Journal of Physical Education

Volume 36 – Issue (4) – 2024 Open Access

P-ISSN: 2073-6452, E-ISSN: 2707-5729
https://jcope.uobaghdad.edu.iq

The effect of rehabilitation exercises with body weight and rubber resistance on the range of motion and the strength of the sprained ankle muscles in female rugby players

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DOI:
https://doi.org/10.37359/JOPE.V36(4)2024.2209

Article history: Received 9/ September/2024 Accepted 10/ November/2024 Available online 28/ December/2024

Abstract

The study aimed to prepare a set of qualifying exercises to improve the muscular strength of the muscles surrounding the ankle joint by applying different resistances according to the nature of the movement of this joint, which is one of the second moving joints (flexion, extension and rotation of the right and left) in order to increase the efficiency of all muscles working on this joint according to those movements and identification On the impact of these exercises and assume that there will be statistical differences between the two tests of the research sample. The researcher used the semi-articulated experimental method with a pre- and post-test for one group. The injury was evaluated on the women's national team players during the season (2021-2022), who numbered (18) players, aged (18-20) years, body masses ranging from (51.5-72.5) kg, and lengths ranging (1.61-1.71) meters With an average of (1.68) meters, and the number of the final sample members reached (6) players, representing (33.3%) of the original research community. The following (arithmetic mean, standard deviation, T.test for correlated samples). The results of the study showed an improvement in the kinematic stretches and the strength of the ankle muscles on the various axes of the movement of the foot. He added, however, that the level of development of the strength of the ankle muscles was greater than the level of development of the kinetic stretches. The researcher recommended the necessity of applying the exercises that were used in the research

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Volume 36 – Issue (4) – 2024 Open Access

P-ISSN: 2073-6452, E-ISSN: 2707-5729
https://jcope.uobaghdad.edu.iq

in the case of an ankle sprain for its effectiveness in improving the functional duty of the foot, and conducting similar research and studies for the rest of the games and on the ankle joint, and special exercises should be prepared for the ankle muscles to avoid injury in the future.

Keywords: flexibility, muscle fibers, tendons.

Introduction

Rugby is one of the most popular sports worldwide, alongside football and cricket. In recent years, the game has gained significant popularity in many countries, attracting players ranging from elementary school students to adults. Rugby requires running, strength, and endurance, as players must contend with various forces during movement, including collisions with opposing players and the physical demands of changing running direction while navigating the playing surface. Additionally, players must run while carrying the ball, which increases the risk of injuries due to overuse during both training and matches. These activities generate loads and stresses on the musculoskeletal system, leading to various injuries such as tendonitis, sprains, and tears of the ligaments surrounding joints, particularly in the lower extremities, including the ankle, which is often prone to sprains and ligament tears. Such injuries are painful and frequently occur during collisions with other players or sudden changes in direction to evade opponents or execute feints. While these injuries are generally not considered severe, they can negatively impact performance and may lead to more complex conditions if not properly addressed by a qualified sports medicine specialist.(Kadhim, 2024)

It is well established that the ankle joint is the most susceptible to injury in sports. Previous studies estimate that approximately 25% of sports injuries involve the ankle (Fong DT, 2007). Even in rugby, which carries a higher risk of injury compared to other sports, the ankle joint is identified as a site with a high incidence of injury (Yeomans C, 2018; Kaux JF, 2015). Furthermore, it has been reported that 17.5% of all injuries sustained by rugby players affect the ankle joint, with lateral ligament injuries due to ankle sprains being the most common. This underscores the importance of focusing on the prevention and treatment of injuries, as well as improving rehabilitation programs (Sankey RA, 2008).

