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The Impact of Rehabilitation Exercises with The Cryo Cooling Device on Improving Some Biomechanical and Biochemical Abilities in Weightlifters Suffering from Carpal Tunnel Syndrome

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Abstract

The research aims to introduce modern methods and techniques to rehabilitate carpal tunnel syndrome (CTS) by using rehabilitation exercises with the Cryo cooling device for weightlifters suffering from this syndrome. The problem statement addresses how sports injuries can be a significant psychological and physical barrier to reaching higher levels of performance. The researcher, being a weightlifting athlete and familiar with local championships and training units, notes that weightlifters in some sports clubs often suffer from various sports injuries, with CTS being one of the most significant. This injury is caused by the extreme movement in snatch and clean and jerk exercises, leading athletes to be away from training for extended periods. The study aims to develop rehabilitation exercises with the Cryo cooling device to improve some biomechanical and biochemical abilities in weightlifters with CTS. The research community included a sample of weightlifters with CTS from Samawah, Basra, Maysan, and Dhi Qar governorates. The key findings indicate that the rehabilitation exercises designed by the researcher using the Cryo cooling device have a positive impact on rehabilitating CTS in weightlifters. The recommendations suggest the use of physical therapy devices due to their importance in improving the injury and reducing pain, contributing to the athlete's return to normal status after the injury.

Keywords: *Carpal Tunnel Syndrome Rehabilitation, Cryo Cooling Device in Sports Therapy, Biomechanical and Biochemical Rehabilitation Techniques*

INTRODUCTION

Rehabilitation is one of the basic natural means in the field of injury treatment, and it represents special importance in reintegrating the injured individual into daily activities and restoring the basic functions of the body and the motor abilities specific to activity. It helps increase the rate of healing of muscular tissues, ligaments, bones, and injured joints. Sports injuries have recently become the main concern for most professionals in the sports field, especially in medical treatment and rehabilitation. The number of sports injuries has been continuously increasing due to the high effort in training and competitions, as well as the effort in repeating specific movements in some sports activities.

Rehabilitation exercises are among the most impactful means in rehabilitating injured players and lead to many effects on the athlete's body. Weightlifting is one of the games that requires a high level of strength to overcome significant resistance, as is the case with weightlifters who complain of pain in the carpal tunnel area due to the pressure caused by using heavy weights during core exercises. Any minor fault during strength training and the tension and repetition of these exercises will reflect negatively on the athlete, whether it is not applying the correct posture for the movement, the lack of general and specific warm-up for the game, in addition to tightening the hands on the carpal tunnel area.

Hence, the importance of the research lies in introducing modern means and techniques to rehabilitate carpal tunnel syndrome injuries through the use of rehabilitative exercises with the Cryo cooling device for players with carpal tunnel syndrome.

Research problem:

Through the researcher's observation as a weightlifting player and a follower of local championships and training units, weightlifters in some sports clubs are exposed to various types of sports injuries, with the most

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important of these injuries being carpal tunnel syndrome. This injury occurs due to the final movement in the snatch and clean and jerk exercises, leading to the athlete's absence from training for long periods. This results in a decline in their physical fitness and achievement levels. Therefore, the researcher decided to introduce modern means and techniques in rehabilitating carpal tunnel syndrome injuries through using therapeutic exercises with a cooling device for weightlifting players.

Research Objectives:

Prepare rehabilitative exercises with the Cryo cooling device to improve some biomechanical and biochemical capabilities in weightlifting players with carpal tunnel syndrome.

Determine the impact of rehabilitative exercises and the Cryo cooling device on some biomechanical and biochemical capabilities in weightlifting players with carpal tunnel syndrome.

Identify the superiority of rehabilitative exercises and the cooling device on biomechanical and biochemical capabilities.

Research Hypotheses:

There is a positive impact of the researcher-prepared rehabilitative exercises and Cryo cooling device on improving some biomechanical and biochemical capabilities in weightlifting players with carpal tunnel syndrome.

There are statistically significant differences between the two research groups.

Research Areas:

Human Field:

Injured players with carpal tunnel syndrome in snatch and clean and jerk weightlifting in Thi Qar, Basra, Samawah, and Maysan provinces.

Time Field:

From October 20, 2023, to April 10, 2024.

Spatial Field:

Baghdad Physical Therapy Center, Muthanna Intensive Physical Therapy Center, Al-Shams Physical Therapy Clinic, Al-Qima Physical Therapy Center, Genetic Blood Diseases Hospital, Success Sports Center, VIP Fitness and Bodybuilding Center, and Physiological Laboratories in Thi Qar, Basra, Samawah, and Maysan provinces. Keywords: Impact, Rehabilitation, Cryo Cooling Device, Biomechanics, Biochemistry, Weightlifters, Carpal Tunnel Syndrome.

