitating the injured area, combined with the use of an anti-gravity treadmill through specialized exercises that target the ankle injury and facilitate the athlete's return to the field as quickly as possible.

The study focuses on a number of athletes with moderate medial ankle ligament tears participating in various sports. The research was conducted over the period from April 1, 2025, to September 1, 2025. The spatial scope of the study includes Al-Bashir Rehabilitation Center in Al-Mansour, Karkh, Baghdad; Power House Hall in Al-Doura – Hay Al-Seha, Baghdad; and Al-Qala'a Gym in Al-Ghazaliya, Baghdad.

Methodology

The research methodology is considered the scientific path that the researcher follows to solve the research problem, as the nature of the problem dictates a specific approach to reach the truth (Hussein, 2022). Therefore, the researcher employed the experimental method, specifically the single experimental group design with pre-test and post-test, due to its suitability for the nature of the problem. The experimental method is among the most effective approaches for achieving practical objectives in a precise scientific manner, in addition to its important role in providing solutions to various problems (Al-Kubaisi, 2004).

Research Sample

The research sample consists of athletes suffering from medial ankle ligament tears in various sports (n=5), who were selected intentionally from Al-Bashir Sports Rehabilitation Center in Baghdad, after obtaining a medical diagnosis and confirming the injury through MRI or X-ray, as well as determining the appropriate pharmacological treatment period. The rehabilitation program was applied over a period of eight weeks at Al-Bashir Rehabilitation Center, which the athletes regularly attend for treatment. The injured right foot was chosen from the sample due to physiological differences between the affected feet, as well as the specific demands of the sport.

Table 1. Description of the Study Sample

Player	Age (years)	Experience (years)	Height (cm)	Weight (kg)	Injury Date	Injury Severity	Sport/Event
1	26	7	175	71	10/3/2025	Moderate	Track & Field
2	23	5	188	90	15/3/2025	Moderate	Track & Field
3	23	2	184	86	13/3/2025	Moderate	Track & Field
4	22	3	180	65	17/3/2025	Moderate	Handball
5	24	4	178	70	19/3/2025	Moderate	Basketball

Table 2. Statistical Description of Strength and Balance Tests for the Study Sample

Test	Mean	S.D.	Skewness
Dorsiflexion Strength of the Foot	0.8	0.1	0.000
Plantar Flexion Strength of the Foot	0.9	0.18	0.382
Medial Flexion Strength of the Foot	0.36	0.11	0.405
Balance	155.2	15.75	0.608
Single-Leg Walking Test	5.94	0.48	0.770

Data Collection Tools

The data for this study were collected using a variety of sources and tools , including Arabic and foreign literature , personal interviews , measurements and tests online information networks , diagnoses by specialized physicians , observation and experimentation. The research team was assisted by supporting staff and information was gathered using forms completed by the study sample and data recording sheets. Additional tools included a measuring tape, elastic bands, a whistle, a stopwatch, fixation tape, foam cylinders, boxes of different heights (20 cm and 40 cm), and a Nikon D750 camera. The devices employed in the study included an Alter-G anti-gravity treadmill, a dynamometer for strength measurement , a goniometer for assessing range of motion, a medical scale for weight and height measurement , a laptop (Acer) for recording test and rehabilitation results and a balance disc , The anti-gravity treadmill is an advanced rehabilitation and training device that allows walking or running while reducing body weight impact on joints and muscles , minimizing pain and accelerating recovery. Using pressurized air in a sealed chamber , it partially lifts the body and supports weight from 20% to 100%, enabling natural movement without stress. The treadmill benefits include injury rehabilitation (e.g., partial medial ankle ligament tears) gradual return to walking , enhanced athletic performance , support for elderly and neurological patients and safe exercise for overweight individuals. Its applications span post-orthopedic surgery, gait improvement in neurological conditions, athletic recovery and reduced joint load during fitness training, making it a safe and effective tool for restoring mobility and performance .



Procedures

The tests with the study sample were conducted on Monday , April 14, 2025 over the course of a single day following the sequential order of procedures outlined for the experiment.

1. Single-Leg Walking Test

The Single-Leg Walking Test was designed to measure walking performance on one leg against gravity . The test was conducted using an anti-gravity treadmill which allows the injured participant to walk while reducing pain and strain on the affected limb thus aiding the restoration of dorsiflexion and plantar flexion movements and strengthening the muscles around the ankle joint. The treadmill operates on a weight-reduction principle using pressurized air and the participant enters a closed air chamber around the lower body . Wearing special shorts with an attached loop the participant connects to the device's loop system and the therapist adjusts the session's time and speed. The performance time is recorded on the treadmill's display from start to finish, measured in minutes (Polyvios Kyritsis, 2016, p.123) .

