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Physical and Kinetic Rehabilitation after the Total Ankle Arthroplasty

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Abstract

The current research aims to design a physical and kinetic rehabilitation program after the total ankle arthroplasty. The experimental method was used through the one group experimental design (pre- and post-measurements). The research sample was purposively selected from those who underwent a total ankle arthroplasty, and it consisted of eight patients whose ages ranged between (50-60 years), and the experiment was applied for about five months. A measurement was carried out for the main variables, which are the age, height and weight, and the physical variables, which are the measurements of muscular strength, range of motion, and the static and kinetic balance of the ankle joint. The results showed that using the rehabilitation program has a positive effect in improving functional efficiency of the new ankle joint in (postural, somatic and physical measurements) based on what was shown through the results of the research group between the pre- and post-measurements in favor of the post-measurements. The most important recommendations were to use the rehabilitation program after the total ankle arthroplasty to improve the functional efficiency of the ankle joint (postural, somatic and physical measurements) and applying it widely in the hospitals and clinics, using the water medium because of its effective role in fast healing and rehabilitation after injury, improving the psychological state and introducing fun and joy to the injured.

Problem and importance of the study:

Ankle arthroplasty is one of the relatively new surgeries recently because it is not as widespread as thigh or knee arthroplasties, despite its existence for more than two decades, it is less common due to the low occurrence of ankle arthritis, however, nowadays such injury has increased that a complete replacement surgery would be required in some cases. This is due to the lack of movement and contemporary diseases that lead to the fusion or adhesion of the joint bones, the inability to move, severe pain, and a lot of inflammation in the bones, all of which require surgery to restore movement, balance, range of motion and the return of the daily activities of the injured person.

(7:143), (15:237)

Back foot consists of two joints (the ankle joint, and the tarsal joint). The ankle joint consists of three bones responsible for the ankle joint's movement upwards and downwards which are (tibia, fibula, and heel bone). The tarsal joint consists of (heel bone and the calcaneus) and allows movement to the two sides.

(6:123), (13:165)

The ends of the bones in these joints are covered with cartilages called articular cartilages in order to provide sliding between each other upwards and downwards. There are many major ligaments of the ankle that provide stability in the joint located (between the tibia and fibula from the front, the fibula and the heel bone from the outside, the tibia, the heel bone and the calcaneus from the inside). (14:56), (17:276)

Ankle arthroplasty is performed in the tarsal joint, in which the articular cartilage between the tibia and the heel bone is replaced with a metal or plastic part. Ankle arthroplasty has developed since the seventies of the

twentieth century, but in the beginning it was a failure and needed to be removed after a short time, the first surgery was performed by Dr. Frank Alvine at the beginning of the seventies in the United States of America and it was approved by the U.S. Food and Drug Administration. After that, the artificial ankle joint went through modifications for around 20 years. In light of this development, the joints were divided into three generations, since its beginning in the seventies until our time. The artificial ankle joint went through several stages starting from its ability to move, stability, ability to persist, to get formed when being installed, and the means to help installing it until it has been developed in its final current form.

(4:276), (8:265), (16:154)

According to the recent increase in performing the ankle arthroplasty, due to the large number of accidents, the increase in individuals' weight, the lack of movement and the neglecance of the necessary physical fitness elements, which causes an excess load on the joint, resulting in the causes of chronic and dangerous infections in the ankle joint, which would require an ankle arthroplasty and the different methods of rehabilitation for the ankle joint, according to the causes of injury, the nature of the patient's body, his/her physical condition and functional efficiency, several methods are often used in physical therapy, because of the novelty of this type of surgical intervention, in addition to the lack of specialized, fixed and codified programs on a sound scientific basis by specialists in the field of orthopedics and specialists in the field of physical and kinetic rehabilitation, which in turn prompted the researchers to develop and design a rehabilitation program to restore the functional efficiency of the ankle joint without pain or movement problems and to ensure the best possible result for the injured in order to return as close as possible to the normal state.

Scientific importance of the study:

Determining the movement capabilities of the ankle joint after the arthroplasty.

Setting the foundations and scientific controls for the special rehabilitation programs after ankle arthroplasty.

Setting the foundations for restoring the functional efficiency of the ankle joint after the arthroplasty.

The practical importance of the study:

Providing a codified rehabilitation program that can be used by qualified specialists to restore the functional and kinetic efficiency of the muscles of the ankle joint after replacement, according to scientific and academic bases and based on the nature of the daily practices and according to its kinetic and functional requirements.

Objectives of the study:

The study aims to identify the effect of a proposed rehabilitation program after ankle arthroplasty through the following points:

Designing a physical and kinetic rehabilitation program.

Improving the muscular strength of the active muscles on the ankle joint.

Improving the range of motion of the ankle joint.

Improving the static and kinetic balance of the ankle joint.

Reducing the severity of pain.

Study hypotheses:

In light of the limitations of the study, its objectives and the procedures followed, the researchers hypothesized:

The proposed rehabilitation program positively affects the active muscles on the ankle joint through the following hypotheses:

There are statistically significant differences between the (pre- and post-measurements) of the muscular strength of the active muscles on the ankle joint in favor of the post-measurement.

There are statistically significant differences between the (pre- and post-measurements) of the range of motion of the ankle joint in favor of the post-measurement.

There are statistically significant differences between the (pre- and post-measurements) of the static and kinetic balance of the ankle joint in favor of the post-measurement.

There are statistically significant differences between the (pre- and post-measurements) in reducing the level of pain during the functional and kinetic performance of the ankle joint in favor of the post-measurement.

Similar studies:

The study of Agnieszka Prusinowska et.al. (2015) "Total Ankle Replacement - Surgical Treatment and Rehabilitation". (2)

The study of Travis J. Dekker et.al. (2017) "Ratio of Range of Motion of the Ankle and Surrounding Joints After Total Ankle Replacement: A Radiographic Cohort Study". (10)

The study of Sagar J. Desai et.al. (2017) "Quality of Life in Bilateral vs. Unilateral End-Stage Ankle Arthritis and Outcomes of Bilateral Vs. Unilateral Total Ankle Replacement". (11)

The study of Jayasree Ramaskandhan et.al. (2018) "Rehabilitation Following Total Ankle Replacement - Results of Prospective Pilot RCT". (18)

The study of Marco Massobrio et.al. (2018) "Total Ankle Replacement: Indications, Rehabilitation and Results". (20)

The study of Stead et.al. (2018) "Mobility Total Ankle Replacement - Short Term Results". (23)

The study of Anne-Constance Franz et.al. (2020) "Hindfoot Balancing in Total Ankle Replacement: the Role of Supramalleolar Osteotomies". (3)

Study procedures:

Methodology:

The experimental method was applied using one experimental group (pre- and post-measurements) for its relevance to the nature of the study.

Domains of the study:

Geographical domain:

Pre-measurements were conducted on the study sample and the content of the proposed rehabilitation program was applied in the New Al-Salama Hospital and Al-Shorouk Hospital, and the places of residence of injured people in Alexandria. The program was completed at Prime Center for Physical and Sports Rehabilitation.

Temporal domain:

The pilot study and research duties related to the program preparation and the main research experience application were conducted from (1/1/2019) to (1/2/2021).

Human domain:

The sample was purposively selected from those who underwent an ankle arthroplasty, and it consisted of eight patients whose age ranged from (50-60 years) and the proposed rehabilitation program was applied to them and its components included the following exercises: "range of motion - muscular strength - static and kinetic balance", ice massage and ice packs were mainly used during the rehabilitation period and during the application of rehabilitative exercises (before, during and after) each session.

The following criteria were considered in selecting the study sample:

That the patient had an ankle arthroplasty - The method of surgery should be the same.

The patient is free of any other organic diseases that prevent him from implementing the rehabilitation program

Table (1)

Statistical characterization of the data of the research sample in the main initial variables before applying the program (n = 8)

Variables	Statistical significance of characterization				
	Arithmetic mean	Mean	Standard deviation	Kurtosis	Skewness
Age (years)	52.87	52	1.67	-0.60	0.46
Height (m)	1.74	1.75	0.03	-0.65	-0.30
Weight (kg)	73.88	74	2.47	-0.69	0.34
Body mass index (BMI)	24.31	24.42	0.93	-0.43	-0.43

Table (1) shows that the skewness ranged between (-0.43 to 0.46), which indicates that the variables are close to moderation, as the skewness coefficient values ranged between ±3 and are very close to zero. The coefficient of kurtosis ranged between (-0.69 to -0.43) and this means that the kurtosis of the average curve can be acceptable and on average, and it is not fluctuating up or down, which confirms the homogeneity of the research group members regarding the initial variables.

Equipment and tools used in the study:

1- Tools and equipment used:

A medical scale for measuring weight.

