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## Preventive exercises according to mechanical utility and their effect on some mechanical strength indicators among athletics after partial tear of the ankle ligaments

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### Abstract

The current study highlighted one of the areas of biomechanics and the principles of sports rehabilitation direction, which is the preparation of standardized exercises as preventive exercises, which are necessary to give to the player after the injury for the purpose of strengthening the muscles and ligaments of the injured joint, and perhaps the partial rupture injury to the ankle that the players are exposed to a lot, especially athletics players such as jumpers, jumpers and obstacle runners, as it places a great burden on the joint at a certain moment, as well as the need to change the position of the joint, which generates the generation of large burdens on the ligaments that surround the joint and muscles, so the study aimed to prepare preventive exercises according to the mechanical benefit of the muscles of the ankle joint in athletics players after the partial rupture of the ankle ligaments, as well as to identify the effect of preventive exercises on the strength of the joint in terms of some indicators of mechanical strength, The researcher followed the experimental approach with one group to suit the nature of the study and its problem, while the exercises were applied to a sample of 8 athletes from athletics who suffer from recurrence of ankle ligament tears. The preventive program was applied by 24 sessions permeated within the physical rehabilitation program for the players and by 3 sessions per week and over 8 weeks, and after the completion of the application of preventive exercises, the researcher came out with the most important conclusions that preventive exercises had a direct impact on the development of mechanical indicators of strength (total force exerted, total pressure of the foot, total thrust force of foot pressure), that there is a significant improvement in the amounts of special strength under study between the injured man and the healthy man in the tests In addition, working according to ranges of motion and mechanical principles and manipulating the amounts of force and resistance moments contribute to adapting to withstand the stress exerted on the muscles and ligaments of the foot.

**Keywords:** Preventive exercises, mechanical strength, athletics, partial tear, ankle ligaments

### 1. Introduction

Reaching the players to the ideal state for all physical and skill qualities and stability for a long time has become difficult, due to the effects it leaves for training and daily events, perhaps the most important of which are sports injuries that stand as an obstacle to completing the athlete's career for a period that may be longer or shorter, since the injury is a major reason for obstructing the march of each player because it forces him to stop training and sports practice, and in order to ensure a continuous and uninterrupted sports career for the athlete, and this is only done by sound scientific planning. And finding solutions to the various events and situations experienced by the athlete, perhaps one of which is proper planning for the injury and reducing it or how to treat it through rehabilitation properly to avoid its recurrence, in addition to that it is necessary to pay attention to the preventive aspect of the various parts of the body and according to the nature of the game practiced to ensure the strengthening of those joints and muscles when exposed to acute effort.

As the field of sports rehabilitation is based on the development of exercises that take into account the specificity of the injury and the location of the injury and the mechanism of the work of the joint or the injured member, so it has become necessary to be rehabilitative exercises taking into account greatly the specificity of the injury and targeting the injured part according to the degree and condition of the injury and these exercises are assigned to the

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principles of physiological, anatomical and mechanical according to the diagnosis of the situation and the physical test of each individual separately, so the mechanical principles that the joints of the body work on, perhaps one of them (the principle of mechanical benefit) and the mechanism of muscular work for all The joints of the body, which depends mainly on two important aspects is (the moment of force and the moment of resistance) as it takes advantage of this principle, which contributes to the events of some adaptations to the muscles working on the joints, perhaps one of which is the ankle joint and the ligaments surrounding it.

Therefore, the player in exerting high strength during physical duty and his ability to produce it in training and competition, which in turn enables the player in the possibility of producing this force depending on ensuring the safety of the internal organs, especially the necessary muscle contractions and appropriate for the required duty and under the control of the nervous and muscular voluntary system and thus access to the possibility of identification and control, that is, without the presence of any symptom that may cause a malfunction of the nervous and muscular system, which causes stress or lack of proper control and injuries such as rupture or spasm and other injuries.

