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# The Influence of Exercises Augmented by Electric Stimulation on Pain Levels and Muscle Strength in Rehabilitating Patients with Carpal Tunnel Syndrome

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**Abstract**

The research aims to prepare rehabilitative exercises accompanied by electrical stimulation and to investigate the effect of these proposed exercises on patients with Carpal Tunnel Syndrome at Al-Yarmouk Teaching Hospital. Arm injuries are among the most common due to incorrect habits in using devices and tools, especially in our present time. In the era of technology, using equipment and tools for extended periods and in incorrect postures burdens neuromuscular function. It is manifested in activities that require repetitive elbow flexion and finger movements. One of these injuries is carpal tunnel syndrome, which occurs due to irritation of the median nerve, resulting in numbness and tingling sensations in the hand and fingers. Since the median nerve is close to the surface of the skin at the elbow, the use of appropriate therapeutic methods that save time and effort to achieve a state of recovery is crucial. It involves considering important pillars. Additionally, selecting diverse and varied exercises and tools is essential to achieve better treatment outcomes. From this, the researchers opted to use rehabilitative exercises with the aid of tools, in addition to other therapeutic methods that include electrical stimulation to reduce pain levels and increase muscular strength in patients with carpal tunnel syndrome. The researchers hypothesized that there would be statistically significant differences between the pre-test and post-test results, indicated by the degree of pain and muscular strength in those afflicted with carpal tunnel syndrome. The researchers employed an experimental methodology involving a pretest-posttest comparison between the experimental and control groups due to its suitability for the nature of the research. The participants were divided into two groups. Both groups underwent pretests, followed by the application of rehabilitative exercises to the experimental group only. Subsequently, both the experimental and control groups were assessed using post-tests. The research population and sample were deliberately selected from the patients at Al-Yarmouk Teaching Hospital, who are affected by Carpal Tunnel Syndrome and represent the research population. After several visits and reviews conducted by the researchers at Al-Yarmouk Teaching Hospital, several patients who were diagnosed with Carpal Tunnel Syndrome and classified as having a moderate level of severity were identified and approached for participation. They were informed about the research and its purpose, as they would form the research sample. A subset of this sample would undergo the proposed rehabilitative exercises as prescribed by the physical therapist in the hospital's Physical Therapy Department. The researchers concluded that the utilized program had a positive impact on all variables. It led to an increase in muscle strength and a reduction in pain for the research sample. and this achieves one of the sustainable development goals of the United Nations in Iraq which is (Good Health). The researchers recommend the importance of continued engagement in strength and flexibility exercises to maintain overall health

**Keywords** | **Rehabilitative exercises, Carpal Tunnel Syndrome**

## Introduction:

Physical activity is considered a necessity of life, especially with the advancements in all fields. Today, individuals lead a routine life where specific ailments and pains have become more prevalent within society. These conditions, tied to the daily strain of tasks that people undertake, are accompanied by a diminished inclination towards engaging in physical activities. The statistics have indicated that joint diseases and stiffness, notably joint pain,