2. Balance Test (Standing on the Injured Leg)

The Balance Test aimed to assess static balance by having the participant stand on the injured leg while lifting the healthy leg folding the arms across the chest , closing the eyes and maintaining stability for as long as possible. The test required that the healthy leg not touch the injured leg and that the eyes remain closed throughout the procedure. A stopwatch , whistle and recording form were used to measure and document the duration of balance recorded from the start to the end of the performance in seconds (Hughes, 2017, p.33) .

3. Muscle Strength Tests for the Ankle Joint

Muscle strength of the ankle joint was measured using a dynamometer designed for this purpose with the injured foot secured in the designated position using specialized straps. Three specific tests were conducted :

a. Dorsiflexion Strength Test: This test measured the maximum dorsiflexion strength of the injured foot . The participant performed maximal dorsiflexion from the initial position and the dynamometer recorded the force in kilograms which was then converted to Newtons by multiplying by 9.81 (Raouf, 2005, p.53).

b. Plantar Flexion Strength Test: This test assessed the maximal plantar flexion strength of the injured foot. Starting from the initial position the participant performed maximal plantar flexion and the recorded force in kilograms was converted to Newtons using the same conversion factor .

c. Medial (Inversion) Strength Test: This test evaluated the maximal inversion strength of the injured foot. The participant executed maximal inversion from the starting position with the force measured in kilograms and subsequently converted to Newtons by multiplying by 9.81.

The researcher conducted a pilot study on April 5, 2025 at Al-Bashir Rehabilitation Center with two athletes to test the equipment, procedures and timing of the tests. The assistant team was prepared and instructed on proper measurement techniques. The pilot aimed to identify challenges assess test suitability, verify equipment, organize procedures and define team roles ensuring smooth and reliable execution of the main experiment.

Rehabilitation exercises began on April 17, 2025 with three weekly sessions over eight weeks (24 units). Exercises included straight-line walking heel and forefoot walking on the treadmill and anti-gravity treadmill exercises. Preliminary tests determined rest periods, repetitions, session duration and exercise intensity based on each participant's initial pain in the injured medial ankle ligament.

The post-tests were conducted on Sunday, July 20, 2025 following the same procedures as the pre-tests. The researcher ensured that all variables recorded during the pre-test were carefully documented and applied during the post-test to maintain consistency and accuracy in the assessment .

Statistical Analysis

Descriptive statistics were used to analyze all study variables for the single group of participants . Pre-test and post-test scores for each variable were summarized using the mean, standard deviation and skewness coefficient to assess the distribution and homogeneity of the data. Skewness values ensured the normality of the data allowing valid comparisons between pre-test and post-test results within the same group. All statistical analyses were performed using SPSS version 26 .

Results

Table 3. Shows the results of the T-test for the pre-test and post-test measurements of the research sample

Variables	Pre-Test Mean $\pm$ SD	Post-Test Mean $\pm$ SD	T-Test Value	P- Value
Dorsiflexion Strength	0.8 $\pm$ 0.1	3.32 $\pm$ 0.43	12.260	0.000
Plantar Flexion Strength	0.9 $\pm$ 0.18	2.7 $\pm$ 0.76	5.503	0.005
Inversion Strength	0.36 $\pm$ 0.11	3.06 $\pm$ 0.42	19.092	0.000
Balance	155.2 $\pm$ 15.75	198.6 $\pm$ 15.88	15.158	0.000
Single-Leg Walking Test	5.94 $\pm$ 0.48	8.5 $\pm$ 0.59	9.704	0.001

All results are under a significance level of 0.05 with degrees of freedom = 4

Discussion

The results of the T-test for the pre-test and post-test measurements of the research sample in Table 3 revealed statistically significant differences in several assessments conducted on participants with medial ankle ligament (deltoid) tears. These differences indicate the positive effect of the rehabilitation exercises combined with the anti-gravity treadmill on muscle strength, balance and the ability to perform sports activities .