As rugby is a contact sport, traumatic injuries to the lower limb joints occur frequently due to the demands of movement and the various required actions. (Jawad et al., 2024) Ankle sprains can arise from contact forces or rotational forces during rapid directional changes or interactions with other players, given the nature of the game's speed and contact. The research problem centers on how to rehabilitate the ankle joint effectively post-injury to ensure increased strength and a

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Volume 36 – Issue (4) – 2024 Open Access

P-ISSN: 2073-6452, E-ISSN: 2707-5729
https://jcope.uobaghdad.edu.iq

swift return to play, along with rapid recovery from injury and restoration of strength and flexibility, which are crucial for successful rehabilitation.(Nashwan, 2024)

Therefore, the objective of this research is to develop a set of rehabilitative exercises aimed at improving the muscular strength of the muscles surrounding the ankle joint. This will involve applying varying resistances according to the specific movements of the ankle, which is characterized by flexion, extension, and rotational motions. (Nashwan & Allawi, 2021) The goal is to enhance the efficiency of all muscles acting on this joint, aligned with these movements, and to assess the impact of these exercises. It is hypothesized that significant statistical differences will emerge between the pre- and post-intervention assessments of the research sample.

Methods and Tools:

The researchers employed a quasi-experimental design with a pretest-posttest approach for a single group. The study evaluated injuries among the national women's team players during the 2021-2022 season, consisting of 18 players aged 18 to 20 years, with a body mass ranging from 51.5 to 72.5 kg and heights between 1.61 and 1.71 meters, averaging 1.68 meters. The final sample comprised 6 players, representing 33.3% of the original research population. Injuries were assessed by a physician using a detailed injury report form for each case.

Measurements of Ankle Joint Range of Motion: (Coetzee & Castro, 2004)

Range of motion was measured using a circular goniometer, with the zero position defined as 0 degrees when the foot is positioned at 90 degrees from a supine position. Dorsiflexion of the foot was measured in degrees from the zero position until the foot's axis was read as a moving arm on the goniometer. Similarly, the degrees for plantar flexion, as well as for medial and lateral foot rotation, were recorded, as illustrated in the corresponding figures for each measurement:

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P-ISSN: 2073-6452, E-ISSN: 2707-5729
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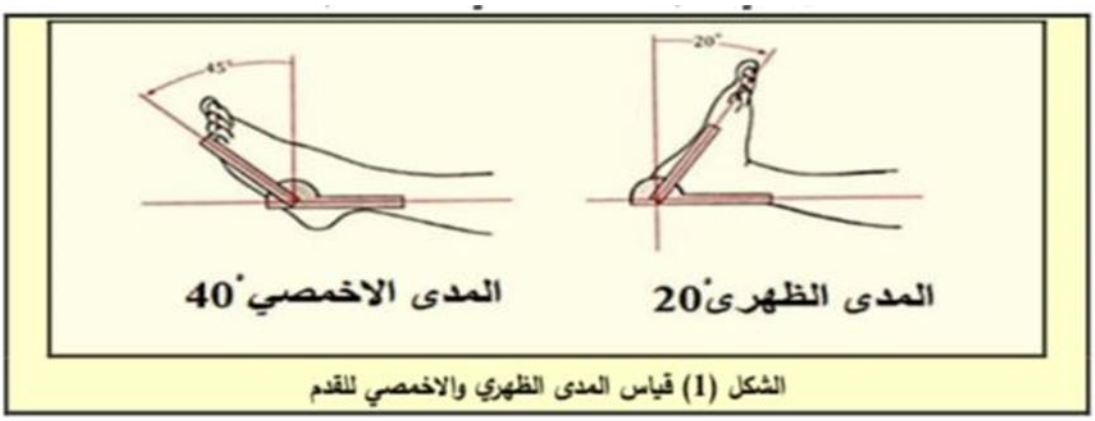
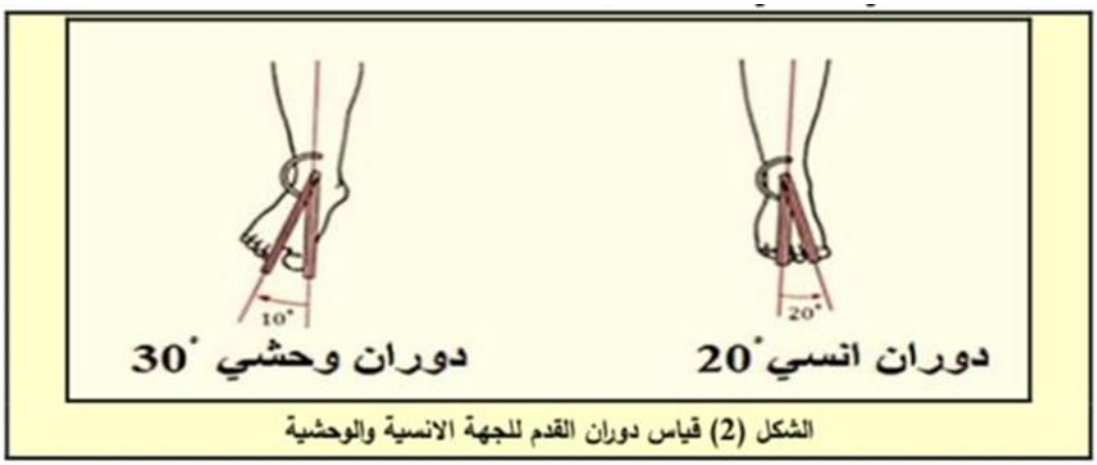
- **Measurement of the dorsal range for foot flexion and the plantar range for foot rotation:**