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registered in health institutions, are primarily due to a lack of physical fitness. It is worth noting that the Arab Scholar Ibn Sina recommended that humans engage in the movement to maintain health. Likewise, the French physician André Simeon emphasized that motion can replace any therapeutic means, but no treatment can replace movement. It underscores the individual's need to engage in sports activities. They are not merely optional but have become a vital necessity. Thus, there is a consensus among institutions and individuals about the positive outcomes of practicing sports. The primary objectives of physical education are to enable an individual to attain overall health and the ability to be productive through physical fitness. This aspect facilitates maintaining a high level of performance over the course of work, contributing to an individual's holistic development and well-being. Its direct impact on functional systems and physical enhancement allows for the development of muscle tissue by increasing its thickness and strength. Furthermore, it aids in engaging in physical activities with minimal effort. To enhance the individual's physical fitness components and consequently improve the functional capacity of the affected body systems, the individual requires participation in well-structured rehabilitation programs. These programs are tailored based on the individual's condition or the specific area of concern that requires treatment. The level of progress in these programs is customized to align with the individual's condition, ensuring a comprehensive and effective approach to rehabilitation. The researchers opted to utilize a rehabilitative program encompassing specific exercises that play a vital and significant role in enhancing muscle strength, alleviating pain, and preserving joint flexibility. These exercises aid individuals in moving their joints in a balanced and correct manner. The challenge emerged from the researchers' review of numerous physical therapy centers and hospitals as well as their examination of the incidence of carpal tunnel syndrome and the timeframes employed in treatment. After consultation with medical specialists and therapists and after investigating the types of treatments used, from exercises to other methods, the researchers concluded that the aim is to reduce time and effort. They emphasized the principle of change, variety, and diversity in exercises in terms of repetitions, numbers, rest periods, and intensity. Moreover, they implemented unique diagnostic techniques to enhance patient outcomes and facilitate their path to recovery. This topic has initially received conditional acceptance under the supervision of doctors and therapists in terms of diagnosis and implementation of the program proposed by the researchers. It is a comprehensive guide to scientific research in physical education sciences, specifically focused on rehabilitating injuries. The study aims to develop a set of rehabilitative exercises that effectively enhance muscle strength and alleviate pain in individuals with carpal tunnel syndrome. It also seeks to identify the differences between the pre-test and post-test for both the experimental and control groups, and recognizing differences in post-tests between the experimental and control groups requires the research to suggest that there are statistically significant differences between the pre-test and post-test for both the experimental and control groups. The study highlights statistically significant differences in the post-test evaluations between the experimental and control groups. The scope of the research falls within the human domain: individuals with carpal tunnel syndrome at Al-Yarmouk Teaching Hospital. The temporal scope is from

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15/11/ 2022 to 15/02/2023, and the spatial domain is Al-Yarmouk Teaching Hospital.

**Method and Procedures:**

The researchers employed an experimental approach due to its suitability for the nature of the study. The research population was defined within Al-Yarmouk Teaching Hospital, consisting of (8) individuals with carpal tunnel syndrome. The research sample, comprising (8) patients, was selected using purposive sampling. Thus, the sample size represents (100%) of the population. The researchers employed a design involving experimental and control groups. The afflicted individuals were divided into two groups. Both groups underwent pre-tests, after which rehabilitative exercises were applied only to the experimental group. Subsequently, both the experimental and control groups were assessed using post-tests. The researchers employed various tools, devices, information collection methods, scientific references, international information networks, and personal interviews. Through this process, questions were posed and answered, allowing for the identification of rehabilitative exercises and tests for the affected individuals. Observation, tests, and measurements related to muscle strength and pain levels were carried out. The researchers designed a questionnaire to gather expert opinions on relevant tests. The researchers presented these tests through a questionnaire to specialists in the fields of physical education, sports science, and physical therapy. It was done to determine the tests needed for the sample of patients. One of these tests included grip strength assessment using a dynamometer, which features a calibrated scale aimed at determining the maximum grip strength. Each participant performed two attempts, and the best result was recorded in kilograms. The other test measures the pain level using the visual analogue scale (VAS), where the patient is shown a sheet divided into ten squares numbered from (1 to 10), starting from the left to the right. The patient is asked to determine the degree of pain they feel while moving the injured part in the specified position. To ensure accuracy, we consulted experts to determine the most critical tests. After conducting the tests, we organized them into a format and submitted them to the experts for their evaluation. After identifying the most crucial tests, the researchers calculated the percentage for all variables, as shown in Table (1). They also calculated the percentage of tests as illustrated in Table (1). It means that (3) experts out of (5) agreed, thus accepting the tests shown in the table below.

**Table (1)**
**It illustrates the endorsed percentages of expert opinions regarding the validity of the tests.**

| Seq. | Selected Tests | Purpose of the Test | Number of Consensual Opinions | Percentage |
|---|---|---|---|---|
| 1 | Muscle strength test | Measurement of Muscle Strength | 5 | %100 |
| 2 | Pain level test using the visual analogy | Measurement of Pain Intensity | 3 | %60 |

**Scientific Foundations for Tests**

**Test Validity:**

A test is considered valid when it measures the hypothesis for which it was designed. This characteristic is one of the most significant features that a test should possess. Hence, the researchers ensured the test's validity by using content and construct validity. It was achieved by relying on the suggestions and feedback of experts and specialists. The researchers also utilized discriminant validity. They applied the test to a group of patients at Al-Yarmouk Teaching Hospital and another group of patients