METHODOLOGY

Research Method:

The researcher used an experimental method with a two-group design (control and experimental) with pre-test and post-test, which is most suitable for the research objectives and hypotheses.

Research Population and Sample:

The researcher identified the research population as weightlifting players with carpal tunnel syndrome due to high loading. The research sample consisted of (8) injured players representing Thi Qar, Basra, Samawah, and Maysan provinces. They were selected purposively.

Research Sample Homogeneity:

To ensure starting from a common baseline and to verify that the results are moderately distributed among the research sample individuals and that the experimental method has an impact in creating differences between the research groups, the researcher conducted homogeneity tests for both groups using mean, standard

deviation, and coefficient of variation in variables such as age, height, body mass, and training age. This is illustrated in Table (1):

Table (1) Homogeneity of Research Sample in Some Basic Variables

#	Variables:	Measurement Unit	Mean	Standard Deviation	Coefficient of Variation
1	Height	Centimeters	169.1250	6.15136	3.637%
2	Age	Years	25.1250	1.88509	7.50%
4	Body Mass	Kilograms	83.0000	7.08409	8.535%
4	Training Age	Years	3.0000	0.1652	%5.506

Data Collection Methods and Devices Used in the Research:

Data Collection Methods:

Arabic and foreign sources and references.

World Wide Web (Internet).

Observation.

Personal interviews.

Testing Devices:

Cobas e 411 device for biochemical analysis of blood samples.

Electronic Centrifuge 80-2 for blood separation.

Rest meter device for electronic height and weight measurements, Japanese-made (2 units).

Cryo cooling device.

Dell computer with a Japanese-made electronic calculator.

Canon Digital video camera (1 unit).

Biolabo diagnostic kits from France for total protein detection.

Biolabo diagnostic kits from France for CPK detection.

Biolabo diagnostic kits from France for LDH detection.

Field Research Procedures:

Research Variable Identification:

After reviewing numerous sources and consulting with the supervisor and a group of experts, the research variables were identified. They were then presented to the scientific committee, and a questionnaire form was prepared to select the appropriate variables that align with the research problem. The identified variables were as follows:

Identify the most important biomechanical capabilities related to high-loading injuries.

Identify the most important biochemical variables related to high-loading injuries.

Description of Biomechanical Tests:

First. Maximum Grip Strength:

Test Name: Handgrip Dynamometer for measuring maximum grip strength.

Purpose: Measure the strength of muscles acting on the wrist from two positions.

Devices and Tools: Video camera, paper, pen.

Performance Description: The injured person holds the handgrip dynamometer with the injured hand and presses it with maximum force while ensuring not to touch the supporting arm of the device to any external object or the injured person's body.

Recording: Record the reading to the nearest kilogram, ensuring to reset the indicator to zero after each attempt (right or left grip), and two attempts are given, with the best one calculated and measured in kilograms, grams, and pounds.

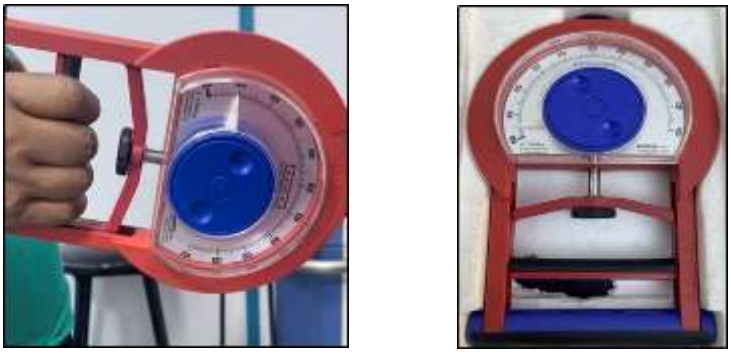

Figure (1): Maximum Grip Strength Test with Dynamometer

Second. Endurance Strength Test:

Test Name: Front Plank Until Exhaustion.

Purpose: Measure the strength of muscles acting on the wrist from two positions.

Devices and Tools: Recording form, whistle, camera.

Performance Description: From a prone position with arms extended at shoulder width or slightly wider, upon command, the participant performs full arm flexion and extension until exhaustion.

Recording: Count the successful repetitions until exhaustion.

Figure (2): Illustration of Endurance Strength Test

Third: Range of Motion:

Test Name: Kinova Software Range of Motion Tests.

Purpose: Determine and measure angles and bending positions and ranges.