الشكل (1) قياس المدى الظهري والاخمصي للقدم

Medial and Lateral Foot Rotation Around the Ankle:



الشكل (2) قياس دوران القدم للجهة الانسية والوحشية

Muscle Strength Testing of the Ankle Joint: (Al-Majeed, 1999)

A dynamometer and a testing platform were used to measure the muscular strength of the ankle muscle group from the following positions: dorsiflexion strength test, plantar flexion strength test, medial ankle flexion strength test, and lateral ankle flexion strength test. The subject adopts a seated position to test ankle strength, with one end of the dynamometer's metal chain attached to the front of the foot being tested, and the other end secured to the dynamometer in a fixed position. The subject then performs the required movement, at which point the dynamometer's

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P-ISSN: 2073-6452, E-ISSN: 2707-5729
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indicator records the measurement. Each subject is given two attempts, with the better score being taken.

الشكل (3) جهاز الدينموميتر لقياس قوة الكاحل

Field Procedures:

A pilot study was conducted on January 15, 2022, at 2:00 PM, during which the specific tests and exercises were applied to two players. This aimed to assess the participants' understanding of how to perform the tests, the time required for execution, the nature of the exercises to be used in the study, and the efficiency of the supporting team.

The researcher conducted the pretests on January 20, 2022, in the "Rugby Gym" at 1:30 PM, beginning with the range of motion assessments. A 15-minute break was provided before resuming the ankle strength tests. The post-tests were conducted on March 15, 2022, following the same timing, procedures, and conditions as the pretests.

Exercises Used:

Resistance was applied at varying positions relative to the ankle joint, exerting force against the muscles acting on the ankle using elastic bands and cloth towels. The location of resistance changed according to the foot's position and support. These exercises were performed for 30 to 35 minutes, four days a week, over a period of six weeks. The difficulty of the exercises was progressively increased based on the achievable range of motion, ensuring that the player did not experience significant pain during performance. Subsequently, the intensity of the exercises and resistance was gradually increased according to pain indicators and the restoration of joint movement within the required ranges. The implementation of these exercises commenced on January 22, 2022, and continued until March 8, 2022.

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P-ISSN: 2073-6452, E-ISSN: 2707-5729
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Statistical Methods:

The Statistical Package for the Social Sciences (SPSS) was used to extract the following statistical measures: mean, standard deviation, and the paired samples t-test (T.test).

Results:

Table 1 presents the values of the differences for the ankle range of motion tests.