A stopwatch

A measuring tape

An electronic genomic device for measuring range of motion

A dynamometer to measure muscular strength (21:62)

2- Rehabilitation tools:-

Beds, chairs and mattresses

Cones and barriers

Stabilization belts and leather core

Dumbbells of different weights

Gradient elastic resisting rubber and hand pedals (1:75)

Measurements used in the study:

Range of motion measurements:

Measuring the range of motion (grip - extension - adduction - abduction) of the thigh joint

Measuring the range of motion (grip - extension) of the knee joint

Measuring the range of motion (grip - extension) of the foot joint (9:86), (22, 145)

Muscular strength measurements:

The strength of the active muscles to (grip - extension - abduction - adduction) of the thigh joint

The strength of the active muscles to (grip - extension) of the knee joint

The strength of the active muscles to (grip - extension) of the foot joint (5:78)

Pain measurements:

Measuring the level of pain by using the visual analogue scale when walking. (12:142)

Ankle joint measurements:

Hockey test

30m free walking test (19:254)

Experts and consultants of the experiment:

Professors specialized in orthopedics, trauma and arthroscopic surgery to evaluate and follow up the health and functional status of the patients throughout the rehabilitation program.

1- Prof. Dr. Ahmed El-Sayed Hassan

Professor of Orthopedics, Traumatology and Artificial Joints Surgery - Faculty of Medicine - Alexandria University

2- Prof. Dr. Mohamed Gamal Morsy

Assistant Professor of Orthopedics, Traumatology and Artificial Joints Surgery - Faculty of Medicine - Alexandria University

3- Prof. Dr. Hossam El-Shafei

Professor of Orthopedics, Traumatology and Artificial Joints Surgery - Faculty of Medicine - Alexandria University

4- Prof. Dr. Tarek El-Khadrawy

Professor of Orthopedics, Traumatology and Artificial Joints Surgery - Faculty of Medicine - Alexandria University

Rehabilitation program:

After reviewing scientific research and references that focused on ankle joint injuries, and based on the researchers' experience in that field of specialization through their work in rehabilitation, it was possible to identify how injuries occur, their causes and complications that can occur in the case of ankle arthroplasty.

(50) exercises were selected from the gradual difficulty rehabilitation exercises to develop the physical, kinetic and functional characteristics of the active muscle groups of the ankle joint, taking into consideration the safety and security factors to preserve the surgery and get rid of its complications.

This is in order to improve the various physical characteristics of the patient in a safe manner and without any pressure or mistakes that lead to the failure of the surgery.

A preliminary conception of the proposed rehabilitation program was developed and presented to a group of experts specialized in medicine, orthopedics, physiotherapy, rehabilitation and physical education to evaluate and comment on the program components and its four stages that would achieve the objective of this study.

According to the experts' comments with approval, deletion or modification (the researchers have accepted a percentage of 75% - 100% of the total comments of modification - deletion - or addition) and the program has been modified to become in its final form. (Attachment 1)

Objectives of the proposed rehabilitation program:

An attempt to restore the kinetic function of the ankle joint after ankle arthroplasty for the injured people (study sample) through:

Commiting to the instructions and duties after surgery to maintain the security, safety and health of the new joint.

The complete absence of pain during the movement of the ankle joint.

Restoring the range of motion as close as possible to the normal range of motion of the ankle joint, within the limits of safety and security factors for the new joint, and based on the instructions of specialized surgeons.

Increasing the muscular strength of the active muscles of the ankle joint.

Return to the normal daily life.

In order to achieve these objectives, the following points have been developed, and should be considered when implementing the program:

Gradually restore the range of motion according to the kinetic ability of the new joint.

Use ice massage before, during and immediately after the rehabilitation session in all stages of the program.

Training to develop the muscular strength should be considered according to the surgeon's instructions, due to the safety and security factors of the new joint.

The program in its final form included four stages that took (about five months) and included (50 exercises).

The first stage included (10 exercises) and took (43-45) days, the second stage included (11 exercises) and took (44-45) days, the third stage included (15 exercises) and took (28-30) days, and the fourth stage included (14 exercises) and took (25-30) days.

These exercises have been codified according to the individual differences for each individual case, and the transition from each stage to the next was carried out according to the achievement of the objectives of each stage and based on the comments of the experts in artificial joint surgery which were analyzed individually. (Attachment 1)

Pilot study:

The pilot study was conducted on a sample of (2) members from within the study population and outside the main sample with the aim of the following points:

The relevance of the method of carrying out the physical and somatic measurements.

Identifying the efficiency of the tools and devices used in both measurements and rehabilitation.

Identifying the relevance and selection of the locations of implementing the program.

Identifying the problems that may occur when implementing the rehabilitation program.

Determining the time period spent in implementing the rehabilitation sessions of the program.

Results of the pilot study:

The tools and devices used in both physical and somatic measurements were valid.

The program is implemented individually.

Adequate explanation of each exercise and taking into account the proper positions and how to perform each exercise according to the kinetic capabilities of the new joint.

Taking into account the psychological aspect of the sample members during the implementation of the rehabilitation program.

Commitment to the special instructions after ankle arthroplasty because of its paramount importance in maintaining the surgery.

Main study:

From (1/1/2019) to (1/2/2021).

The cases scheduled for the total ankle arthroplasty were followed-up and when each case was identified, a case data

form was recorded individually. The rehabilitation program was implemented with the cases as follows:

The first case:

As of (1/1/2019), approximately 15 days after the operation, the first stage of rehabilitation begins and lasts for (45 days), followed by the second stage of rehabilitation with the same case for a period of (45 days), the third stage for a period of (30 days), and the fourth and final stage for a period of (30 days), therefor the period of application of the rehabilitation program that was followed with this case is approximately 150 days.

The second case:

As of (29/4/2019), approximately 14 days after the operation, the first stage of rehabilitation begins and lasts for (43 days), followed by the second stage of rehabilitation with the same case for a period of (44 days), the third stage for a period of (28 days), and the fourth and final stage for a period of (25 days), therefor the period of application of the rehabilitation program that was followed with this case is approximately 140 days.

The third case:

As of (13/9/2019), approximately 14 days after the operation, the first stage of rehabilitation begins and lasts for (44 days), followed by the second stage of rehabilitation with the same case for a period of (43 days), the third stage for a period of (29 days), and the fourth and final stage for a period of (26 days), therefor the period of application of the rehabilitation program that was followed with this case is approximately 142 days.

The fourth case:

As of (16/1/2020), approximately 14 days after the operation, the first stage of rehabilitation begins and lasts for (45 days), followed by the second stage of rehabilitation with the same case for a period of (44 days), the third stage for a period of (30 days), and the fourth and final stage for a period of (27 days), therefor the period of application of the rehabilitation program that was followed with this case is approximately 146 days.

The fifth case:

As of (27/3/2020), approximately 15 days after the operation, the first stage of rehabilitation begins and lasts for (43 days), followed by the second stage of rehabilitation with the same case for a period of (44 days), the third stage for a period of (28 days), and the fourth and final stage for a period of (25 days), therefor the period of application of the rehabilitation program that was followed with this case is approximately 140 days.

The sixth case:

As of (1/7/2020), approximately 16 days after the operation, the first stage of rehabilitation begins and lasts for (45 days), followed by the second stage of rehabilitation with the same case for a period of (45 days), the third stage for a period of (30 days), and the fourth and final stage for a period of (30 days), therefor the period of application of the rehabilitation program that was followed with this case is approximately 150 days.

The seventh case:

As of (24/8/2020), approximately 14 days after the operation, the first stage of rehabilitation begins and lasts for (44 days), followed by the second stage of rehabilitation with the same case for a period of (44 days), the third stage for a period of (29 days), and the fourth and final stage for a period of (27 days), therefor the period of application of the rehabilitation program that was followed with this case is approximately 144 days.

The eighth case:

As of (1/9/2020), approximately 15 days after the operation, the first stage of rehabilitation begins and lasts for (45 days), followed by the second stage of rehabilitation with the same case for a period of (44 days), the third stage for a period of (29 days), and the fourth and final stage for a period of (28 days), therefor the period of application of the rehabilitation program that was followed with this case is approximately 146 days.

The cases followed each other individually so that the four stages of rehabilitation are applied and according to mentioned periods within the program, where the periods ranged between approximately (140-150) days.

The rehabilitation program was implemented in a sequence and activity overlap with the sample members during the period from (1/1/2019) to 1/2/2021.

The program was applied to a sample of (8) individuals.

Pre-measurements were carried out for each case after (14-16) days after the surgery, according to the comments and recommendations of the surgeons for the safety and security factors of the total ankle arthroplasty.

Post-measurements were also carried out after the completion of the program implementation for each case by the end of the fourth stage, and the post-measurements were carried out for the last cases of the research sample on (1/2/2021).

All the measurements under study were made on one experimental group, and on the healthy limb, “the healthy ankle joint” as a control group to be guided with in evaluating the level of progress and improvement in the results of physical measurements, and the extent of access as close to the normal state of the study sample and according to the kinetic capabilities of the nomal joint.