Devices and Tools: Recording form, video camera, paper, pen.

Performance Description: From a sitting position, the participant performs the following:

Flexion of the wrist downwards (angle of lateral flexion of the carpal metacarpal joint).

Flexion of the wrist upwards (angle of lateral elevation of the carpal metacarpal joint).

These positions are recorded to extract the range of motion.

Recording: The recording is inputted into the software, and angles are determined to determine the maximum range that the wrist joint can reach in the aforementioned positions.

Wrist flexion upwards" and "wrist flexion downwards.

Figure (3): Illustration of Range of Motion Test using Kinova Device

Second: Description of Biochemical Tests:

First: LDH Enzyme Test:

Using the diagnostic kit on a German-made Biolyzer 300 device. The concentration ratio of LDH enzyme (Lactate Dehydrogenase) activity was measured to obtain the desired results. A quantity of blood estimated at 3 milliliters was drawn for this purpose. The normal range for LDH is (135-225 IU/L) international units per liter.

Second: Measurement of CPK Enzyme:

Using the diagnostic kit on a German-made Biolyzer 300 device.

The concentration ratio of CPK enzyme (Creatine Phosphokinase) activity was measured to obtain the desired results. A quantity of blood estimated at 3 milliliters was drawn for this purpose. The normal range for CPK is (24-195 IU/L) international units per liter.

Four: Total Protein Test

Using the diagnostic kit for the Total Protein in Blood Test on a French-made device. The reading of total protein analysis in the blood is considered normal if the reading ranges from 6.0 to 8.0 g/dl.

Pilot Experiments:

First Pilot Experiment:

The first pilot experiment was conducted on Sunday, December 17, 2023, at the Thi Qar Center for Physical Therapy and Rehabilitation on a sample size of 3 individuals. The objectives were:

Timing the performance of rehabilitation exercises for the sample.

Defining the roles of the assisting team members effectively.

Ensuring the safety of equipment and tools.

Identifying any obstacles or errors related to implementing rehabilitation exercises.

Determining the number of repetitions for each exercise used in the rehabilitation program.

Assessing the suitability of rehabilitation exercises for the research sample.

Determining the number of exercises used in each rehabilitation session.

Identifying and calculating the time required for each exercise in the rehabilitation program.

Organizing, arranging, and sequencing rehabilitation exercises based on their level of difficulty.

Second Pilot Experiment:

The second pilot experiment was conducted on Monday, December 18, 2023, at the Thi Qar Center for Physical Therapy and Rehabilitation on a sample size of 3 individuals. The objectives were:

Determining the amount of blood drawn from the players.

Understanding the process of transferring blood from the testing site to the laboratory for analysis.

Implementing the methodology for biochemical tests.

Ensuring the safety of blood transportation.

Confirming the accuracy and integrity of the tests .

Pre-Tests:

The researcher, with the assistance of the supporting staff and medical team, conducted pre-tests on the research sample for variables (biomechanical and biochemical variables) on Monday and Tuesday, December 25-26, 2023, at 8:30 AM. The pre-tests were as follows:

Day 1: Biomechanical tests were conducted, including maximal strength, endurance, and range of motion, at the Baghdad Intensive Physical Therapy Center.

Day 2: Biochemical tests were conducted at the Sumar and Dar Al-Salam laboratories, including LDH, CPK, and total protein tests.

Implementation of Rehabilitation Exercises with Cryo:

The researcher prepared rehabilitation exercises for weightlifting athletes with carpal tunnel syndrome injuries. These exercises were tailored to the degree and severity of the injury and aimed to improve and strengthen the muscles and ligaments related to the study topic, focusing on technical performance. These exercises were characterized by the use of appropriate tools and equipment, with joint movements designed to increase joint flexibility and strengthen surrounding muscles and tendons. The researcher utilized a progressive approach in performing these exercises, starting from easy to difficult and from stability to movement. Additionally, suitable tools and weights were used to achieve the desired optimal performance, adhering to scientific methods for injury rehabilitation.

Here are the details of the rehabilitation exercises:

The rehabilitation program started with the research sample on Thursday, December 28, 2023, at 9:00 AM at Baghdad Intensive Medical Therapy Center.

The rehabilitation program was applied to the research sample for a duration of 6 weeks, with three rehabilitation sessions per week.

After consulting specialized doctors, it was confirmed to apply Cryo sessions with exercises during the first two weeks post-injury, followed by once a week to prevent inflammation.

Rehabilitation sessions were scheduled on Sundays, Tuesdays, and Thursdays.

The duration of each rehabilitation session was 45 minutes.