	Variables	test	f	df	S.	Sig.	T	Sig.
1	**Dorsiflexion Test**	**Pre-test**	12.43	1.18	6.5	1.312	4.951	.000
		Post-test	18.93	52				.000
2	**Plantar Flexion Test**	**Pre-test**	21.97	1.36	11.56	2.164	5.34	.000
		Post-test	33.53	29				.000
3	**Mediation Rotation Test**	**Pre-test**	9.10	2.07	6.21	1.397	4.444	.000
		Post-test	15.31	17				.000
4	**Lateral Rotation Test**	**Pre-test**	16.97	1.34	9.85	2.003	4.917	.000
		Post-test	26.82	39				.000

Table (1) Difference values for ankle range of motion tests

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P-ISSN: 2073-6452, E-ISSN: 2707-5729
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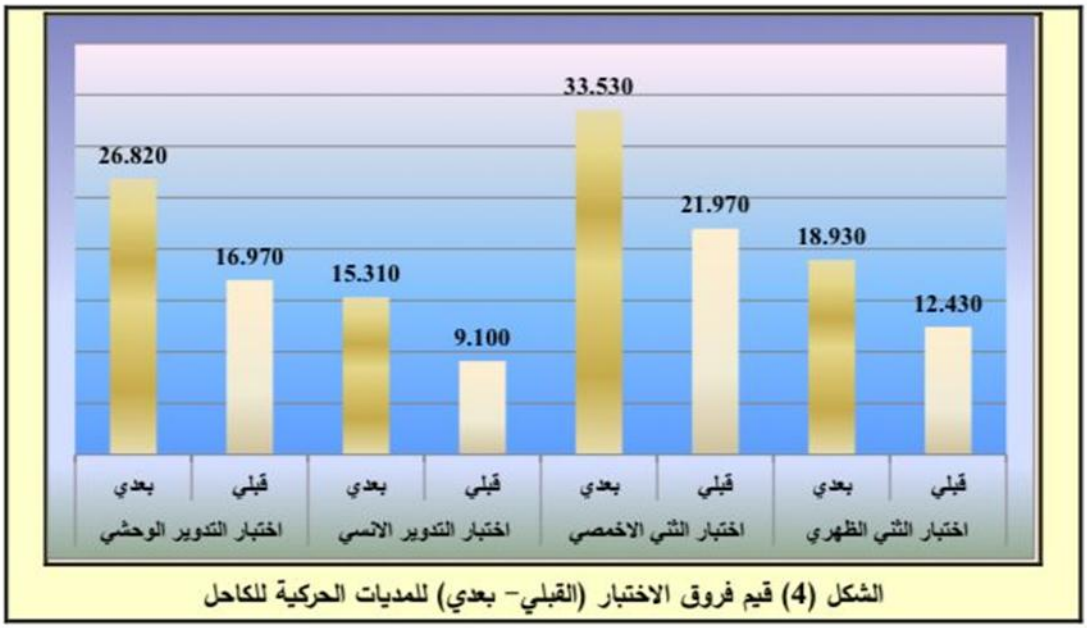

Figure 4: Values of Test Differences (Pre-Test - Post-Test) for Ankle Range of Motion

	Variables	test	f	df	S.	Sig.	T	Sig.
1	Dorsiflexion Test	Pre-test	10.17	1.472	8.50	.619	13.729	.000
		Post-test	18.67	.516				.000
2	Plantar Flexion Test	Pre-test	9.00	1.549	7.00	.856	8.174	.000
		Post-test	16.00	.894				.000
3	Mediation Rotation Test	Pre-test	8.67	1.633	7.67	.955	8.032	.000
		Post-test	16.33	1.211				.000
4	Lateral Rotation Test	Pre-test	9.00	1.549	6.67	.803	8.305	.000
		Post-test	15.67	1.033				.000

Degree of freedom = 5.... significant at (sig) > (0.05).