Statistical treatments:

Statistical treatments were applied using the statistical software packages provided by SPSS software to extract the following elements:
T-Test
Arithmetic mean
Skewness coefficient
Median
Standard deviation

Presentation and discussion of the results:

I) Presentation of the results:

A: Presentation of the significance of differences between the pre- and post-measurement in the muscular strength variables

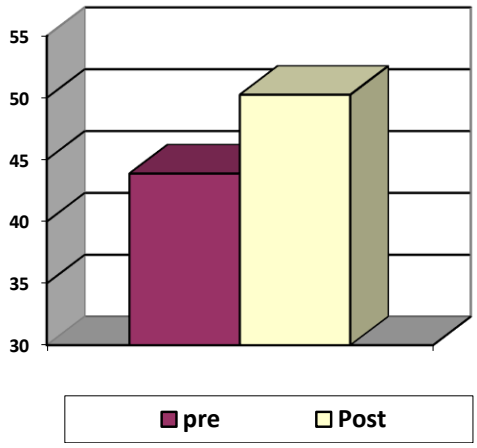
Table (2)

The differences between the pre- and post-measurements of the experimental group regarding the (muscular strength measurements of the active muscles of the thigh joint) for the healthy and injured feet (n = 8)

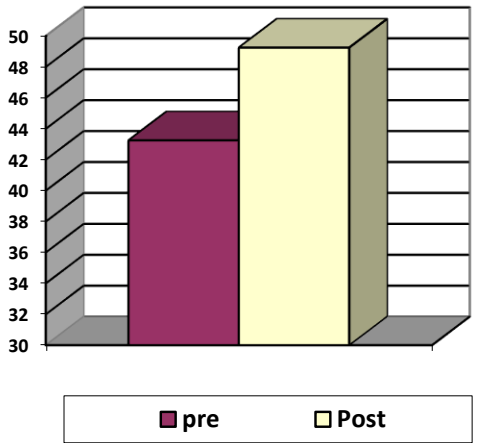
Statistical significances muscular strength measurements of the active muscles of the thigh joint		Pre-measurements		Post-measurement		Difference between the two means		T value	Improvement Percentage %
		X	±P	X	±P	X	±P		
grip	healthy (kg)	43.88	2.11	50.25	2.12	6.37	0.86	20.84*	14.51%
	injured (kg)	43.25	2.25	49.25	2.12	6.00	0.53	32.10*	13.87%
extension	healthy (kg)	38.25	2.12	42.88	2.03	4.63	0.52	25.28*	12.09%
	injured (kg)	36.36	1.70	41.50	2.14	5.14	2.14	6.80*	14.13%
abduction	healthy (kg)	38.88	2.03	44.25	2.12	5.38	0.52	29.37*	13.83%
	injured (kg)	37.75	2.12	42.75	2.12	6.18	1.71	10.23*	16.38%
adduction	healthy (kg)	35.63	2.26	39.88	1.46	4.25	0.89	13.56*	11.93%
	injured (kg)	34.88	2.03	38.63	1.41	3.75	0.71	15.00*	10.75%

Significant at the level 0.05 = 2.36

Table (2) shows that there are differences between the pre- and post-measurements at the level of 0.05 in all muscular strength measurements of the active muscles of the healthy and injured feet thigh joints in favor of the post-measurement, where the T value ranged between (6.80 to 32.10) and these values are greater than the tabular T value at the level of 0.05, and the improvement percentage ranged between (10.75% to 16.38%) in favor of the post-measurement.

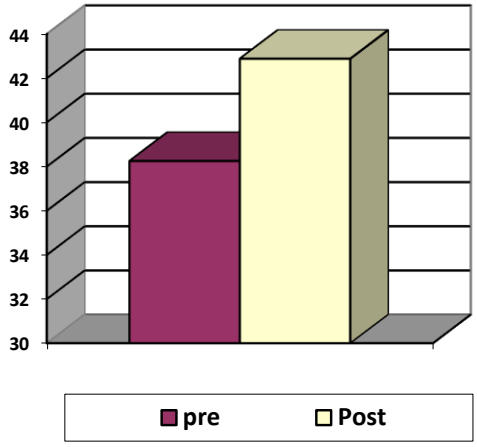


healthy (kg)

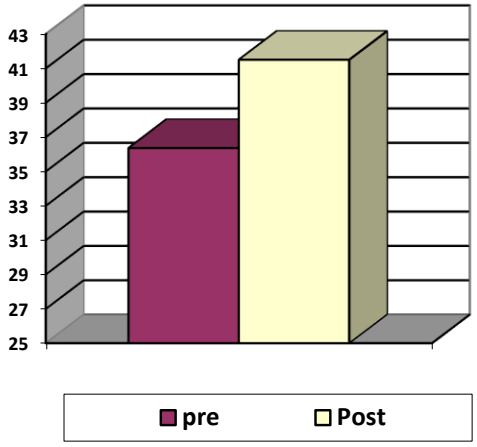


injured (kg)

Strength of the active muscles in gripping the thigh joint

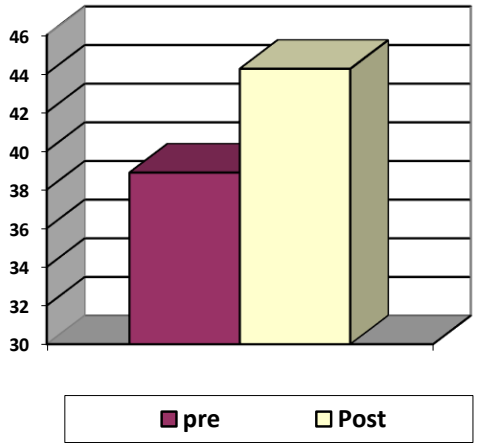


healthy (kg)

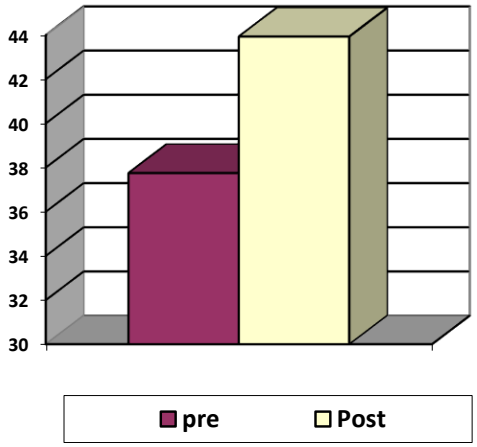


injured (kg)

Strength of the active muscles in extending the thigh joint



healthy (kg)



injured (kg)

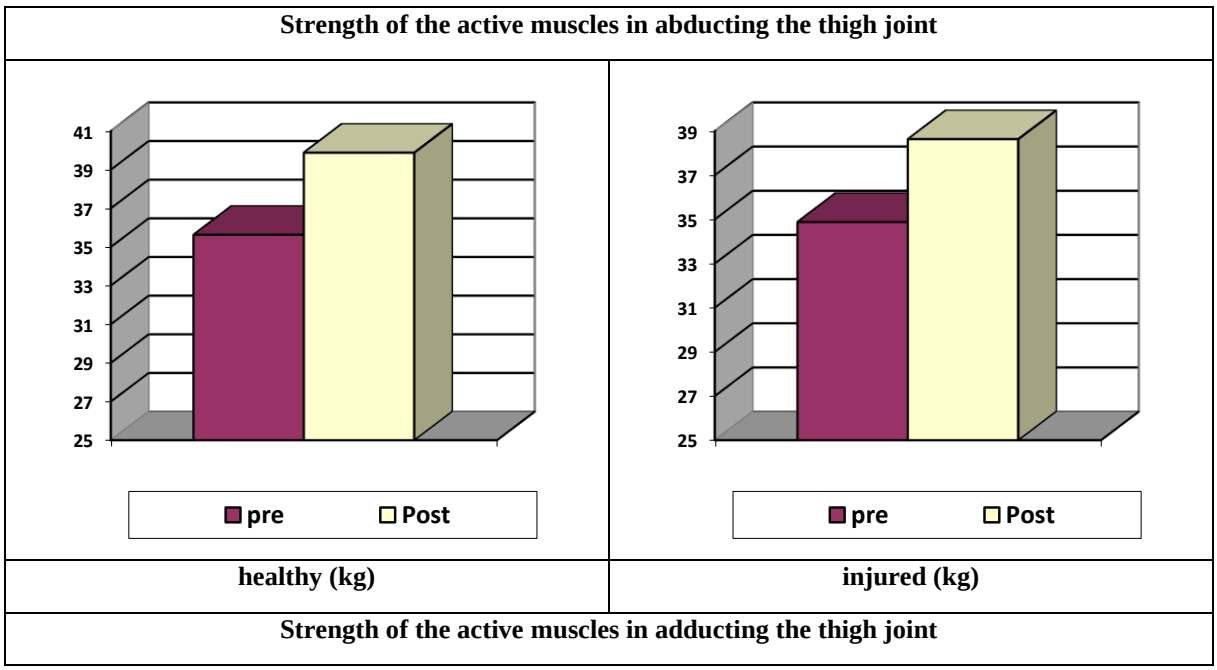


Figure (1) differences between the pre- and post-measurements of the experimental group regarding the (muscular strength of the active muscles of the thigh joint)

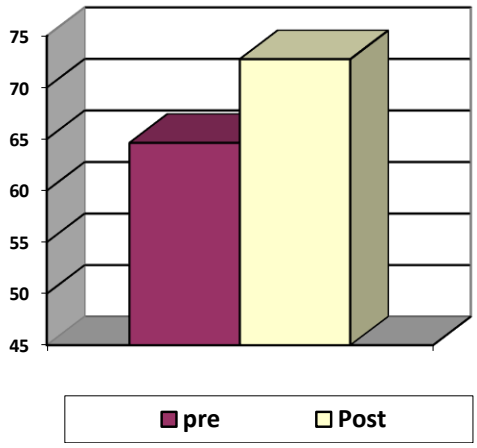
Table (3)