The results demonstrated a significant improvement in dorsiflexion strength increasing from 0.8 ± 0.1 in the pre-test to 3.36 ± 0.49 in the post-test with a T-test value of 12.260 and a significance level of 0.0000. This substantial improvement indicates a positive effect of the rehabilitation exercises on enhancing ankle muscle strength which is crucial for improving an individual's ability to withstand load and perform various sports activities.

Improving muscle strength around the ankle is not only essential for athletic performance but is also a key component of rehabilitation following injuries such as ligament tears or sprains which weaken the surrounding muscles , reduce ankle stability and increase the likelihood of recurrent injuries. Strengthening exercises help restore the muscular support needed to stabilize the ankle and reduce stress on the joint during movement. Exercises that target the anterior and posterior muscles of the lower leg, as well as the supporting muscles around the ankle play a central role in improving joint stability (Sohrabi et al., 2024).

Increased muscle strength enhances the ankle's capacity to tolerate mechanical forces during sports activities that involve sudden changes in direction or continuous loading such as jumping or running. Strengthening the muscles surrounding the ankle reduces joint stress and consequently lowers the risk of reinjury . The ability of these muscles to withstand load and adapt to various movement challenges determines the athlete's potential to return to the required level of sports performance (Prieske et al., 2016) .

Studies have shown that strength training contributes to preventing future injuries . Athletes who performed ankle-strengthening exercises demonstrated significant improvements in muscular stability and avoided subsequent injuries . Strengthening the muscles around the ankle enhances muscular balance and endurance reducing the likelihood of sprains and recurrent injuries (Baltich et al., 2014) .

In addition to preventive effects improved ankle muscle strength also enhances overall sports performance . Athletes focusing on ankle strength notice better performance in movements requiring increased power , such as sprinting , jumping and activities involving rapid directional changes . These improvements are not limited to professional athletes; they apply to anyone who regularly engages in sports as enhanced muscle strength contributes to higher performance levels and reduced muscular fatigue .

The study results demonstrated a significant improvement in plantar flexion strength increasing from 0.9 ± 0.18 in the pre-test to 2.7 ± 0.76 in the post-test with a T-test value of 5.503 and a significance level of 0.0050 indicating statistically significant differences between the two measurements. This improvement reflects the positive effect of the rehabilitation exercises in strengthening the plantar flexor muscles which are responsible for the forward propulsion of the foot and are essential for both daily and sports-related movements.

Plantar flexor muscles are primary drivers of ankle movement during walking, running, jumping and landing generating the push-off force against the ground. When the medial ankle ligament or any of the internal support structures are injured , these muscles are often affected in terms of strength and neuromuscular response. Therefore , focusing on strengthening them is crucial for rehabilitation and achieving movement stability.

The noticeable improvement in this type of muscle strength indicates that the exercises used in the rehabilitation program were effective in restoring muscular balance around the ankle joint and enhancing endurance . These results are consistent with Fong et al. (2007) who reported that plantar flexor strengthening exercises improve overall ankle muscle strength and reduce balance loss during dynamic movements . Their study concluded that plantar flexor weakness is directly associated with increased risk of reinjury and impaired motor performance, making it a priority in post-ankle injury rehabilitation .

Additionally , Mattacola and Dwyer (2002) found that strengthening the plantar flexor muscles enhances overall ankle functional capacity and contributes to improved athletic performance in jumping, running and landing tasks, particularly following ankle ligament injuries. They recommended incorporating targeted resistance training for the plantar flexors into rehabilitation programs to reduce recovery time and improve motor efficiency.

Improved plantar flexion strength not only enhances motor performance but also contributes to better ankle stability by providing dynamic support during situations that require both balance and flexibility . Hall et al. (2018) confirmed that athletes who improved their plantar flexor strength exhibited greater ankle control during complex movements, such as longitudinal and lateral jumps thereby reducing the risk of sprains.

The study results demonstrated a significant improvement in ankle inversion (medial) strength, which increased from 0.36 ± 0.11 in the pre-test to 3.06 ± 0.42 in the post-test with a T-test value of 19.092 and a significance level of 0.0000. This improvement reflects the positive effect of the rehabilitation exercises in enhancing the strength of the muscles responsible for ankle inversion serving as an important indicator of restored functional capacity of the ankle and foot.

Inversion strength is closely associated with the muscles responsible for medial flexion such as the anterior foot muscles and surrounding ligaments. These muscles contribute to the dynamic stability of the ankle and foot enabling the individual to perform diverse movements such

as longitudinal and lateral jumps, which require rapid changes in direction. The ability of these muscles to execute such movements effectively and powerfully is critical in preventing injuries including sprains caused by inadequate response to sudden or complex mechanical stresses .