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at the same hospital later, and the selection of the patients was done intentionally. The sample selection was intentional., consisting of (8) follows: -

individuals. The results were analyzed using the (t-test) for unrelated equal data, and the findings were as

**Table (2)**
**It displays the arithmetic means, standard deviations, calculated T-values, and tabulated values for both pre-test and post-test for the experimental and control groups to test for equivalence.**

| Variables | Experimental group | | Control group | | Calculated (t) value | Statistical significance |
|---|---|---|---|---|---|---|
| | Arithmetic mean | Standard deviations | Arithmetic mean | Standard deviations | | |
| Anterior muscular strength test. | 9,14 | 1,177 | 9,28 | 1,421 | 0,185 | Non-significant |
| Posterior muscular strength test. | 8,12 | 1,540 | 8,68 | 1,275 | 0,686 | Non-significant |
| Lateral muscular strength test. | 7,57 | 0,505 | 7,32 | 0,684 | 0,722 | Non-significant |
| Pain Level during lateral elevation. | 5,42 | 1,988 | 5 | 2,309 | 0,337 | Non-significant |
| Pain Level during external rotation. | 3,71 | 1,704 | 4,07 | 1,397 | 0,400 | Non-significant |
| Pain Level during internal rotation. | 4,71 | 2,288 | 3,72 | 1,112 | 0,953 | Non-significant |

## Test Reliability:

Test reliability refers to the consistency or reliability of test scores over-reapplied to the same individuals under similar conditions. In other words, if the same test is administered to the same group of individuals at different times, it should yield similar or closely related results, provided that the testing conditions remain consistent.

In this study, the researchers assessed the reliability of the tests using the test-retest method with a time interval of (6) days. The initial tests were conducted on Tuesday, 3-1-2023, and then repeated for the second time on Sunday, 8-1-2023. By calculating Pearson's correlation coefficient, the conducted tests showed high reliability. See Table (3) for analysis results.

**Table (3)**
**shows the reliability and objectivity coefficients of the selected tests**

| Seq. | Tests | Reliability Coefficient | Objectivity coefficients |
|---|---|---|---|
| 1 | Muscle Strength Test | 0.95 | 0.89 |
| 3 | Visual Analogue Scale for Pain Level | 0.96 | 0.95 |

## Test Objectivity

To verify the objectivity of the proposed tests for an application, the researchers sought the assistance of two evaluators. The objectivity of a test can be determined by the correlation between the scores given by two evaluators who assess the same group of individuals simultaneously. Subsequently, the results are statistically analyzed by finding the simple correlation coefficient between the scores. The findings revealed a strong correlation between the scores of the first and second evaluators, indicating the objectivity of the tests, as shown in Table No. (5).

## Rehabilitation Program

The duration of the rehabilitation program is (8) weeks.
The total number of rehabilitation units is (24), with three units per week.
Rehabilitation days are Sunday, Tuesday, and Thursday.
The program duration for exercises is (10-20) minutes.

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The program duration for using the device is (10-20) minutes.

**Results:**

**Table(4)**
**It shows the arithmetic means, standard deviations, and the calculated t-values between the pre-test and post-test for the control group in the variables under study.**

| Variables | Pre-test | | Post-test | | AMD | SDD | Calculated (t) value | Statistical significance |
|---|---|---|---|---|---|---|---|---|
| | Arithmetic mean | Standard deviations | Arithmetic mean | Standard deviations | | | | |
| Anterior muscular strength test. | 9,28 | 1,421 | 8,71 | 0,581 | 0,57 | 1,874 | 0,805 | Non-significant |
| Posterior muscular strength test. | 8,68 | 1,275 | 8,96 | 0,734 | 0,28 | 1,123 | 0,660 | Non-significant |
| Lateral muscular strength test. | 7,32 | 0,684 | 7,44 | 1,397 | 0,12 | 1,146 | 0,277 | Non-significant |
| Pain Level during lateral elevation. | 5 | 2,309 | 4,72 | 0,360 | 0,28 | 1,217 | 0,608 | Non-significant |
| Pain Level during external rotation. | 4,07 | 1,397 | 4 | 1,290 | 0,07 | 1,328 | 0,139 | Non-significant |
| Pain Level during internal rotation. | 3,72 | 1,112 | 3,57 | 0,333 | 0,15 | 1,095 | 0,363 | Non-significant |