Cryo treatment was applied for a duration ranging from 5 to 10 minutes before the exercises by the therapist.

The rehabilitation exercises were individually tailored for the research sample during the rehabilitation sessions.

The exercises progressed in difficulty from easy to challenging.

All exercises were performed without experiencing pain limits.

Post tests

After completing the proposed rehabilitation exercises for players with Carpal Tunnel Syndrome, the researcher conducted post-rehabilitation tests. These tests were conducted on Saturday, February 10, 2024, at 8:30 AM, ensuring the same location, time conditions, and procedures as the pre-rehabilitation tests.

Statistical methods:

After collecting the data, it was processed using the statistical package (SPSS.V12), and the most important statistical procedures used were:

Mean

Standard deviation

Median

Sum of ranks

Wilcoxon test for correlated groups

Mann-Whitney test for independent groups.

RESULT AND FINDINGS

Presentation and analysis of the pretest and posttest results

for the first control research group in the biomechanical and biochemical tests, their analysis, and discussion:

Table (2) shows the mean values, standard deviation, average ranks, sum of ranks, Wilcoxon value, and statistical significance of the pretest and posttest measurements for the first control group in the biomechanical and biochemical variables.

Variables	Statistical Indicators	Sample	Pre	Post	Rank Mean	Rank Sum	z	Sig	Significance
Maximum Strength	Mean	4	4.0000	34.2500	0.00	0.00	1.365	0.04	Significant
	Standard Deviation	4	1.22474	4.34933	2.50	10.00			
Strength Endurance	Mean	4	4.0000	44.1250	0.00	0.00	1.231	0.02	Significant
	Standard Deviation	4	0.91287	7.28440	2.50	10.00			
Range of Motion: Wrist Flexion	Mean	4	25.0000	71.7500	0.00	0.00	0.976	0.000	Significant
	Standard Deviation	4	6.90994	1.70783	2.50	10.00			
Range of Motion: Wrist Extension	Mean	4	30.0000	67.0000	0.00	0.00	0.865	0.000	Significant
	Standard Deviation	4	18.25742	2.58199	2.50	10.00			
CPK Test	Mean	4	268.5000	94.0000	0.00	0.00	0.965	0.000	Significant

	Standard Deviation	4	13.98809	1.41421	2.50	10.00			
LDH Test	Mean	4	292.5000	193.5000	0.00	0.00	1.109	0.015	Significant
	Standard Deviation	4	9.32738	5.44671	2.50	10.00			
Total Protein	Mean	4	18.5250	9.2000	0.00	0.00	0.953	0.000	Significant
	Standard Deviation	4	0.98107	0.79582	2.50	10.00			

From Table (2), it is evident that there is a difference and variation among the calculated values for all research variables. The mean for the pre-measurement of the maximum force variable was 4.0000 with a standard deviation of 1.22474, while the rank mean was 0.00 and the rank sum was 0.00. For the post-measurement, the mean was 34.2500 with a standard deviation of 4.34933, the rank mean was 2.50, and the rank sum was 10.00. Using the non-parametric Wilcoxon test, the Z-value was 1.365 at a significance level of 0.04, indicating statistically significant differences favoring the post-measurement.

As for the variable "force endurance," the mean for the pre-measurement was 4.0000 with a standard deviation of 0.91287, the rank mean was 0.00, and the rank sum was 0.00. The mean for the post-measurement was 44.1250 with a standard deviation of 7.28440, the rank mean was 2.50, and the rank sum was 10.00. Using the non-parametric Wilcoxon test, the Z-value was 1.231 at a significance level of 0.02, indicating statistically significant differences favoring the post-measurement.

For the variable "range of motion" in the downward bending of the wrist, the mean for the pre-measurement was 25.0000 with a standard deviation of 6.90994, while the rank mean was 0.00 and the rank sum was 0.00. For the post-measurement, the mean was 71.7500 with a standard deviation of 1.70783, the rank mean was 2.50, and the rank sum was 10.00. Using the non-parametric Wilcoxon test, the Z-value was 0.976 at a significance level of 0.000, indicating statistically significant differences favoring the post-measurement.

For the variable "range of motion" in the upward bending of the wrist, the mean for the pre-measurement was 30.0000 with a standard deviation of 18.25742, while the rank mean was 0.00 and the rank sum was 0.00. For the post-measurement, the mean was 67.0000 with a standard deviation of 2.58199, the rank mean was 2.50, and the rank sum was 10.00. Using the non-parametric Wilcoxon test, the Z-value was 0.865 at a significance level of 0.000, indicating statistically significant differences favoring the post-measurement.