Ankle joint injury is one of the most common injuries, especially among practitioners of games and events that require jumping and jumping, as well as the fact that the ankle joint bears approximately 98% of body weight and control, especially during training or competition, as athletics players, especially jumping and jumping players, are exposed during competitions or training units to partial rupture of the ligaments of the ankle joint due to exercises or performance of the effectiveness that requires a high degree of strength, ability and speed, as well as effort. The large muscular and weak ligaments of the ankle joint, as well as the weakness of the physical preparation of the player before the performance in a manner that is not commensurate with such an effort, as well as the large number of cases of friction between the foot and the ground with body weight or additional weights in which the weight of the body is supported and based on this joint significantly, which leads to their cessation of training for a short period to the extent that may prevent them from practicing the effectiveness.

The importance of the study emerged in the researcher's engagement to highlight the importance of preventive programs for injured players or those who suffer from recurrence of injury, especially in the post-injury period, which requires the correct return to practice exercises efficiently and with a capacity closer to what it was from the occurrence of injury for the purpose of adapting to exercises and development events by employing and benefiting from some mechanical principles that match the work of the human loco motor system by highlighting their choice of preventive exercises according to The principle of mechanical benefit with the aim of strengthening the ligaments that act on the ankle joint.

### 1.2 Study problem

The ankle joint injury is one of the common injuries for many players, especially athletics players, since the nature of athletics activities requires strength and speed at the same

time and changing the position of the body at a certain moment, especially jumpers and jumpers, as this joint bears a great burden on the ankle joint due to the total body weight and the force required to be exerted and the change in the position of the body between the moments of support and leaving the ground, which makes the joint vulnerable to stress and injury, so it is necessary to take into account training programs, especially Exercises that are developed within the strengthening and rehabilitation programs to take into account the mechanical principles in this to give the body and its members strength as well as the body by the nature of its creation from God Almighty works according to a mechanical system through the movement of joints between them, Therefore, it has become necessary to work on the ankle joint by strengthening the working ligaments and muscles by including rehabilitation programs or exercises targeting the force imposed on it and how to overcome it through the principle of mechanical interest on it, so the problem of the researcher emerged for the above by neglecting the preventive aspect in the training programs of the players, especially the players who suffer from injury to this joint and sufficiency with the rehabilitation program on the one hand, and on the other hand, the lack of rehabilitation and preventive programs by not taking into account some mechanical foundations Therefore, the researcher proceeded to conduct this study.

### 1.3 Study objectives

1. Preparing preventive exercises according to the mechanical benefit of the ankle joint in the athletes after the injury to the partial rupture of the ankle ligaments.
2. Identify the effect of exercise according to the preventive mechanical benefit of the ankle joint in the values of some indicators of mechanical strength among the athletes after a partial rupture of the ankle ligaments.
3. Identify the differences between a healthy foot and a foot with partial rupture of ankle ligaments in the values of some indicators of mechanical strength among the athletes.

### 1.4 Study hypotheses

There were no statistically significant differences in the values of some indicators of mechanical strength between pre- and post-tests in athletics after partial ankle ligament rupture.

### 2.1 Methodology

The researcher followed the experimental approach by designing one group with a pre- and post-test to suit the nature of the problem and its objectives.

### 2.2 Research sample

The researcher sought to choose the research sample and intentionally, which was represented by athletics players in Wasit Governorate who were injured with partial rupture of ankle ligaments from jumpers and jumpers for the sports season 2023-2024, as the researcher limited the period in selecting the injured players over a period of 4 months to obtain a sufficient sample of those who suffer from recurrence of partial rupture of ankle ligaments, as the number of repeated members of the sample injured 5 players to represent the research sample.