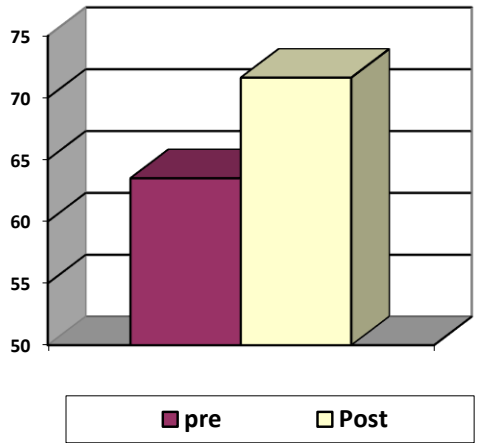
The differences between the pre- and post-measurements of the experimental group regarding the (muscular strength measurements of the active muscles of the knee joint) for the healthy and injured feet (n = 8)

Statistical significances muscular strength measurements of the active muscles of the knee joint		Pre-measurements		Post-measurement		Difference between the two means		T value	Improvement Percentage %
		X	±P	X	±P	X	±P		
grip	healthy (kg)	64.63	3.25	72.75	2.82	8.13	0.64	35.86*	12.57%
	injured (kg)	63.50	3.16	71.63	2.88	8.13	0.83	27.54*	12.80%
extension	healthy (kg)	44.38	1.69	51.63	1.92	7.25	0.46	44.30*	16.34%
	injured (kg)	26.88	1.81	50.50	1.77	23.63	0.52	129.11*	87.91%

Significant at the level 0.05 = 2.36

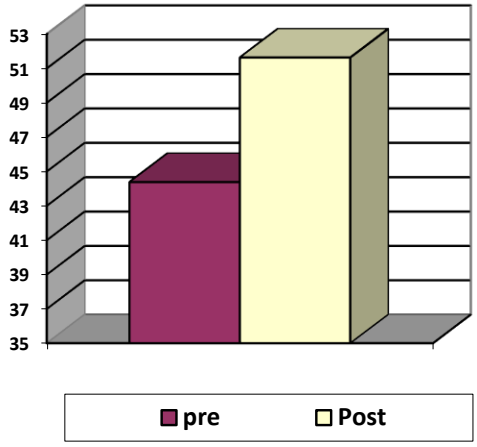
Table (3) shows that there are differences between the pre- and post-measurements at the level of 0.05 in all muscular strength measurements of the active muscles of the healthy and injured feet knee joints in favor of the post-measurement, where the T value ranged between (27.54 to 129.11) and these values are greater than the tabular T value at the level of 0.05, and the improvement percentage ranged between (12.57% to 87.91%) in favor of the post-measurement.

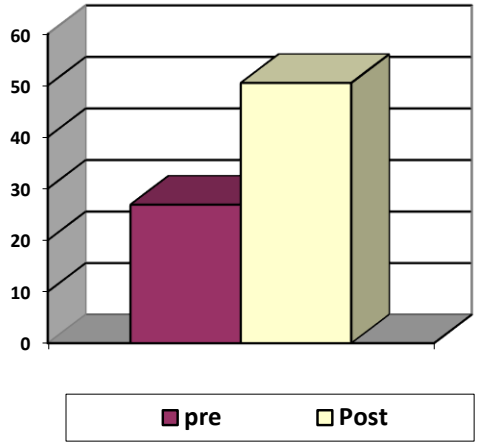




healthy (kg)	injured (kg)

Strength of the active muscles in gripping the knee joint





healthy (kg)	injured (kg)

Strength of the active muscles in extending the knee joint

Figure (2) differences between the pre- and post-measurements of the experimental group regarding the (muscular strength of the active muscles of the knee joint)

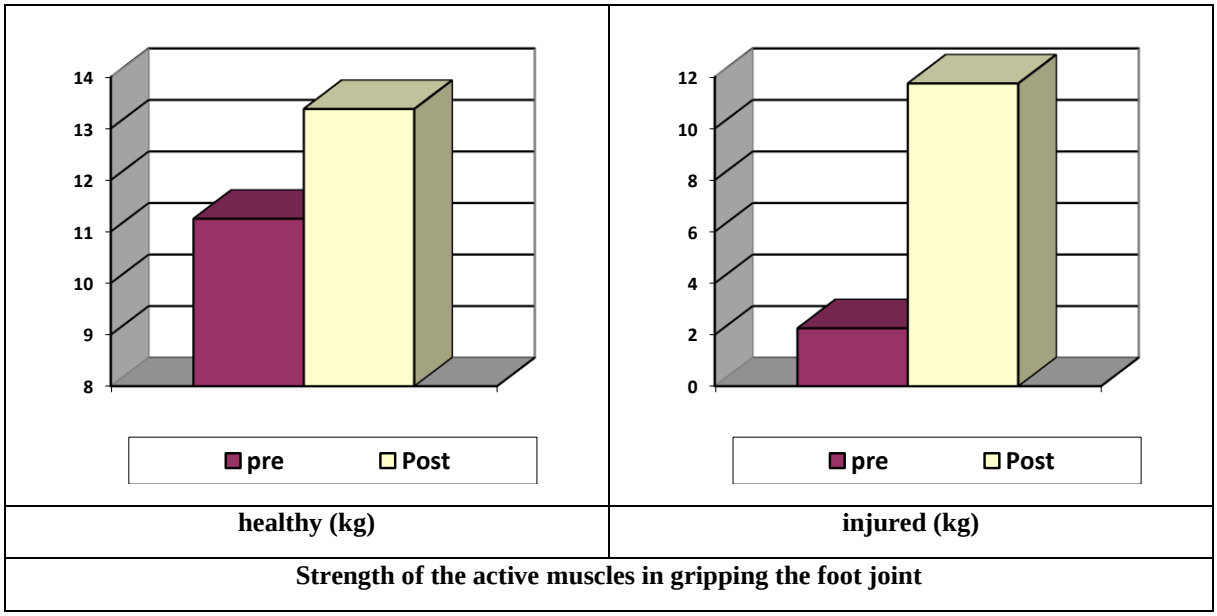
Table (4)

The differences between the pre- and post-measurements of the experimental group regarding the (muscular strength measurements of the active muscles of the foot joint) for the healthy and injured feet (n = 8)

Statistical significances muscular strength measurements of the active muscles of the foot joint		Pre-measurements		Post-measurement		Difference between the two means		T value	Improvement Percentage %
		X	±P	X	±P	X	±P		
grip	healthy (kg)	11.25	1.83	13.38	2.26	2.13	0.64	9.38*	15.89%
	injured (kg)	2.25	0.60	11.75	2.12	9.50	1.56	17.24*	422.22%
extension	healthy (kg)	8.13	1.81	10.38	1.60	2.25	0.46	13.75*	27.69%
	injured (kg)	1.13	0.23	8.13	1.81	7.00	1.63	12.18*	622.22%

Significant at the level 0.05 = 2.36

Table (4) shows that there are differences between the pre- and post-measurements at the level of 0.05 in all muscular strength measurements of the active muscles of the healthy and injured feet in favor of the post-measurement, where the T value ranged between (9.38 to 17.24) and these values are greater than the tabular T value at the level of 0.05, and the improvement percentage ranged between (15.89% to 622.22%) in favor of the post-measurement.



healthy (kg) | **injured (kg)**

Strength of the active muscles in gripping the foot joint

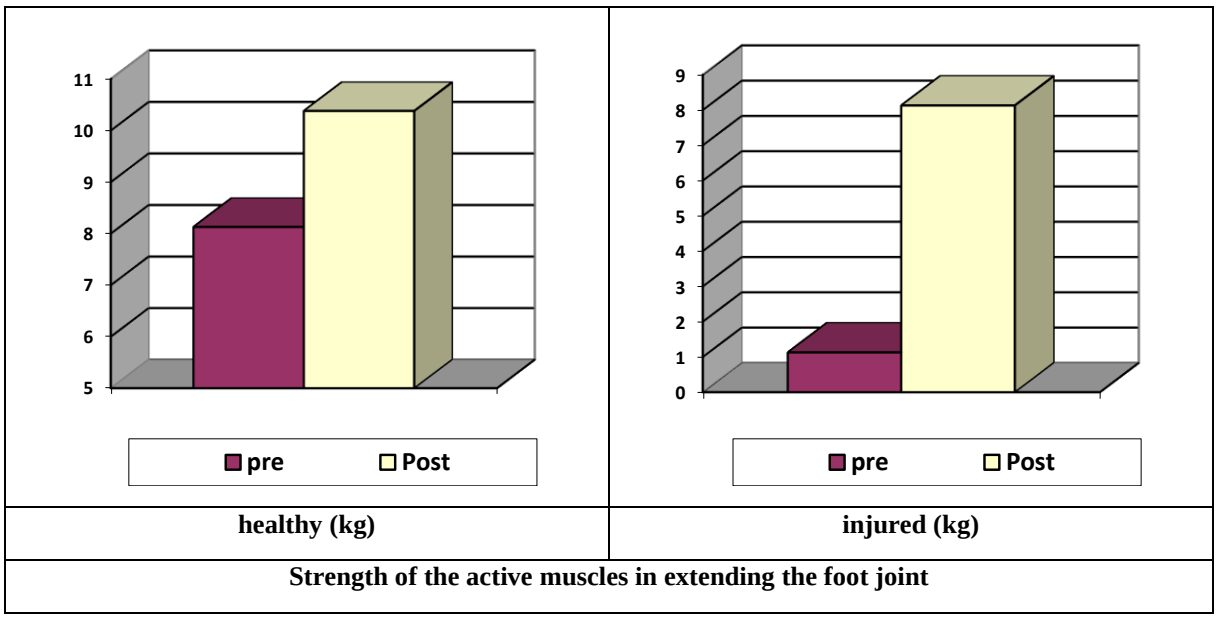


Figure (3) differences between the pre- and post-measurements of the experimental group regarding the (muscular strength of the active muscles of the healthy and injured feet joints)