For the CPK variable, the mean for the pre-measurement was 268.5000 with a standard deviation of 13.98809, while the rank mean was 0.00 and the rank sum was 0.00. For the post-measurement, the mean was 94.0000 with a standard deviation of 1.41421, the rank mean was 2.50, and the rank sum was 10.00. Using the non-parametric Wilcoxon test, the Z-value was 0.965 at a significance level of 0.000, indicating statistically significant differences favoring the post-measurement.

For the LDH variable, the mean for the pre-measurement was 292.5000 with a standard deviation of 9.32738, while the rank mean was 0.00 and the rank sum was 0.00. For the post-measurement, the mean was 193.5000 with a standard deviation of 5.44671, the rank mean was 2.50, and the rank sum was 10.00. Using the non-parametric Wilcoxon test, the Z-value was 1.109 at a significance level of 0.015, indicating statistically significant differences favoring the post-measurement.

For the total protein variable, the mean for the pre-measurement was 18.5250 with a standard deviation of 0.98107, while the rank mean was 0.00 and the rank sum was 0.00. For the post-measurement, the mean was 9.2000 with a standard deviation of 0.79582, the rank mean was 2.50, and the rank sum was 10.00. Using the non-parametric Wilcoxon test, the Z-value was 0.953 at a significance level of 0.000, indicating statistically significant differences favoring the post-measurement.

2-3Presentation and analysis of the results of the pre- and post-measurements for the second experimental research group in the tests

Table (3) shows the mean, standard deviation, average ranks, sum of ranks, Wilcoxon value (Z), and the statistical significance of pre-test and post-test measurements for the second experimental group in the biomechanical and biochemical variables.

Variables	Statistical Indicators	Sample	Pre	Post	Rank Mean	Rank Sum	z	Sig	Significance
Maximum Strength	Mean	4	4.0000	49.0000	0.00	0.00	0.675	0.000	Significant
	Standard Deviation	4	0.91287	6.97615	2.50	10.00			
Strength Endurance	Mean	4	4.7500	52.8750	0.00	0.00	0.987	0.012	Significant
	Standard Deviation	4	1.32288	2.52900	2.50	10.00			
Range of Motion: Wrist Flexion	Mean	4	27.7500	83.5000	0.00	0.00	0.895	0.000	Significant
	Standard Deviation	4	5.50000	9.11043	2.50	10.00			
Range of Motion: Wrist Extension	Mean	4	27.5000	68.0000	0.00	0.00	0.749	0.000	Significant
	Standard Deviation	4	15.00000	2.82843	2.50	10.00			
CPK Test	Mean	4	257.7500	193.5000	0.00	0.00	0.604	0.000	Significant
	Standard Deviation	4	20.22169	1.29099	2.50	10.00			
LDH Test	Mean	4	291.2500	206.7500	0.00	0.00	0.895	0.000	Significant
	Standard Deviation	4	7.67572	10.87428	2.50	10.00			
Total Protein	Mean	4	18.4250	7.6250	0.00	0.00	0.856	0.000	Significant
	Standard Deviation	4	1.48857	1.10868	2.50	10.00			

From our observation of Table (3), there is a difference and variability in the calculated values for all research variables. The mean for the maximum strength variable in the pre-test was 4.0000 with a standard deviation of 0.91287. The average rank was 0.00, and the sum of ranks was 0.00. In the post-test, the mean for the same variable increased to 49.0000 with a standard deviation of 6.97615. The average rank was 2.50, and the sum of ranks was 10.00. Using the non-parametric Wilcoxon test, the Z-value was 0.675 at a significance level of 0.000, indicating a statistically significant difference favoring the post-test measurement.

Regarding the strength endurance variable, the mean in the pre-test was 4.7500 with a standard deviation of 1.32288. The average rank was 0.00, and the sum of ranks was 0.00. In the post-test, the mean for this variable was 52.8750 with a standard deviation of 2.52900. The average rank was 2.50, and the sum of ranks was 10.00. Using the Wilcoxon test, the Z-value was 0.987 at a significance level of 0.012, indicating a statistically significant difference favoring the post-test measurement.

The mean for the range of motion in the downward wrist flexion variable was 27.7500 with a standard deviation of 5.50000 in the pre-test. The average rank was 0.00, and the sum of ranks was 0.00. In the post-test, the mean for this variable was 83.5000 with a standard deviation of 9.11043. The average rank was 2.50, and the sum of ranks was 10.00. Using the non-parametric Wilcoxon test, the Z-value was 0.895 at a significance level of 0.000, indicating a statistically significant difference favoring the post-test measurement.