**Table(5)**
**It shows the arithmetic means, standard deviations, and the calculated t-values between the pre-test and post-test for the experimental group in the variables under study.**

| Variables | Pre-test | | Post-test | | AMD | SDD | Calculated (t) value | Statistical significance |
|---|---|---|---|---|---|---|---|---|
| | Arithmetic mean | Standard deviations | Arithmetic mean | Standard deviations | | | | |
| Anterior muscular strength test. | 9,14 | 1,177 | 12 | 0,974 | 2,86 | 1,084 | 6,992 | Significant |
| Posterior muscular strength test. | 8,12 | 1,540 | 11,87 | 0,413 | 3,75 | 1,268 | 7,828 | Significant |
| Lateral muscular strength test. | 7,57 | 0,505 | 11 | 1,602 | 43’3 | 0,985 | 9,220 | Significant |
| Pain Level during lateral elevation. | 5,42 | 1,988 | 1,71 | 1,112 | 3,71 | 1,218 | 8,065 | Significant |
| Pain Level during external rotation. | 3,71 | 1,704 | 1,33 | 0,577 | 2,38 | 0,994 | 6,346 | Significant |
| Pain Level during internal rotation. | 4,71 | 3,288 | 2,16 | 0,602 | 2,55 | 1,213 | 5,567 | Significant |

**Table (6)**
**It shows the arithmetic means, standard deviations, and the calculated t-values between the post-tests for the experimental and control groups in the variables under study.**

| Variables | Experimental group | | Control group | | Calculated (t) value | Statistical significance |
|---|---|---|---|---|---|---|
| | Arithmetic mean | Standard deviations | Arithmetic mean | Standard deviations | | |
| Anterior muscular strength test. | 12 | 0,974 | 8,71 | 0,581 | 7,121 | Significant |

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| | | | | | | |
|---|---|---|---|---|---|---|
| Posterior muscular strength test. | 11,87 | 0,413 | 8,96 | 0,734 | 8,483 | Significant |
| Lateral muscular strength test. | 11 | 1,602 | 7,44 | 1,397 | 4,106 | Significant |
| Pain Level during lateral elevation. | 1,71 | 1,112 | 4,72 | 0,360 | 6,323 | Significant |
| Pain Level during external rotation. | 1,33 | 0,577 | 4 | 1,290 | 4,635 | Significant |
| Pain Level during internal rotation. | 2,16 | 0,602 | 3,57 | 0,333 | 5,035 | Significant |

## Discussion:

### Discussing the Results of the Muscle Strength Test:

From the results shown in the table above, it is evident that there are significant differences between the pre-test and post-test for the muscle strength variable (frontal, posterior, lateral) for the research sample. The researchers attribute these differences to the rehabilitation curriculum followed by the sample members, which helped in enhancing muscle strength. This improvement is due to their adherence to all the details of the program and their commitment to attending its rehabilitation units. Also, the exercises designed to improve muscle strength with regular and graduated repetitions and rest times between repetitions and between sets contributed to this improvement and the development of muscle strength in the injured shoulder, and the duration of the rehabilitation program applied to the sample of the study led to the acquisition of strength for the muscle groups. It was confirmed by Jamal Sabri, who stated that "to achieve significant gains in muscular strength, the training duration should not be less than eight weeks" (8). As mentioned by (Zuhad and Mawahib), "the repetitions in performing each exercise led to the development of strength, and one of the main methods for strength development lies in the number of repetitions of the exercises or sets and gradually reducing the rest period" (14).