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P-ISSN: 2073-6452, E-ISSN: 2707-5729
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Table (2) Difference values for ankle muscle strength tests

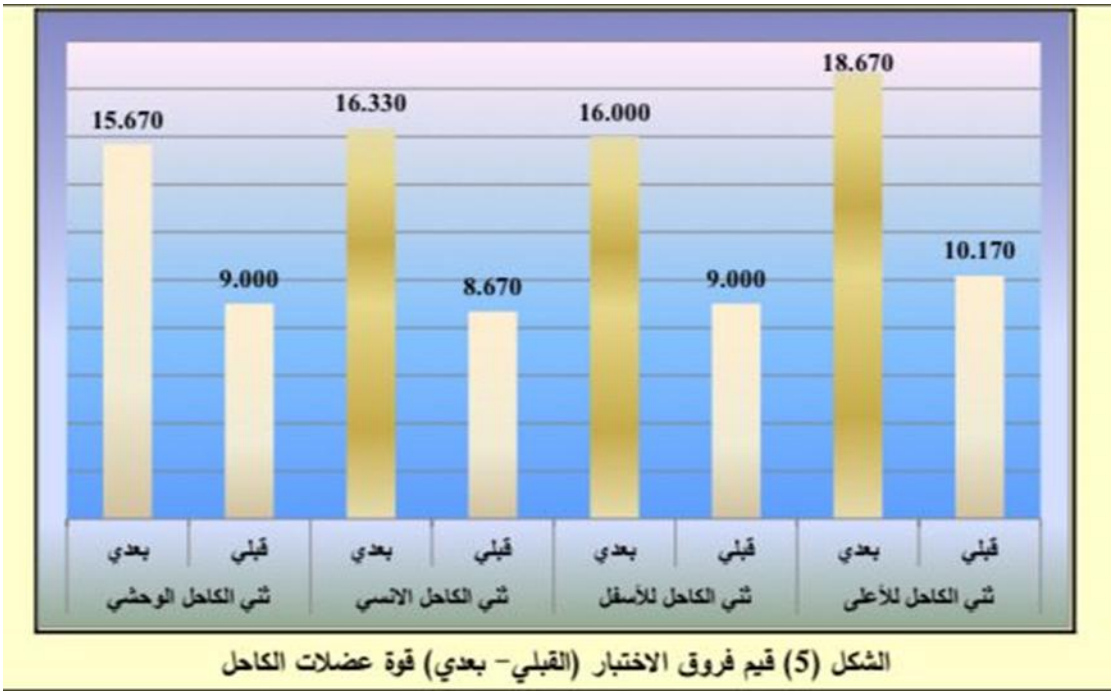

Figure 5: Values of Test Differences (Pre-Test - Post-Test) for Ankle Muscle Strength

Discussion

Table 1 shows significant differences favoring the post-tests of all the range of motion (ROM) assessments conducted on the research sample. The table also indicates that the plantar flexion ranges are greater than the corresponding dorsal flexion ranges, and the lateral rotation ranges exceed those of the medial rotation. Generally, flexion rates are higher than rotation rates, which aligns with the anatomical function of the joint, ligaments, and muscles, as well as the required movement demands. These variables demonstrated different rates of increase: the dorsal flexion test showed an increase of 52.29%, while plantar flexion increased by 52.62%. Medial rotation exhibited a 68.24% increase, and lateral rotation showed a 58.04% increase, suggesting that the rates of increase for rotation are higher than those for flexion.

Table 2 reveals significant differences favoring the post-tests of all ankle muscle strength assessments within the research sample. It shows that the ranges for upward and downward flexion are greater than those for medial and lateral flexion. The rates of increase for these variables also

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Volume 36 – Issue (4) – 2024 Open Access

P-ISSN: 2073-6452, E-ISSN: 2707-5729
https://jcope.uobaghdad.edu.iq

varied: upward ankle flexion increased by 83.58%, downward flexion by 77.78%, medial flexion by 88.35%, and lateral flexion by 74.11%.

These results indicate a significant improvement in joint movement according to these ROM parameters, which is essential for sustaining actions such as pushing, jumping, and running during play and training. (Manaf, 2022) The ankle is a weight-bearing joint composed of various bones, tendons, and ligaments that collectively support the body's weight while allowing for mobility. Any lack of coordination in dynamic position control can lead to an imbalance in limb movements. Strengthening exercises for the ankle may assist individuals suffering from pain, injury, or movement difficulties (Gribble, 2016).