B: Presentation of the significance of differences between the pre- and post-measurements of the range of motion variables

Table (5)

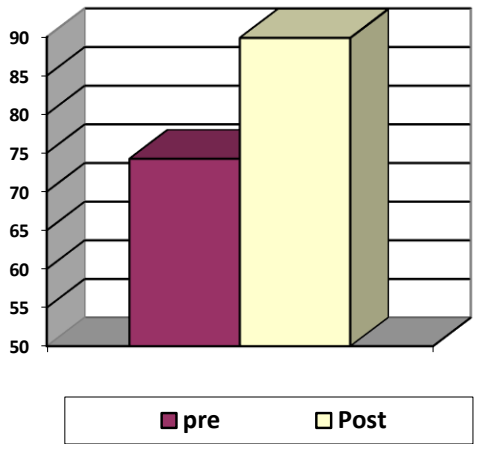
The differences between the pre- and post-measurements of the experimental group regarding the (range of motion measurements of the thigh joint) for the healthy and injured feet (n = 8)

Statistical significances range of motion measurements of the thigh joint		Pre-measurements		Post-measurement		Difference between the two means		T value	Improvement Percentage %
		X	±P	X	±P	X	±P		
thigh joint of the healthy foot	grip (degree)	74.25	4.27	89.88	3.83	15.63	0.52	85.39*	21.04%
	extension (degree)	20.13	1.81	25.75	1.49	5.63	0.52	30.74*	27.95%
	adduction (degree)	11.25	1.04	15.63	1.41	4.38	0.52	23.91*	38.89%
	abduction (degree)	25.75	2.82	33.38	1.69	7.63	1.19	18.16*	29.61%
thigh joint of the injured foot	grip (degree)	73.38	4.24	88.88	3.83	15.50	0.53	82.02*	21.12%
	extension (degree)	19.13	1.81	24.75	1.49	5.63	0.52	30.74*	29.41%
	adduction (degree)	10.13	1.13	14.78	1.26	4.66	0.55	23.89*	46.00%

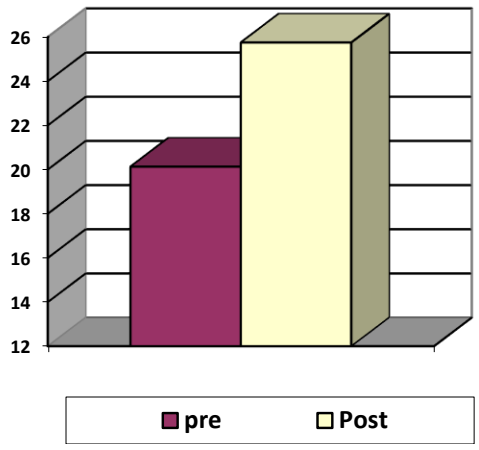
	abduction (degree)	**24.75**	**2.82**	**32.64**	**1.94**	**7.89**	**2.63**	**8.49***	**31.88%**

Significant at the level 0.05 = 2.36

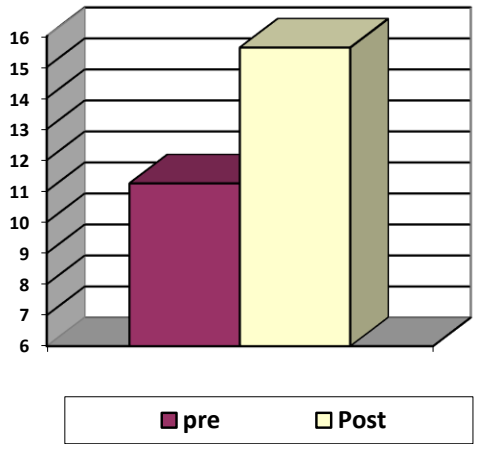
Table (5) shows that there are differences between the pre- and post-measurements at the level of 0.05 in all range of motion measurements of the thigh joint in favor of the post-measurement, where the T value ranged between (8.49 to 82.02) and these values are greater than the tabular T value at the level of 0.05, and the improvement percentage ranged between (21.04% to 46.00%) in favor of the post-measurement.



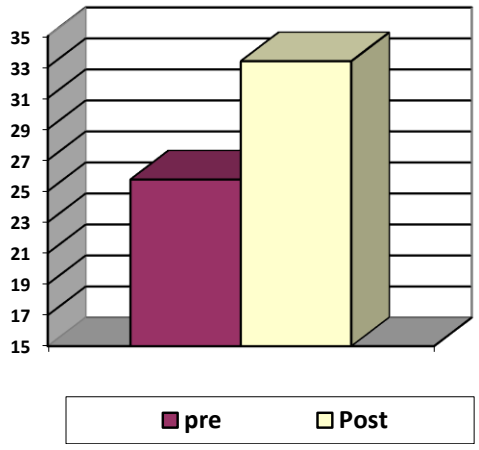
grip (degree)



extension (degree)



adduction (degree)



abduction (degree)

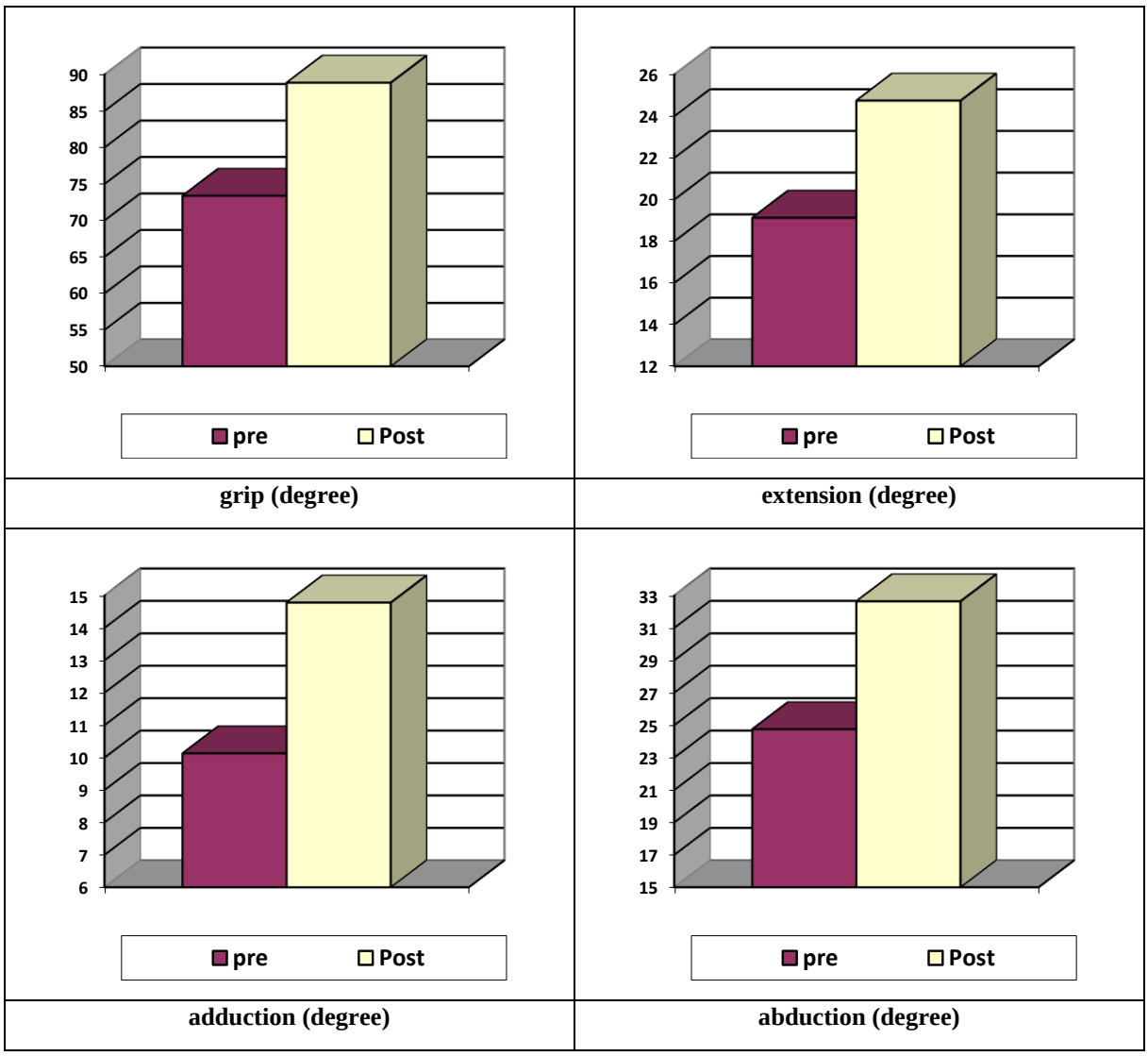


Figure (4) differences between the pre- and post-measurements of the experimental group regarding the (range of motion of the healthy and injured thigh joints)