the variety of exercises used in the rehabilitation curriculum prepared by the two researchers helped in improving this characteristic, this was mentioned by Raad Jabir where he said “The muscular applications of exercises depend on the type of training used, which gives them strength that is reflected in their development” (11). Also Riham and Abeer see in their study that (There are basic goals of rehabilitation, the most important of which are reducing the degree of pain, improving the level of muscle strength, and restoring the range of motion of the joint) (12) Furthermore, the effectiveness of these exercises contributed to the development of rapid muscle response, reflecting the good coordination within the muscle through recruiting motor units for muscular work, as indicated by Abu El-Ela Ahmed Abdel-Fattah, "the participation of motor units and the timing of their operation; the more units involved in the contraction, the higher the level of muscle strength" (5). Both Huda and Riam pointed out in their study (that exercises given according to modern scientific principles and programs contribute significantly to improving muscular strength, as muscular strength is the force or tension that a muscle or group of muscles can produce against resistance in its maximum voluntary contraction) (6). The researchers emphasize that there are numerous and diverse benefits to muscular strength. Therefore, it is essential to maintain and restore it to its pre-injury state. It can be achieved through regular engagement in strength training exercises, which effectively enhance muscular strength, muscle tone, and ligament strength and subsequently increase tendon and joint force. According to Jamal Sabri, "developing muscular strength improves health by stabilizing muscles and joints, making the body better equipped to handle emergencies" (8). The two researchers attribute the cause of these differences to the components of the rehabilitation program applied to the sample, which played a role in developing

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muscular strength. "Muscular strength serves as the foundation for acquiring other physical attributes" (2). Duaa confirmed in her study that "there are numerous and diverse benefits to muscular strength that must be maintained and restored to its pre-injury state through engagement in strength training exercises" (4). The observed improvement resulted from electrical stimulation. (Alaa and Adnan) also pointed out that "electrical stimulation enhances neuromuscular transmission and increases the stimulation of existing motor units, leading to enhanced muscular strength and effectiveness" (3).

**Discussion of visual analogue Results:**

Upon observing the tables above, we note that there are differences between the pre-test and post-test for the variable of visual analogue in cases of (lateral elevation, external rotation, and internal rotation), favoring the post-test for the research sample. The researchers attribute this improvement to the effectiveness of the rehabilitation program they developed as well as the diversity of exercises used in the program. Upon reviewing the preceding tables and subsequently their discussions, we observe that the achieved improvement in muscular strength contributed to alleviating the pain experienced by the participants, as evidenced by the results of the visual analogue. It is affirmed by McKenzie, who stated "Exercises should be performed carefully to include the level that prevents pain, especially in the initial stage of performance" (9). Rana and Warda affirmed that the reason behind these differences (can be attributed to the therapeutic interventions as well as the progressively graded therapeutic exercises in the rehabilitation program that had the most significant impact in increasing muscular strength and reducing pain levels, alleviating spasms and stiffness. Consequently, pain scores for the participants decreased compared to their previous levels) (7). The researchers believe that effective use of progressive rehabilitation exercises contributed to rehabilitating the sciatic nerve. These exercises increased blood flow to the affected area, removing waste and debris, reducing pressure and alleviating pain. It is affirmed by Abbas Hussein, who stated that "performing therapeutic exercises improves blood circulation, enhancing the delivery of blood to organs and the musculoskeletal system regularly. It helps increase the nutrient supply to compensate for deficiencies caused by the injury, thereby compensating for the damaged tissue" (1). Athraa and Suad pointed out that a decrease in pain intensity serves as an indicator of recovery. As pain intensity decreases, the affected individual becomes able to perform near-normal medial movements. On the other hand, if there is pain, it may indicate an underlying problem because it can affect the way muscle's function. Pain can also be a sign of potential damage (10). Additionally, Ruaa and Abeer emphasized that structured rehabilitation exercises are a fundamental component in most sports activities. These exercises improve both the nervous and muscular systems and body coordination. Moreover, they contribute to reducing pain levels (13).

**Conclusions:**

1. The program prepared by the two researchers, which was used, had a positive effect on all variables. It led to an increase in the muscular strength of the research sample.
2. The program also affected muscle and joint flexibility. The rehabilitation exercises helped in improving flexibility. There were significant differences in pain levels between the pre-test and post-test.

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**Recommendations:**

1. The researchers have developed a rehabilitation program that physical therapy centers should implement.
2. It is essential to continue performing strength and flexibility exercises to maintain overall health.
3. Emphasis on using all the contents of the program to ensure its success.

**Author's declaration:**

**Conflicts of interest**: None

We confirm that all tables and figures in this article are ours and written by the researchers themselves.