Ribeiro et al. (2009) reported that inversion strengthening exercises significantly improve ankle muscle strength and range of motion enhancing motor response during complex lateral movements. Their study applied regular strengthening exercises to a group of athletes demonstrating that improved inversion strength reduces the risk of sprains or tears particularly in athletes exposed to high dynamic loads .

Similarly, Aritonang and Wahyuni (2023) showed that inversion strength plays a key role in enhancing muscular stability around the ankle joint especially during activities requiring rapid directional changes such as sprinting or evasive maneuvers. Their findings indicated that resistance exercises targeting inversion muscles enhance the ability of the muscles to respond to sudden loads, thereby minimizing injury risk .

These findings align with Huang et al. (2022) who emphasized that the strength of ankle inversion muscles is essential for maintaining dynamic stability during complex movements. Athletes with weak inversion muscles demonstrate limited capacity to perform movements correctly while rehabilitation exercises aimed at strengthening these muscles help restore the ability to execute lateral movements quickly, ultimately improving overall athletic performance.

The balance test results showed a significant improvement increasing from 169.2 ± 7.12 in the pre-test to 198.6 ± 15.88 in the post-test with a T-test value of 15.158 and a significance level of 0.0000. This substantial improvement indicates that the rehabilitation exercises played a key role in enhancing overall balance reflecting better joint stability and the body's ability to maintain equilibrium during movement essential for restoring normal function after injuries. Balance exercises are a fundamental part of rehabilitation programs especially for injuries affecting joint stability such as ankle or knee injuries. Balance is not merely the ability to remain still but involves adapting to and responding to external forces during movement such as sudden changes in direction or loss of footing. By strengthening the muscles supporting the joint and improving neuromuscular responses balance exercises reduce the risk of future injuries and enhance safe and effective performance of sports movements. Improvement in balance among the participants indicates better body coordination in responding to forces during daily or athletic activities and reflects the restoration of muscular and ligamentous coordination around the injured joint. Recent studies highlight balance training as a crucial method for enhancing post-injury motor stability; for example Plummer et al. (2019) demonstrated that balance exercises improve functional capacity and muscular stability around injured joints which aligns with the significant improvements observed in the balance test in this study .

The single-leg walking test results demonstrated a clear improvement in ankle functional capacity increasing from 5.94 ± 0.48 in the pre-test to 8.5 ± 0.59 in the post-test with a T-test value of 9.704 and a significance level of 0.0010. This marked improvement indicates a substantial enhancement in the ankle's ability to adapt to daily activities and perform movements requiring balance and stability such as walking and standing on one leg. The single-leg walking test is a crucial functional assessment used to evaluate motor stability and endurance after ankle injuries. It demands integrated neuromuscular control as the individual must maintain balance on one leg for a specified duration while stabilizing the ankle against dynamic challenges, such as movement or sudden directional changes . Improvement in this test reflects the ankle's restored capacity to perform daily motor activities normally indicating overall functional recovery (Trojian & McKeag, 2006). These findings are consistent with Ma et al. (2024) who reported that enhancing single-leg walking ability is a key indicator of functional ankle recovery post-injury. In their study athletes who underwent strengthening and flexibility rehabilitation exercises for the ankle showed significant improvement in single-leg walking performance, reflecting restored muscular stability and motor efficiency .

Conclusions

The study concluded that the rehabilitation program was highly effective in improving strength and stability. Exercises targeting muscular power and neuromuscular coordination, which contributed to better balance, functional performance and reduced risk of reinjury. The use of the anti-gravity treadmill facilitated safe , progressive training allowing participants to perform daily and athletic activities with improved control and confidence. Overall , the combination of strength, flexibility and balance exercises not only accelerated recovery but also supported injury prevention and optimized athletic performance highlighting the importance of continuous functional assessment through single-leg walking and balance tests to monitor progress and determine readiness for return to activity .

Recommendation

It is recommended to implement continuous rehabilitation programs focusing on muscle strengthening and balance exercises combined with regular functional assessments using single-leg walking and balance tests. Training should target endurance , rapid-response movements and dynamic stability, while education on injury prevention and use of advanced measurement tools can enhance outcomes . Future research should continue evaluating modern rehabilitation techniques to improve ankle function and performance .



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