Table (6)

The differences between the pre- and post-measurements of the experimental group regarding the (range of motion measurements of the knee joint) for the healthy and injured feet (n = 8)

Statistical significances		Pre-measurements		Post-measurement		Difference between the two means		T value	Improvement Percentage %
range of motion measurements of the knee joint		X	±P	X	±P	X	±P		
knee joint of	grip (degree)	114.63	4.27	130.25	8.05	15.63	3.89	11.36*	13.63%

the healthy foot	**extension (degree)**	**11.63**	**1.41**	**2.88**	**0.83**	**8.75**	**0.71**	**35.00***	**75.27%**
knee joint of the injured foot	**grip (degree)**	**113.50**	**4.28**	**129.50**	**8.28**	**16.00**	**4.11**	**11.02***	**14.10%**
	extension (degree)	**10.63**	**1.41**	**2.88**	**0.83**	**7.75**	**0.71**	**31.00***	**72.94%**

Significant at the level 0.05 = 2.36

Table (6) shows that there are differences between the pre- and post-measurements at the level of 0.05 in all range of motion measurements of the knee joint in favor of the post-measurement, where the T value ranged between (11.02 to 35.00) and these values are greater than the tabular T value at the level of 0.05, and the improvement percentage ranged between (13.63% to 75.27%) in favor of the post-measurement.

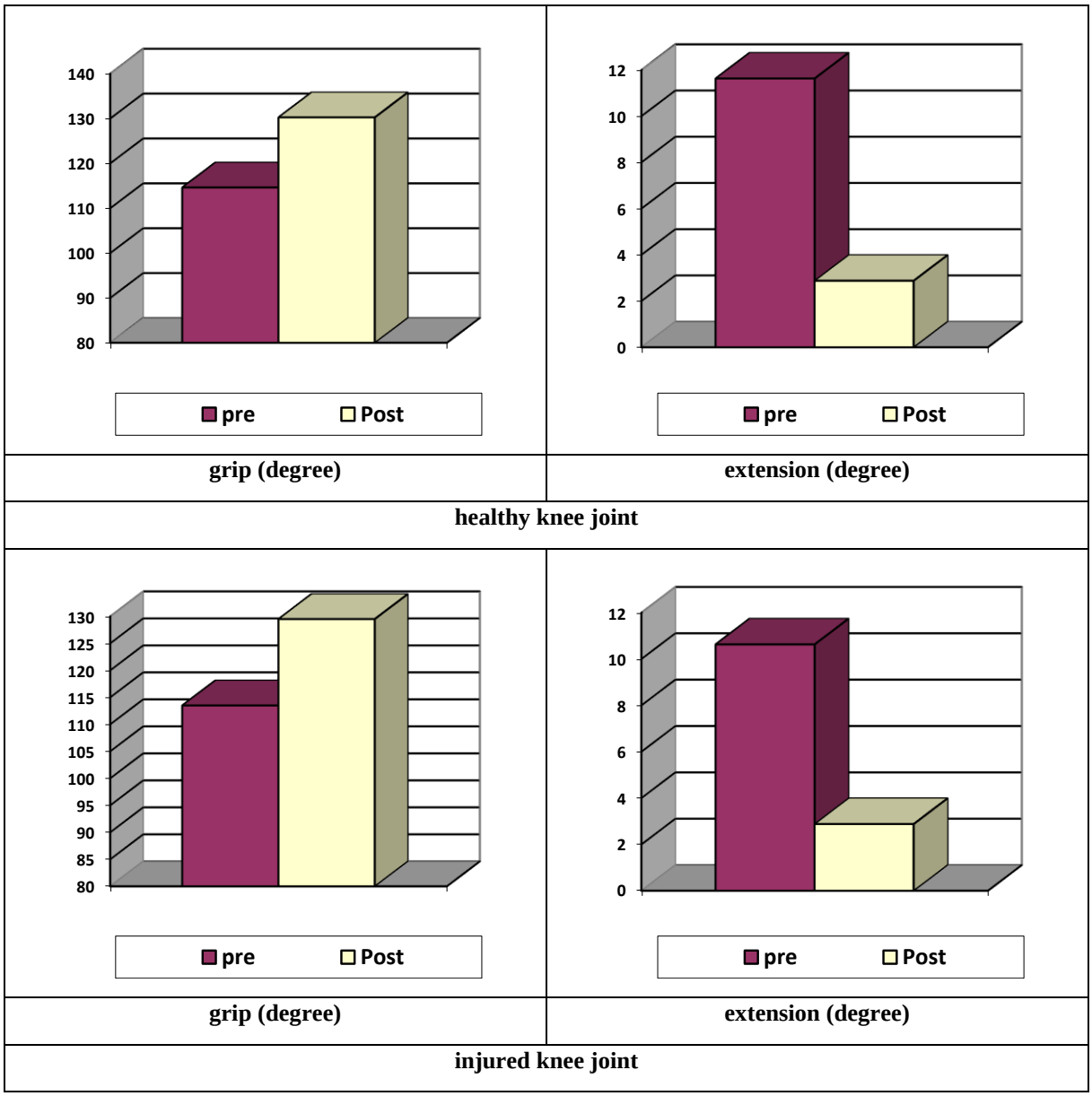


Figure (5) differences between the pre- and post-measurements of the experimental group regarding the (range of motion of the healthy and injured knee joints)

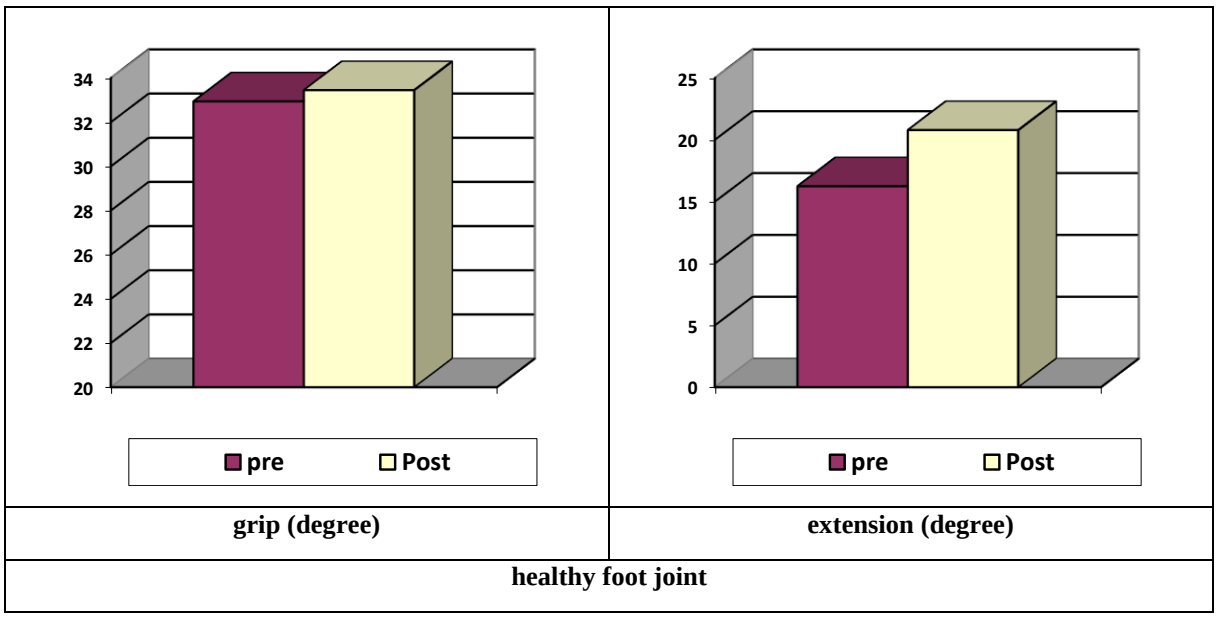
Table (7)

The differences between the pre- and post-measurements of the experimental group regarding the (range of motion measurements of the foot joint) for the healthy and injured feet (n = 8)

Statistical significances		Pre-measurements		Post-measurement		Difference between the two means		T value	Improvement Percentage %
range of motion measurements of the foot joint		X	±P	X	±P	X	±P		
joint of the healthy foot	grip (degree)	32.94	2.22	33.45	1.92	0.50	1.25	1.14	1.52%
	extension (degree)	16.25	1.04	20.79	1.08	4.54	1.31	9.84*	27.95%
joint of the injured foot	grip (degree)	23.50	1.93	31.66	2.29	8.16	2.31	9.98*	34.71%
	extension (degree)	10.81	0.74	15.25	1.28	4.44	0.70	17.96*	41.09%

Significant at the level 0.05 = 2.36

Table (7) shows that there are differences between the pre- and post-measurements at the level of 0.05 in the (extension of the healthy foot and the extension and extension of the injured foot) for the healthy and injured feet in favor of the post-measurement, where the T value ranged between (9.84 to 17.96) and these values are greater than the tabular T value at the level of 0.05. There were no differences between the pre- and post-measurements in gripping the healthy foot, and the improvement percentage ranged between (1.52% to 41.09%) in favor of the post-measurement.