**Table 1:** Homogeneity of the sample

Variables	Measurement unit	Mean	Median	Standard deviation	Torsion coefficient
Mass	Kg.	64.283	65	6.486	0.385
Height	cm.	175	177	4.105	0.496
Age	Year	24.571	24	5.294	0.694
Foot length	cm.	26.428	26	0.475	0.406
Foot mass	Kg.	2.185	2	0.743	0.704
Leg length	cm.	84.384	84	0.486	0.301
Leg mass	Kg.	11.586	12	1.489	0.847

### 2.3 Tools and devices

The means used in the research by the researcher were scientific references, personal interviews, the international information network (Internet), tests and measurement).

The tools and devices used in the research are (foot scan, rubber cords of different lengths and tensions, electronic stopwatch, medical weighing scale, laptop, adhesive tape, tape measure, junmeter.

### 2.4 Study procedures

#### 2.4.1 Identification of variables and tests

The researcher identified the research variables, which represent their measurement by the foot scan metric device by the normal walk of both feet (healthy and previously injured) and identified them, the total force exerted by the feet (injured and healthy) while walking: it is the amount of force exerted by the foot during the contact of the foot with the ground and is measured in units of new tons. The total pressure of the feet (injured and healthy) while walking: it is the maximum amount of pressure recorded for each foot when in contact with the ground, and is measured in units (net / cm<sup>2</sup> . s). The total thrust force of the pressure of the feet (injured and healthy) while walking: it means the amount of force that the foot draws in a certain time perpendicular to the area of the foot in contact with the ground and is measured in units (net. s/cm<sup>2</sup>).

#### 2.4.2 Exploratory Experiment

The exploratory experiment was conducted on two members of the sample on (15/10/2023), as two types of rubber ropes of different shapes and stresses (Stripe\_Circular) were selected and the best was chosen in proportion to the performance of motor duty to perform the exercises according to the mechanical benefit (resistance arm, force arm) depending on the locations of the targeted foot muscles in each exercise and taking into account the sample and the severity of the injury.

### 2.5 Main experience

**2.5.1 Pre-tests:** The researcher conducted the pre-tests on the research sample on the injured players on (2/11/2023), which included measuring the study variables by the foot scan, and the researcher was keen to adjust all the conditions related to the test in terms of time, place, tools used, method of implementation and the assistant work team, in order to work on providing and controlling them in the post-test.

**2.5.2 Preventive exercises prepared according to mechanical benefit:** The researcher sought to prepare a set of preventive exercises that target the muscles surrounding the foot and the responsibility to move the foot according to its ranges (pronation, prostration, lifting and lowering) according to the ankle joint, as preventive exercises were prepared on the members of the research sample with the help of theoretical studies of scientific references and previous similar studies, the preventive program included its application over a period of (6) weeks distributed by 4 units

per week to become (24) units within the training units and part of the main section, The repetition, the required intensity and rest times were determined according to the ability of the sample members and the severity of the injury, so as not to cause stress to the muscles and tissues that are in the process of post-injury muscle building, taking into account the gradient in intensity during the training units for adaptation and strengthening events for these muscles and ligaments surrounding the injured foot, as for the rest period for each exercise and according to each severity, the researcher has determined it by inquiring by him personally for each injured person after performing each exercise and each group in order to ensure the correct rationing of these Exercises according to the target range for each movement and the intensity performed in a way that does not cause fatigue and stress and not performing the last repetitions of the exercise with the same efficiency as the first repetitions, and the preventive exercises included exercises of distancing, rounding, medial and lateral inversion of the ankle joint according to scientifically fixed motor ranges with basic resistance ropes of different stresses gradually.

As for the intensity of the rubber ropes on the intensity of each rope as a level of special difficulty, the researchers depending on the tightening of rubber ropes adopted by the researcher, for example (the yellow rope represents the first level of intensity) the researcher adopted in the first and second weeks in order to adapt to the exercises and ensure that the researcher does not cause any muscle strain on the tissues and muscles of the injured, followed by the red rubber cord in the third week as a second level of intensity, but in the fourth week the researcher adopted the rope with Green color as a third level of intensity, as for the fifth week, the researcher decreased the level of intensity by the degree of being based on the ripple in the rehabilitation (1:3), so he relied on the rubber rope with a red color, either for the sixth week, I rely on the rubber rope with a red color, as for the seventh week, the researcher relied on the fourth level of intensity represented by the blue rubber rope, but for the last week, the researcher adopted the fifth level of intensity, which is Black color.