The greater range of motion is indicative of muscle recovery, determined by the strength of the muscle groups responsible for movement. To enhance this range, rehabilitation or training is necessary, whether in the short term or following prolonged injury (Jaber, 2010).

In terms of physical exercises, it is important to note that the researchers employed both static and dynamic methods in their rehabilitation sessions, incorporating stretching, relaxation, and proper training techniques that utilized a combination of isometric and dynamic contractions. This ultimately serves the development of joint range of motion. Flexibility refers to the ability of muscles, associated tendons, and surrounding ligaments to extend sufficiently to allow full or extensive movement. Flexibility significantly contributes to reducing the incidence of sports injuries and muscle tears, as well as in overall preventative measures (Qablan, 2012).

Stretching exercises act as countermeasures to movement restrictions by extending the muscles to their maximum possible length. These exercises help to separate and align muscle fibers, allowing them to lie parallel and alleviating adhesions. Regular performance of these exercises can gradually restore most muscle tissues to their natural length over time. The researchers noted that the improvement in range of motion is not solely due to stretching and joint strengthening exercises, but is also associated with a reduction in pain over time. Thus, the enhancement of the range of motion is also linked to the alleviation of injury-related pain by the end of the program, which leads to an increased range of motion and further stretching of the muscles involved (Raouf, 2005).

One of the primary objectives of rehabilitation exercises is to protect the athlete from injury. One method is through high degrees of flexibility training for muscles, ligaments, and tendons, as it significantly enhances safety in performance (Al-Jabali, 2000). Furthermore, the use of elastic bands and supports has a substantial impact on joint range of motion, compelling the

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P-ISSN: 2073-6452, E-ISSN: 2707-5729
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athlete to perform movements in various directions, thus stimulating neural signals and enhancing sensory levels to correspond with the range of motion. This type of activity increases joint flexibility and reduces movement restrictions, promoting blood flow to the areas that significantly nourish the responsible ligaments and muscles. The use of elastic bands, which provide varying resistance levels depending on the tension applied, yields positive results in the sensory stimulation of the affected area and aligns with joint flexibility (Dill KE, 2014).

These exercises and tools play a crucial role in increasing joint strength and enhancing physical activity. When these exercises are balanced between strength training and both positive and negative stretching—especially when using elastic bands—they significantly impact the joint's range of motion. There is a relationship between strength and the angle of the ankle joint, especially when these rehabilitation exercises incorporate resistance that compels the joint to achieve a greater range of motion according to training periods (E. Kato, 2013).

Research indicates that the use of resistance plays an important role in improving or maintaining physical performance, and stretching exercises enhance the flexibility of the ankle joint (R. L. Gajdosik, 2007). Regarding the impact of these exercises on joint strength, researchers have noted that strength results are substantial due to the recruitment of numerous motor units. The increase in motor unit recruitment is a consequence of training or implementing rehabilitation exercises tailored to muscle capability, (Ismaeil & Jawad, 2023) indicating the efficacy of the exercises included in the rehabilitation program, which in turn increases muscle strength and the effectiveness and number of motor units. The use of elastic bands providing resistance based on the level of tension, (Munaf et al., 2021) coupled with both static and dynamic training methods, is vital for developing muscle strength and contractions. Static muscle training is important for stabilizing and guiding muscle groups to support the athlete's sport-specific form. The benefits of these exercises are maximized when sufficient time is allocated for them. They lead to slight increases in the size of the muscle subjected to such exercises, and athletes can perceive the true value of these training sessions through their sense of strength and improved performance, particularly when training doses are organized correctly between work and rest, (Manaf, 2015) allowing full relaxation of the muscle during isometric exercises, thus overcoming potential issues and injuries. Consequently, significant strength development becomes apparent. Static training offers a greater advantage for developing muscle strength compared to dynamic training (Al-Amir, 2010).