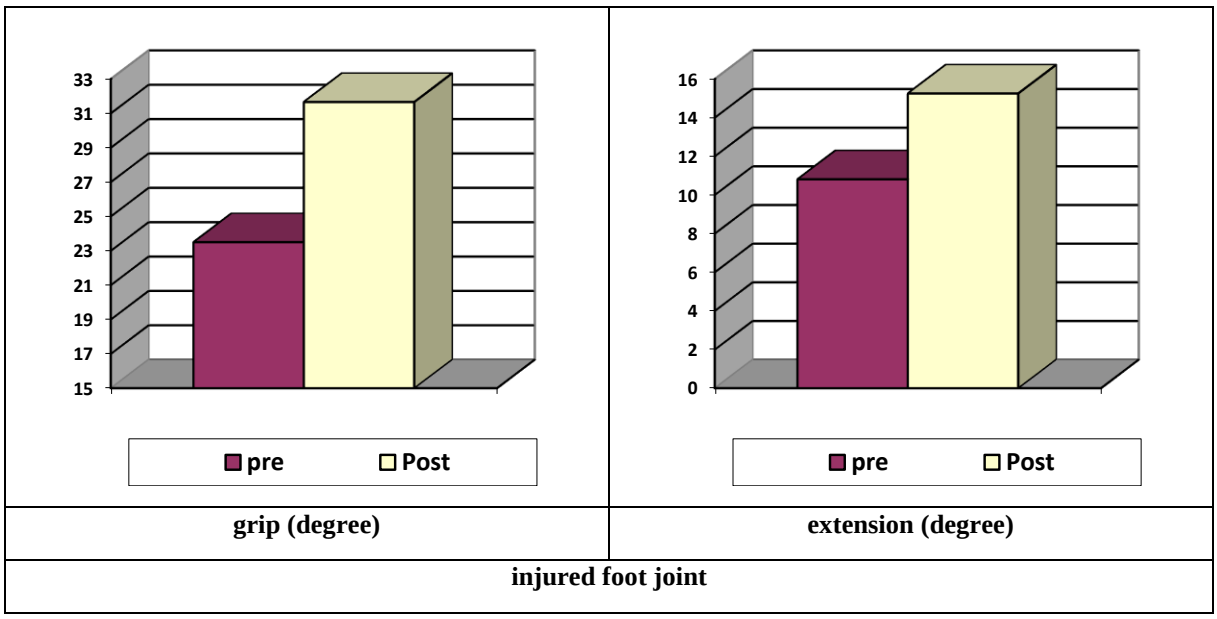


Figure (6) differences between the pre- and post-measurements of the experimental group regarding the (range of motion of the healthy and injured feet joints)

C: Presentation of the significance of differences between the pre- and post-measurements of balance

Table (8)

The differences between the pre- and post-measurements of the experimental group regarding the (balance test) for the healthy and injured feet (n = 8)

Statistical significances / balance test		Pre-measurements		Post-measurement		Difference between the two means		T value	Improvement Percentage %
		X	±P	X	±P	X	±P		
standing on the instep and raising the other foot (sec.)	healthy instep (sec.)	36.88	6.83	128.88	36.35	92.00	6.82	14.09*	249.49%
	injured instep (sec.)	7.88	2.36	118.50	37.86	110.63	36.11	8.66*	1404.76%

Significant at the level 0.05 = 2.36

Table (8) shows that there are differences between the pre- and post-measurements at the level of 0.05 in the balance test for the healthy and injured feet in favor of the post-measurement, where the T value ranged between (8.66 to 14.09) and these values are greater than the tabular T value at the level of 0.05, and the improvement percentage ranged between (249.49% to 1404.76%) in favor of the post-measurement.

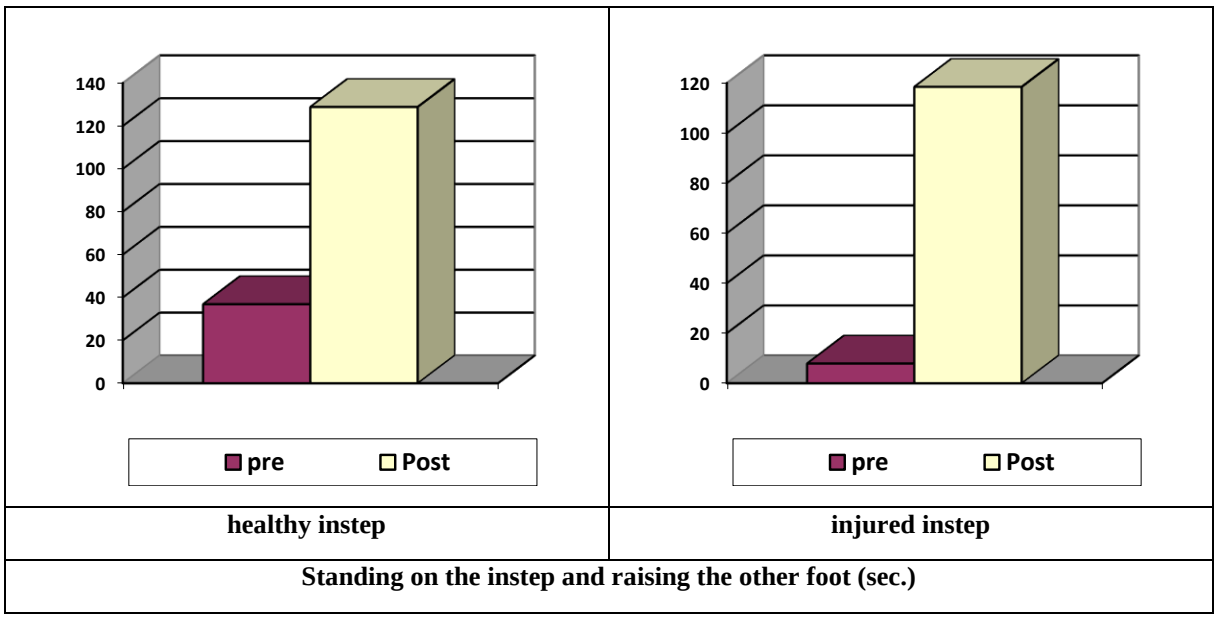


Figure (7) differences between the pre- and post-measurements of the experimental group regarding the (balance test)

D: Presentation of the significance of differences between the pre- and post-measurements of the level of pain

Table (9)

The differences between the pre- and post-measurements of the experimental group regarding the (level of pain) (n = 8)

Statistical significances / Measurements		Pre-measurement		Post-measurement		Difference between the two means		T value	Improvement Percentage %
		X	±P	X	±P	X	±P		
level of pain	pain test while walking (score out of 10)	8.63	1.06	8.38	1.06	3.25	0.46	19.86*	37.68%

Significant at the level 0.05 = 2.36

Table (9) shows that there are differences between the pre- and post-measurements, and the improvement percentage was (37.68%) in favor of the post-measurement.

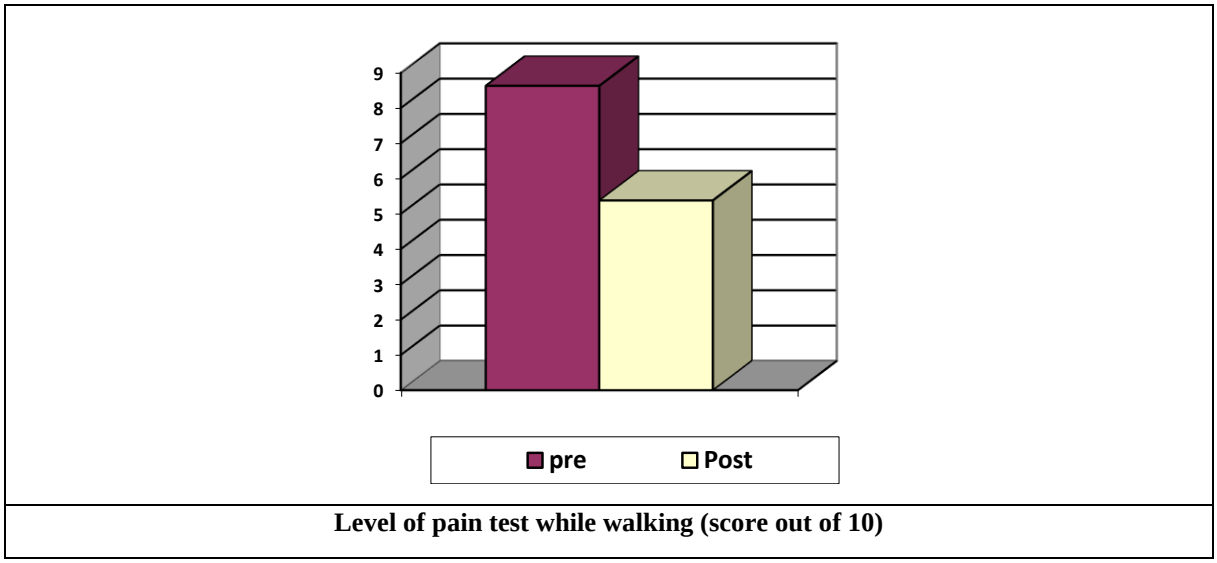


Figure (9) differences between the pre- and post-measurements of the experimental group regarding the (the level of pain)