**2.5.3 Post-tests:** After the implementation of the prepared preventive exercises was completed, the post-tests were conducted on the members of the sample, and the researcher was keen to provide the conditions of the pre-test and its procedures followed, which included measuring the biomechanical variables by a device (foot scan for the ankle joint).

**2.6 Statistical means:** In extracting the results of the study, the researcher relied on the statistical bag for educational and social sciences (SPSS) ver.23.

### 3.1 Results

#### 3.1.1 Presentation of pre- and post-tests of the biomechanical variables

**Table 2:** It shows the arithmetic means, standard deviations, calculated value of (T), value of (SIG) and significance of the biomechanical variables under study under study for healthy and injured feet

Variables		Pre-test		Post-test		(T) Value	Sig value	Sig Level
		M.	ST.D	M.	ST.D			
Total force exerted	Intact	714.384	4.695	747.393	4.697	3.893	0.018	Sig.
	Injured	583.284	3.601	684.496	5.690	6.285	0.000	Sig.
Total pressure of the foot	Intact	448.386	5.958	492.486	6.393	4.489	0.002	Sig.
	Injured	302.485	4.349	424.586	4.469	6.808	0.000	Sig.
Total momentum of foot pressure	Intact	485.385	6.294	512.586	5.697	3.711	0.004	Sig.
	Injured	315.281	5.148	406.495	6.588	5.276	0.000	Sig.

**3.1.2 Presentation of the values of the development ratios, the differences between the pre-tests and the differences**

**between the post-tests for the biomechanical variables under study and for both feet (Intact and injured).**

**Table 3:** It shows the percentage of development between the pre- and post-tests and the percentage of difference between the healthy foot and the injured foot in the post-test in the biomechanical variables under study

Variables		Pre-test	Post-test	Development ratio	Difference ratio	
					Pre-test	Post-test
Total force exerted	Intact	714.384	747.393	4.620%	18.351%	8.411%
	Injured	583.284	684.496	17.352%		
Total pressure of the foot	Intact	448.386	492.486	9.835%	32.539%	13.787%
	Injured	302.485	424.586	40.365%		
Total momentum of foot pressure	Intact	485.385	512.586	5.604%	35.045%	20.697%
	Injured	315.281	406.495	28.931%		

Through the data contained in Tables 2 and 3, which shows that there is a lack of balance in exerting strength and total pressure of the foot on the ground and the total push for foot pressure in one step, and that there are differences in the values of the pre-test between the healthy and injured foot of the study variables in terms of strength and pressure between the healthy and injured legs, which is a real indicator of the inadequacy of rehabilitation programs and the lack of restoration of sufficient capacity of muscles and ankle ligaments in the possibility of controlling the production of force in one of the greater the difference between the feet, the greater the impact of the injury (the injury leads to the inability of the affected organ to move, which causes a weakening of the level of general strength in the affected joint) [1].

From this point of view, the researcher believes that the need to include preventive exercises to be accompanied and included in the physical exercises in order to gain ability and efficiency and compensate for strength and lost muscles and ligaments of the properties as a result of injury, so what appeared the values of the dimensional measurement and the results appeared attributed by the researcher compared with the results before and with the ratios of differences between the injured and healthy feet in the post-test to the effectiveness of preventive exercises were prepared according to scientific foundations and identical mechanical principles and simulated for the work of The joint and structural structure of the foot by how the exercises dealt with the strength moments, which were represented by the muscles of the foot and the resistance moments, which were represented by the intensity and length of the rubber cords, According to the mechanical law of moments (force x arm = resistance x arm), the more resistance is shed on the working muscles, which led to greater neuromuscular stimulation of the units involved in muscular work and thus enabled the muscle and adapted it to shed force according to its range of motion on which the foot joint moves (inversion outward and inward, rounding and fating), in addition to that, the researcher indicates that the process of controlling stress scientifically and codified, especially that the study dealt mainly on the