However, if isometric training is utilized excessively, particularly when focusing on one side, while neglecting balanced training, it negatively impacts muscle movement qualities. Thus, the researcher adopted balanced training by incorporating dynamic exercises into the prescribed

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P-ISSN: 2073-6452, E-ISSN: 2707-5729
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rehabilitation regimen. This type of contraction alters the muscle length and facilitates muscular adaptation. Positive isotonic contractions are essential for executing athletic movements, leading to an increase in muscle strength, albeit to a lesser extent than that achieved through isometric contractions. Consequently, physical therapists should consider employing either type of exercise (static or dynamic) or a combination of both in patient rehabilitation, particularly in advanced stages (Georgios Koutras et al., 2012).

In this context, the researchers adapted their exercises based on the tools used and the progression of muscle loading. The use of a graduated approach in rehabilitation exercises yielded positive results in improving muscle strength, considering the varying levels of resistance during the phases of contraction and relaxation. Training with elastic bands that expose the joint to specific types of resistance, (Kadhim, 2024) along with special balance balls and movements performed on them, constitutes an effective method for preparing athletes by utilizing progressively increasing resistances capable of generating or countering strength, enhancing muscle volume and improving performance, alongside changes in joint components, without necessarily employing maximum or sub-maximal resistance (Al-Nimer, 2001).

Furthermore, resistance training has been shown to enhance muscle strength in healthy athletes undergoing rehabilitation, indicating improvements in muscle performance (Harries, 2012). Performance readiness refers to the muscle's capability to withstand rapid and sudden movements in various directions. (Awad et al., 2024) Initially, the program included slow movements aligned with the pain level observed in certain exercises. Rehabilitation using resistance training also bolsters muscle strength to protect against future injuries or recurrences post-rehabilitation. The researchers considered the progression of load components in terms of intensity, repetition, (Karam Salam Ismaeil & Kadhim, 2023) environmental rest periods, and variations in exercises, which are significantly important and have unique characteristics in both training and rehabilitation. Research has shown that the neuromuscular system responds more effectively when stimulated variably, necessitating surprising adaptations, implying the performance of diverse exercises for several days while altering repetitions, intensity, and exercises on different days (Faraj, 2012).

Static training, where effort remains constant and speed is stationary, tends to favor strength at the expense of speed. The greater the resistance used in training, the more positively it reflects on strength development at the expense of speed, and vice versa in the case of reduced resistance and increased speed during exercise. The development of the dynamic stretching technique favors speed over strength (Saleh, 2015). Furthermore, resistance training, both static

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P-ISSN: 2073-6452, E-ISSN: 2707-5729
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and dynamic, has proven successful in increasing joint strength during a 6-8 week rehabilitation period (Jensen, 2014).

The prescribed exercises allowed the sample to perform a greater number of movements during their specific training without experiencing pain, as previously noted during advanced rehabilitation periods. One study found that the use of resistance or elastic bands provided greater resistance in the ankle during single-leg jump tests, demonstrating better control of required movements and injury prevention (Alex Souto Maio et al., 2020).

The goals of ankle injury rehabilitation include controlling chronic inflammatory processes, restoring full range of motion in the ankle, increasing muscle strength, and improving sensory capabilities, which can be achieved through various physical therapy exercises (Shaharudin, 2018). Proper exercise techniques and correct terminologies can significantly assist in fully restoring the ankle's function and strength. The researcher recommends incorporating flexibility and stretching exercises for the joint along with training exercises, as they are highly beneficial for early rehabilitation.(Kazim et al., 2019)

Conclusions

The study results indicate improvements in the range of motion and strength of the ankle muscles across different foot movement axes. Additionally, it was observed that the level of strength development in the ankle muscles exceeded that of the range of motion improvements. The researchers recommend the implementation of the exercises used in this study for ankle sprain rehabilitation due to their effectiveness in enhancing the functional capacity of the foot, and suggest further research and studies on other sports and the ankle joint, alongside the need for specific training programs for ankle muscles to prevent future injuries.

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P-ISSN: 2073-6452, E-ISSN: 2707-5729
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