**Ethical-Clearance**: this manuscript approved by local ethical committee of physical education and sport sciences college for women on (April /2023)

**Author's contributions:**

All contributions of this study were done by the researchers (A.M. and N.A.) who get the main idea and work on writing and concluding also with number of experts, Usama Ahmed in Statistics, Huda Shihab in revision, Inaam Ghalib in translating, Mazin Hadi in proofreading

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# تأثير تمرينات بمصاحبة التحفيز الكهربائي بدلالة درجة الألم والقوة العضلية في تأهيل المصابين بمتلازمة العصب الزندي

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**2&1 جامعة بغداد/ كلية التربية البدنية و علوم الرياضة للبنات**

**مستخلص البحث**

يهدف البحث الى اعداد تمرينات تأهيلية بمصاحبة التحفيز الكهربائي والتعرف على تأثير هذه التمرينات المقترحة على المصابين بمتلازمة العصب الزندي في مستشفى اليرموك التعليمي، حيث تعد اصابات الذراعين من اكثر الاصابات حدوثاً نتيجة للعادات الغير صحيحة في استخدام الاجهزة والادوات ولاسيما في وقتنا الحاضر وفي عصر التكنولوجيا باستخدام اجهزة وادوات ولفترات زمنية طويلة وبأوضاع حركية خاطئة من حيث تسببها بعباءً على العمل العضلي العصبي متمثلة بالأنشطة التي تتطلب ثني المرفق بشكل متكرر وحركات الاصابع ومن هذه الاصابات اصابة متلازمة العصب الزندي والتي تحدث نتيجة تهيج العصب الزندي مما يجعل اليد والاصابع في حالة خدر ووخز حيث يعد من الاعصاب القريبة الى سطح جلد المرفق لذا فأن استخدام الوسائل العلاجية المناسبة والتي تختصر الوقت والجهد للوصول الى حالة الشفاء من الركائز المهمة الي يجب الاخذ بها بالإضافة الى اختيار كل ما هو متنوع ومختلف من تمارين وادوات للوصول الى نتائج افضل في العلاج ومن هنا ارتأت الباحثتان استخدام تمرينات تأهيلية بمساعدة أدوات بالإضافة الى استخدام وسائل علاجية اخرى تتضمن التحفيز الكهربائي لتقليل درجة الألم وزيادة القوة العضلية للمصابين بمتلازمة العصب الزندي وافترضت الباحثتان هناك فروق ذات دلالة إحصائية بين نتائج الاختبار القبلي والبعدي بدلالة درجة الألم والقوة العضلية للمصابين بمتلازمة العصب الزندي واستخدمت الباحثتان المنهج التجريبي بعمل مقارنة بين الاختبار القبلي والبعدي بين مجموعتي البحث التجريبية والضابطة نظرا" لملائمة المنهج التجريبي لطبيعة البحث. حيث تم تقسيم المصابين الى مجموعتين، تؤدي المجموعتين الاختبارات القبلية ثم يتم تطبيق التمرينات التأهيلية على المجموعة التجريبية فقط. بعدها يتم اختبار المجموعتين التجريبية والضابطة بالاختبار البعدي. وتم تحديد مجتمع البحث وعينته بالطريقة العمدية وهم المصابين في مستشفى اليرموك التعليمي وهم يمثلون مجتمع البحث نفسه. وبعد عدة مراجعات قامت بها الباحثتان لمستشفى اليرموك التعليمي وتثبيت عدد المراجعين الذين دخلوا اليها لأصابتهم بمتلازمة العصب الزندي وتحديد الدرجة المتوسطة وجمعهم والتوضيح لهم كونهم سيكونون عينة البحث وقسم منهم سيطبق التمرينات التأهيلية المقترحة من قبل اخصائي العلاج الطبيعي في شعبة العلاج الطبيعي في المستشفى واستنتجت الباحثتان ان البرنامج الذي تم استخدامه اثر تأثيراً ايجابياً في المتغيرات كافة حيث أدى الى زيادة القوة العضلية وتخفيف درجة الألم لعينة البحث، وهذا ما يحقق احد اهداف التنمية المستدامة للامم المتحدة في العراق (الصحة الجيدة). وتوصي الباحثتان ضرورة الاستمرار في أداء تمرينات القوة والمرونة للمحافظة على الصحة العامة

**الكلمات المفتاحية** | **تمرينات تأهيلية، العصب الزندي**