ankle joint and the muscles working on it taking into account Limited movement of the joint due to injury and then gradation according to the ability of the joint to move and range of motion and the ability to withstand the joint some external force, which led to the joint gaining the required movement with more forces than usual, and the speed of response of the surrounding muscles as a result of working with each muscle of the foot according to its movement by shedding additional moments graded difficulty, in addition to that, the muscles led to the generation of a force greater than the force (resistances directed on it), At the same time, it has the ability to change the position of the foot from the stage of pressure and contact to the stage of rising pushing the ground and moving the walking step of the second leg, and on the other hand, the researcher explains the development and attributes it to the fact that preventive exercises according to the moments, especially the moments of resistance of different stresses led to the ability of the foot when walking in the distribution of body centers of gravity on both feet, on the contrary, in the tribal test, which was difficult to be the correct and ideal distribution of body weight on both feet, i.e. not The presence of complete balance of the body when standing or walking due to damage to some tissues of the foot and the incompleteness of its strength and healing in the inability of the ankle joint to move correctly with the weight of the body, so that the body decreases its distribution is greater and a greater proportion on the healthy foot at the expense of the injured foot due to its inability to endure and therefore the amounts of push will decrease when pressing the foot, Which causes a reduction in the process of absorption of shock (foot contact time with the ground) when moving through exercises to move away to the outside and rounding inward with the legs, as an indicator of the movement of walking will lead to the emergence of a simple development of the amount of thrust, which showed the results in increasing a small percentage of push, and this is what he pointed out that the less the amount of pressure, the more it leads to a decrease in the individual's ability to push the foot and vice versa, as this is due to the safety of the foot in terms of Anatomical is largely related to mechanical and kinetic



laws and when any defect occurs, it will result in hindering the push process at the end of the movement [2].

The application of preventive exercises according to the mechanical benefit of the joint and direct targeting of the motor duty of the working muscles led to the development of force moments on all axes of the work of the ankle joint and thus strengthen the muscle groups of the foot and the ligaments surrounding the ankle joint, and this is what he pointed out (Nasser Hussein, quoting Abd Ali Nassif and Qasim Hassan: 2016) "Paying attention to the physical, mechanical and technical aspects of the movements of the human body and on more than one axis and direction, and knowing the extent of the impact of the correct application of biomechanical indicators that have to do with the level of strength development of muscles Surrounding the joints of the body is one of the important things that must be considered by the trainers of the field of training, with the need for these exercises to be commensurate and compatible with the mechanical requirements with what the performance requires in terms of composition, path, the amount of special force and the moments of its use" [3].

In summary, the preventive exercises have given fruit and improved the effectiveness of the ligaments and muscles surrounding the ankle joint, since the strength of the injured foot joint has improved its amounts and pressure and push when leaning on the ground and its ratio has become close to the proportion of healthy foot amounts because the convergence of the results of strength between the two parties is evidence of healing, stability and balance of movement and this is what the researcher agreed with what he referred to (Osama Riad: 1999). "The evolution of the level of strength in the injured ankle is measured compared to its level in the healthy ankle of the same individual and this method is effective for the purpose of ensuring the healing of the injury, which leads to the player's rapid return to activity [4]. While (Raysan Khreibit, and Abu Ela Abdel Fattah) (2016) pointed out that strength exercises with their fixed and mobile training method have an important role in treating most injuries and increasing strength and large muscle size [5]. and confirmed a study (Ayman Abda: 2003), which recommended the need to develop training programs targeting the muscular strength of the working muscle groups (motor) in performance and interview (anti) because strength programs lead to avoiding the occurrence of injuries [6].