Regarding the range of motion in the upward wrist flexion variable, the mean in the pre-test was 27.5000 with a standard deviation of 15.00000. The average rank was 0.00, and the sum of ranks was 0.00. In the post-test, the mean for this variable was 68.0000 with a standard deviation of 2.82843. The average rank was 2.50, and the sum of ranks was 10.00. Using the Wilcoxon test, the Z-value was 0.749 at a significance level of 0.000, indicating a statistically significant difference favoring the post-test measurement.

For the CPK variable, the mean in the pre-test was 257.7500 with a standard deviation of 20.22169. The average rank was 0.00, and the sum of ranks was 0.00. In the post-test, the mean for this variable was 193.5000 with a standard deviation of 1.29099. The average rank was 2.50, and the sum of ranks was 10.00. Using the Wilcoxon test, the Z-value was 0.604 at a significance level of 0.000, indicating a statistically significant difference favoring the post-test measurement.

As for the LDH variable, the mean in the pre-test was 291.2500 with a standard deviation of 7.67572. The average rank was 0.00, and the sum of ranks was 0.00. In the post-test, the mean for this variable was 206.7500 with a standard deviation of 10.87428. The average rank was 2.50, and the sum of ranks was 10.00. Using the Wilcoxon test, the Z-value was 0.895 at a significance level of 0.000, indicating a statistically significant difference favoring the post-test measurement".

The mean for the total protein variable in the pre-test was 18.4250 with a standard deviation of 1.48857. The average rank was 0.00, and the sum of ranks was 0.00. In the post-test, the mean for this variable was 7.6250 with a standard deviation of 1.10868. The average rank was 2.50, and the sum of ranks was 10.00. Using the Wilcoxon test, the Z-value was 0.856 at a significance level of 0.000, indicating a statistically significant difference favoring the post-test measurement.

Presentation and analysis of the post-test results for both research groups in the bio-kinetic and bio-chemical variables, along with their discussion.

Table (4) shows the mean, standard deviation, average ranks, sum of ranks, Mann-Whitney U value, and statistical significance of the post-test measurements for both the first control group and the second experimental group in bio-kinetic and bio-chemical variables.

Variables	Statistical Indicators	Sample	Post-test Group 1	Post-test Group 2	Mean Rank	Sum of Ranks	U	Sig	Significance
Maximum Strength	Mean	4	34.2500	49.0000	2.63	10.50	0.500	0.029	Significant
	Standard Deviation	4	4.34933	6.97615	6.38	25.50			
Strength Endurance	Mean	4	44.1250	52.8750	2.75	11.00	1.000	0.043	Significant
	Standard Deviation	4	7.28440	2.52900	6.25	25.00			
Range of Motion: Wrist Flexion	Mean	4	71.7500	83.5000	2.50	10.00	0.324	0.020	Significant
	Standard Deviation	4	1.70783	9.11043	6.50	26.00			
Range of Motion: Wrist Extension	Mean	4	67.0000	68.0000	3.38	13.50	1.000	0.049	Significant
	Standard Deviation	4	2.58199	2.82843	5.63	22.50			
CPK Test	Mean	4	94.0000	193.5000	2.50	10.00	0.500	0.029	Significant
	Standard Deviation	4	1.41421	1.29099	6.50	26.00			
LDH Test	Mean	4	193.5000	206.7500	2.88	10.50	0.645	0.032	Significant
	Standard Deviation	4	5.44671	10.87428	6.13	24.50			
	Mean	4	9.2000	7.6250	6.25	25.00	1.500	0.042	Significant

Total Protein	Standard Deviation	4	0.79582	1.10868	2.75	11.00			

From our observation of Table (4), it is evident that the mean for Group 1 in the post-test for maximum strength in the post-test dimension was (34.2500) with a standard deviation of (4.34933). The mean rank was (2.63), with a sum of ranks of (10.50). In contrast, in the post-test for maximum strength in the post-test dimension for Group 2, the mean was (49.0000) with a standard deviation of (6.97615). The mean rank was (6.38) with a sum of ranks of (25.50). Using the non-parametric Mann-Whitney U test, the U value was (0.500) at a significance level of (0.029), indicating a statistically significant difference favoring the post-test dimension for Group 2.

we note from Table (4) that the mean for Group 1 in the post-test for endurance in the post-test dimension was (44.1250) with a standard deviation of (7.28440). The mean rank was (2.75) with a sum of ranks of (11.00). In the post-test for endurance in the post-test dimension for Group 2, the mean was (52.8750) with a standard deviation of (2.52900). The mean rank was (6.25) with a sum of ranks of (25.00). Using the Mann-Whitney U test, the U value was (1.000) at a significance level of (0.043), indicating a statistically significant difference favoring the post-test dimension for Group 2.