II) Discussion and interpretation of the results

Discussion and interpretation of the results of verifying the first hypothesis concerning the pre- and post-measurements of the experimental group in regard to the muscular strength variable

The results showed that there are positive effects of the proposed rehabilitation program, including its codified physical and kinetic rehabilitation exercises inside and outside the water medium, and the strengthening of the active muscles on the thigh joint, whether they are (gripping - extensor - adductors - abductors) because this joint is affected by the surgery after the complete replacement of the ankle joint in the injured limb and its muscle group gets weak, therefor rehabilitation helps improving the affected part with attention to the rest of the other parts and not neglecting them because the whole body is one unit that is affected positively or negatively by each other and the rehabilitation program is concerned with training the healthy and injured parts at the same time. There was an effect of the rehabilitation program with values ranged between 2.8 to 12.3, and these values express the effectiveness of the rehabilitation program in improving and developing the strength of the active muscles of the thigh joint. The importance of such vital muscle group lies in the lower limb, as it is in the lower half of the (knee), which is the link between the upper part (thigh) and the lower part (ankle).There is a great participation of the flexor and extensor muscles of the knee, which are the muscles that contribute to the movement and stability of the ankle joint. Therefore, there was a fundamental improvement for both healthy and injured parts since it is the main focus of the rehabilitation program in that area, and due to its severe impact from the surgery in the affected limb, there is an improvement in the strength of the active muscles under research in favor of the post-measurement. It is the basis of physical activity whether in the daily activities such as ascending and descending the stairs and walking or in the sports activities. Muscular strength is one of the most important elements of physical and kinetic fitness. It is also due to the effect of the rehabilitation program, including exercises to improve and develop the muscular strength of the ankle joint, whether these exercises are performed using tools or perfomed inside and outside a water medium and the using fixed muscular strength exercises. Strength training according to the method of the stable muscular activity increases the muscular strength of the muscle groups on the ankle joint, and the use of aids to perform training with a fairly high resistance, which confirms that the muscles of the affected limb suffer from a very severe weakness in the muscular strength compared to the right side in the pre-measurement.

A.B. Imhoff (2015) notes that the development of the muscular strength leads to an increase in the muscular mass and the strengthening of the connective tissues, also performing the muscular strength training within the program and its contents leads to the opening of the largest number of capillaries, which helps to increase the arterial blood pressure in the active muscle and increase the muscle fibers, also performing the training program regularly and gradually help increasing the cross-section in the muscle, increasing the size of fast fibers, increasing the size and strength of tendons and ligaments, increasing the density of blood capillaries. Muscular strength training contributes to increasing the efficiency of the injured person physically and functionally. The results of immobility that follow the injury may lead to the loss of endurance, muscular strength and flexibility, and the patient may lose self-confidence as well in the ability to practice his/her life and sports activities. Muscular strength is important for the daily human movement, and it is represented in the resistance to

fatigue. It is the pillar on which the movement depends. It is also an important factor for the protection from injuries. The balanced development of the muscular strength, joint flexibility and muscle elongation has an important effect in increasing the kinetic efficiency of the ankle joint. Diversity of the physical exercises and muscular strength exercises has a positive effect on improving the functional performance of the ankle joint and the lower limb. There is no doubt that the diversity of muscle activity has the greatest impact on improving the muscular strength of the lower limb muscles, especially the Achilles tendon area, which represents a weak point for athletes and non-athletes due to the vitality of this area with heavy loads and weights on it and activity more than other parts in the body, which leads to the injuries of athletes and non-athletes during the practice of various activities. (1)

Stead (2018) and Marco (2018) agreed that rehabilitative exercises are the main focus in rehabilitating the injured because they contribute to strengthening the muscles, ligaments and joints, and help increasing the efficiency of the injured people physically, psychologically and functionally. (20), (23)

Marco Massobrio (2018) also points out that the results of immobility that follow the injury and represent the patient's loss of endurance, muscular strength and flexibility, may lead to losing self-confidence in their abilities to practice sports activity again. (20)

Discussion and interpretation of the results of verifying the second hypothesis concerning the pre- and post-measurements of the experimental group in regard to the range of motion variable

The results showed that there are positive effects of the range of motion measurements in each of the thigh, knee and foot joints for the effect of the proposed rehabilitation program and the regular performance of exercises by the sample members in each stage of the rehabilitation program, and that led to an improvement in the lengthening of the muscles around the thigh and knee joints and the muscles around the ankle joint, also as a result of the increase of the joint range of motion, the muscular strength and muscle tendons improved, and thus the kinetic efficiency of the joints increased too.

Dekker Travis (2017) notes that rehabilitation exercises are a tight structural movement of the body to modify its movement, improve the functions of the muscle, and maintain a good body structure. The exercises increase the muscular strength and increase the range of motion of the lower limb joints (thigh - knee - foot), which contributed to improving the way of walking and going up and down the stairs, which are the most important and vital daily activities for all of the cases generally and the ankle joint in particular, however, the joints of the lower limb are negatively affected as a result of the surgery and as a result of the complete replacement of the ankle joint.

The rehabilitation program reduced the negative effects and made an improvement in the muscular strength and the range of motion, shortened the rehabilitation period and helped in fast healing. (10)

Nancy (2016) indicates that muscular strength development exercises should be accompanied by flexibility exercises to lengthen the muscles and increase the positive effects on strength and flexibility, since the development of muscular strength notably increases with the increase of the range of motion of the joint, where the full range of motion of the joint and the lengthening of the active muscles on it leads to maximum strength results as the lengthened muscles perform their function with high efficiency. (22)

Discussion and interpretation of the results of verifying the third hypothesis concerning the pre- and post-measurements of the experimental group in regard to the balance variable

The positive improvement in the balance while standing on the healthy and injured feet is due to the effect of the physical and kinetic exercises, in addition to the inclusion of the program to a group of muscular strength, flexibility, balance and endurance exercises and the performance of these exercises inside and outside the water medium, their diversity and performance in different muscular activity angles and with various tools while working on muscular balance between all muscle groups of the lower limb and their natural proportions and according to the followed muscular activity.

Anne Constance (2020) also indicates that balance is the ability to maintain the mass center within the limits of the fulcrum base and improving the balance leads to avoiding and reducing injuries. (3)

Discussion and interpretation of the results of verifying the fourth hypothesis concerning the pre- and post-measurements of the experimental group in regard to the level of pain variable

The results showed a decrease in the level of pain in the affected foot, and this may be due to the effect of the rehabilitation program, represented in the muscular strength, range of motion, balance, endurance, removal of the tumor, symptoms of surgery and inflammation of the injured ankle, as the rehabilitation exercises aimed at relieving the pain, and the rehabilitation program had an important role in improving the muscular tone of the muscles of the lower limb, activating blood and lymph circulation, and relieving pain resulting from the surgery, and this was agreed by Franchignoni. (2012) (12)

Conclusions:

In light of the research objectives and its methodology, and based on the sample and the statistical analysis, the presentation and discussion of the results, the researchers concluded that the proposed rehabilitation exercise program outside and inside the water medium contributed to the return of the injured to a semi-normal state, and that was obvious through:

1. Restoring the muscular strength of the active muscles of the ankle joint.
2. Restoring the range of motion of the ankle joint, and that was obvious from the results of the pre- and post-measurements, in favor of the post-measurement
3. Restoring the static and kinetic balance of the ankle joint, and that was obvious from the results of the pre- and post-measurements, in favor of the post-measurement.
4. Reducing the level of pain for the injured, and that was obvious from the results of the pre- and post-measurements, in favor of the post-measurement.

The previous conclusions contributed to achieving the research objective, which is to improve the strength and range of motion of the joints of the ankle joint, increase the efficiency of performing life activities, and reduce the pain in the affected area, by subjecting the research sample to the proposed program outside and inside the water medium.

Recommendations:

Based on the results of this study, the researchers recommend the following:

1- Using the proposed rehabilitation program when rehabilitating after ankle arthroplasty.

2- Integrating the elements of physical rehabilitation of the muscles, which are developed through the (range of motion - muscular strength exercises - static and kinetic balance).

3- Treating the kinetic problems that the patient is face after the surgery.

4- Considering health education for the injured people.

5- Keeping on practicing the exercises of the last stage after completing the rehabilitation program.

6- Starting the implementation of the rehabilitation program on the ankle joint 14 days after the surgery.

7- Rehabilitation should be used in the water medium because of its positive impact on the patient's return to practice the normal life and sports activities.

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