#### 4. Conclusions and Recommendations

##### 4.1 Conclusions

- The preventive exercises prepared directly affected the development of biomechanical indicators of strength (total force exerted, total pressure of the foot, total thrust force of foot pressure).
- There is a significant improvement in the amounts of special strength under study between the infected man and the healthy man in the post-tests.
- Working according to ranges of motion and mechanical principles and manipulating the amounts of force and resistance moments contribute to adaptation to withstand the stress exerted on the muscles and ligaments of the foot.

##### 4.2 Recommendations

- The need to understand the mechanical principles of the human body and develop therapeutic exercises for the players.
- The need to include preventive exercises within the

physical training curriculum for players after injury or to avoid its occurrence.

- The need to fully understand the rehabilitation programs and rely on mechanical variables that are an indicator of muscle and ligament strength, including the variables of the study studied.
- Conducting other studies of other injuries according to the principle of mechanical interest.

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#### Exercises used

##### First: Exercises for rounding (foot rounding)

Install the rubber band on the foot, and then

- Bring the foot closer to the inside at an angle ( ), and return to the starting position with the repetition of the exercise for 10 seconds.
- Bring the foot closer to the inside at an angle ( ) and hold for 10 seconds.
- Bring the foot inward at an angle ( ) and slowly return to the starting position with the exercise repeated for 15 seconds.
- Bring the foot closer to the inside at an angle ( ) and install for 2 seconds, and then return to the starting position with the repetition of the exercise for 15 seconds.

##### Second: Exercises for distance (foot distancing)

Install the rubber band on the foot, and then

- Move the foot out at an angle ( ), and return to the starting position with the repetition of the exercise for 10 seconds.
- Move the foot out at an angle ( ) and hold for 10 seconds.
- Move the foot out at an angle ( ) and slowly return to the starting position with the exercise repeated for 15 seconds.
- Move the foot out at an angle ( ) and install for 2 seconds, and then return to the starting position with the repetition of the exercise for 15 seconds.

##### Third: Exercises for Rounding Forward

Install the rubber band on the foot, and then

- Bring the foot towards the leg forward at an angle ( ), and return to the starting position with the repetition of the

exercise for 10 seconds

- Bring the foot towards the leg forward at an angle ( ) and hold for 10 seconds.
- Bring the foot towards the leg forward at an angle ( ) and slowly return to the starting position with the repetition of the exercise for 15 seconds.
- Bring the foot towards the leg forward at an angle ( ) and install for 2 seconds, and then return to the starting position with the repetition of the exercise for 15 seconds.

**Fourth:** Exercises for Deportation to the Outside

Install the rubber band on the foot, and then

- Move the foot away from the leg outward at an angle ( ), and return to the starting position with the repetition of the exercise for 10 seconds.
- Move the foot away from the leg outward at an angle ( ) and hold for 10 seconds.
- Move the foot away from the leg outward at an angle ( ) and slowly return to the starting position with the exercise repeated for 15 seconds.
- Move the foot away from the leg to the outside at an angle ( ) and install for 2 seconds, and then return to the starting position with the repetition of the exercise for 15 seconds.

**Fifth:** Compound exercises for more than one axis

Install the rubber band on the foot, and then

- Move the foot away from the leg outward at an angle ( ) and install it for 5 seconds, and then bring it closer to the inside and stability for 5 seconds and then repeat it 6 times by decreasing the installation time by 1 second for each repetition.
- Bring the foot closer to the inside at an angle ( ), and install it for 5 seconds, and then remove it to the outside and stability for 5 seconds and then repeat it 6 times by decreasing the installation time by 1 second for each repetition.
- Bringing the foot closer to the inside and out continuously for 10 repetitions.
- Carrying out the process of turning outward and then inward continuously for 10 repetitions.