Furthermore, from Table (4), the mean for Group 1 in the post-test for kinetic range in downward wrist flexion in the post-test dimension was (71.7500) with a standard deviation of (1.70783). The mean rank was (2.50) with a sum of ranks of (10.00). In contrast, in the post-test for kinetic range in downward wrist flexion in the post-test dimension for Group 2, the mean was (83.5000) with a standard deviation of (9.11043). The mean rank was (6.50) with a sum of ranks of (26.00). Using the Mann-Whitney U test, the U value was (0.324) at a significance level of (0.020), indicating a statistically significant difference favoring the post-test dimension for Group 2.

Additionally, from Table (4), the mean for Group 1 in the post-test for kinetic range in upward wrist flexion in the post-test dimension was (67.0000) with a standard deviation of (2.58199). The mean rank was (3.38) with a sum of ranks of (13.50). In contrast, in the post-test for kinetic range in upward wrist flexion in the post-test dimension for Group 2, the mean was (68.0000) with a standard deviation of (2.82843). The mean rank was (5.63) with a sum of ranks of (22.50). Using the Mann-Whitney U test, the U value was (1.000) at a significance level of (0.049), indicating a statistically significant difference favoring the post-test dimension for Group 2

Group 1 in the post-test for LDH variable had a mean of (193.5000) with a standard deviation of (5.44671). The mean rank was (2.63), with a sum of ranks of (10.50). In contrast, Group 2 in the post-test for LDH variable had a mean of (206.7500) with a standard deviation of (10.87428). The mean rank was (2.88), with a sum of ranks of (10.50). The Mann-Whitney U test yielded a U value of (0.645) at a significance level of (0.032), indicating a statistically significant difference favoring the post-test dimension for Group 2.

In the post-test for total protein variable, Group 1 had a mean of (9.2000) with a standard deviation of (0.79582). The mean rank was (6.25), with a sum of ranks of (25.00). On the other hand, Group 2 in the post-test for total protein variable had a mean of (7.6250) with a standard deviation of (1.10868). The mean rank was (2.75), with a sum of ranks of (11.00). The Mann-Whitney U test yielded a U value of (1.500) at a significance level of (0.042), indicating a statistically significant difference favoring the post-test dimension for Group 2.

DISCUSSING AND ANALYZING THE RESULTS

Biomechanical Variables:

Upon reviewing Table 4, which presents the post-test measurements for the first research group that utilized rehabilitation exercises and the second control group that used rehabilitation exercises with the Cryo cooling device, it is evident that there are statistically significant differences in favor of the second group that used the Cryo cooling device along with rehabilitation exercises prepared by the researcher. Through the use of

appropriate tools and equipment such as elastic bands and medicine balls, there was a noticeable improvement in the research variables (maximum strength, endurance, and range of motion in wrist flexion and extension). These exercises also contributed to improving muscle tone, ligament strength, and tendon health, thereby enhancing the overall health of the participants. This aligns with the findings of Sameeha Khalil (2005), who stated that therapeutic exercises accompanied by therapeutic devices work to strengthen the muscles acting on the joint.

The exercises with the Cryo cooling device led to improvement and pain reduction, as well as increased joint mobility in the wrist joint. This was highlighted by Peter E. Baldry (2005), who mentioned that various physiotherapy interventions, including movement rehabilitation exercises, work to naturally alleviate pain and significantly impact joint pain reduction.

The researcher attributes this development to the fact that rehabilitation exercises with the Cryo cooling device led to a noticeable improvement in maximum strength. This is because rehabilitation exercises helped recruit multiple muscle fibers in the hand, as mentioned by Qasim Hassan (1988), who explained that maximum strength increases when the muscle fibers are fully stimulated or when the maximum number of necessary muscle fibers are recruited. Moreover, the researcher implemented rehabilitation exercises with the Cryo cooling device based on principles of sports training, gradually increasing intensity, which aligns with the findings of Mahnoud Al-Bashtawi and Ahmed Al-Khawja (2010), who emphasized the necessity of linking stretching exercises with strength exercises to ensure balanced musculoskeletal development and avoid one-sided development.

The researcher also believes that rehabilitation exercises with the Cryo cooling device contributed to physiological development in joint muscles and ligaments, reflecting positively on overall body flexibility, muscle strength, and wrist joint ligaments' endurance. This aligns with the views of Amer Rashid (1986), who stated that an individual's effectiveness in many activities depends on overall body flexibility or specific joint flexibility; individuals with higher flexibility exert less effort than those with lower flexibility. Samiha Riadh (1998) further supports this by stating that therapeutic interventions can help alleviate pain by increasing the number of endorphins and serotonin in the body, thereby reducing pain perception and enhancing the individual's quality of life.

The researcher attributes the improvement in variables such as flexibility, maximum strength, and endurance, as well as the biochemical variables, to the diversity of exercises regularly performed. These exercises also contributed to tissue and nerve relaxation around the joint, reducing pain sensation during joint movement, as emphasized by Montasser (2004), who noted that rehabilitation exercises are among the most important factors in pain relief and restoring specific motor skills.

Mackenzie R (1989) points out that exercises should be performed carefully to include levels that prevent pain, especially in the initial stage of performance.

The researcher believes that rehabilitation exercises with the Cryo cooling device led to stimulating a greater number of motor units by improving the functional work of the wrist joint and creating physiological adaptations. These adaptations result in an improvement in the type of muscle fibers involved in muscle contraction and the development of characteristics and synchronization of the relevant motor units. This is indicated by Komi, who stated that muscular adaptation requires more time, possibly extending to months or years depending on the quality and quantity of training. We observe an improvement in strength endurance under short-term conditions, but this increase is due to muscle coordination resulting from initial nerve adaptations by increasing the number of nerve impulses. Qadri Bakri (1996) emphasized that the muscle consists of a large number of motor units that sequentially alternate their work during muscle contraction to perform a specific task, as long as the stimulus to activate this muscle is continuous, the workload on the muscle tissue is distributed alternately.

Biochemical variables:

Through examining Table (5), it becomes evident that there are significant differences in the pre-test and post-test results in favor of the post-test in measuring the level of creatine phosphokinase (CPK) enzyme concentration. The presence of a high quantity of this enzyme in the blood indicates damage to one of these muscles. Enzymes for biochemical indicators have been relied upon as they are indicative of the improvement in damaged and impaired tissues among weightlifters during the units where rehabilitation exercises were applied to the injury. This was affirmed by Mindy Millard and others (1985), stating that CPK enzyme activity after training is influenced by several variables including chronological age, training age, gender, training intensity, and duration.

The researcher believes that rehabilitation exercises increase the strength of the muscle cell wall, reducing the leakage rate of CPK enzyme upon injury. This positively reflects on physical capability, as noted by Noask, stating that muscles adapt to reduce damage post-performance due to strength training and weightlifting exercises characterized by increased repetitions.

Elevated levels of lactate dehydrogenase (LDH) enzyme were due to muscle and ligament tears surrounding the joint. This resulted in an increase in acids and leaked proteins into the bloodstream, further stimulating the free nerve endings responsible for pain. As a natural response to improved metabolic processes in muscles, the capacity of muscles associated with the wrist joint in consumption and ATP energy production increased, leading to the enzyme not being released into the serum, causing the improvement brought about by rehabilitation exercises with the Cryo cooling device. High concentrations of LDH enzyme and changes in LDH isoenzyme ratios indicate a form of tissue damage, with LDH concentrations rising typically when cellular breakdown begins.

The exercises prepared by the researcher with the Cryo cooling device improved joint functionality, aligning with injury and rehabilitation principles tailored to the patient's capabilities by regulating rest times and using optimal repetitions. This resulted in positive changes in total protein, as indicated by Bahaa Ibrahim Salama (2018), where positive changes achieve physiological adaptation of body systems.

CONCLUSION

The researcher concludes that rehabilitation exercises prepared by using Cryo cooling devices have a positive impact on rehabilitating wrist tunnel syndrome injuries among weightlifting athletes. The researcher also concludes that rehabilitation exercises prepared using Cryo cooling devices have a positive effect on improving biomechanical variables among weightlifting athletes. Furthermore, the researcher concludes that rehabilitation exercises prepared using Cryo cooling devices have a positive impact on improving biochemical variables among weightlifting athletes. Based on the results, it is evident that a duration of 6 weeks for both groups is suitable for achieving optimal recovery from injury and developing biomechanical and some biochemical variables among the players.

RECOMMENDATIONS

The researcher recommends the use of rehabilitation exercises with Cryo cooling devices in rehabilitating wrist tunnel syndrome injuries among weightlifting athletes. Regular screening of body devices and joints is recommended to prevent injury. Athletes are advised to avoid excessive strain to prevent sudden injuries to the wrist joint. The researcher recommends the use of physical therapy devices due to their importance in improving injury and reducing pain, which contributes to the athlete's return from injury to a normal state.

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