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REHABILITATION OF LUMBAR SPINAL DEVIATIONS USING AQUATIC EXERCISES: A STUDY ON STUDENTS OF THE TECHNICAL INSTITUTE IN AL-DIWANIYAH GOVERNORATE

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ABSTRACT

This study investigates the effectiveness of aquatic exercises in rehabilitating lumbar spinal deviations among students at the Technical Institute in Al-Diwaniyah Governorate. Lumbar spinal deviations, such as lordosis, kyphosis, and scoliosis, are prevalent conditions affecting the student population, often leading to musculoskeletal issues and reduced quality of life. The research employs a structured aquatic exercise program designed to address these deviations, utilizing the buoyancy and resistance properties of water. The study involves a sample of students with diagnosed lumbar spinal deviations who participate in a supervised aquatic exercise intervention over a specified period. Pre- and post-intervention assessments include clinical evaluations, imaging studies, and subjective reports from participants. The research aims to measure the impact of aquatic exercises on spinal alignment, muscle strength, and overall functional improvement. Preliminary findings suggest that aquatic exercises contribute positively to the rehabilitation of lumbar spinal deviations, offering a low-impact and supportive environment for targeted exercises. The outcomes of this study hold significance for designing comprehensive rehabilitation programs in educational settings, emphasizing the potential of aquatic exercises as a valuable therapeutic modality for addressing lumbar spinal deviations and promoting overall musculoskeletal health in student populations.

Keywords: Rehabilitation of deviation, spinal region, spinal column, aquatic exercises.

INTRODUCTION

Importance of the Research

The interest in health aspects stems from the fact that humans are the ultimate goal of life. All countries that have developed economically, industrially, and socially have directed their attention towards caring for individuals and their health. These countries have harnessed all their resources in various fields, sciences, and knowledge to serve the people. The different growth stages that individuals go through face factors that affect their ability to maintain a good physique and a healthy appearance. This, in turn, leads to deviations that distort their appearance and hinder their productivity, especially the spinal region, which is influenced by various factors including genetic, health-related, and psychological factors, especially shyness resulting from changes in body measurements and functions. Therefore, it is necessary to focus on sports activities that help maintain body shape and its organs in a healthy manner. The alignment of the body and its freedom from physical deformities are closely related to the health of the respiratory and circulatory systems, as they exert pressure on the diaphragm. The importance of this lies in developing a rehabilitation program for spinal deformities

through the use of a set of aquatic exercises for students at the Technical Institute in Diwaniya. This involves identifying the causes of these deformities through clinical and laboratory examinations, assessing their impact on the body and physique, and finding appropriate solutions before these deviations worsen and require surgical intervention. The main problem of the research is spinal deformities, particularly spinal deviation in students due to incorrect walking and the loads carried by individuals such as school bags or work-related activities. The research aims to develop a rehabilitation program that includes aquatic exercises to rehabilitate spinal deviations in students and to understand the impact of aquatic exercises on the angle of spinal deviation.

Research Fields:

1. Human Field: Students at the Technical Institute suffering from spinal column deviations
2. Time Field: Extended period from 15/1/2023 to 13/8/2023
3. Spatial Field: The sports hall at the institute, the Italian swimming pool, and physiotherapy centers in the Diwaniya Governorate.

Methodology of the research and its field courage

Research Methodology

The nature of the research requires knowledge of the impact (specific), so the researcher used the experimental method with a design (two equivalent groups) (first experimental group and second experimental group) as shown below.

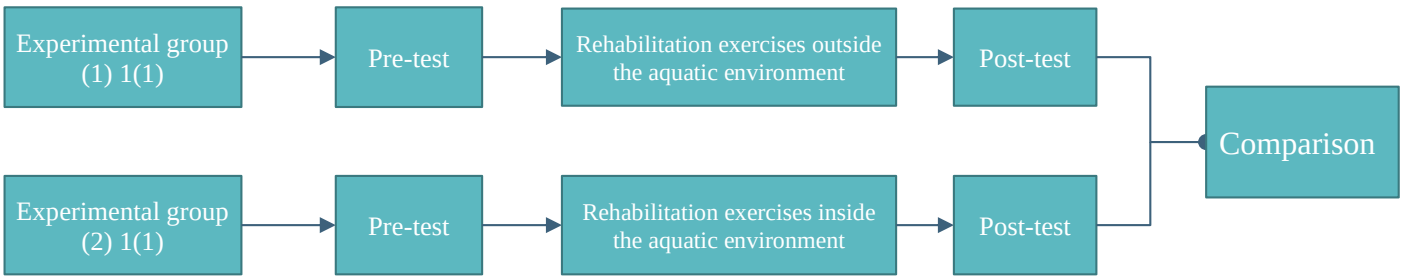


Figure (1) The experimental design of the research.

Research Sample:

The researcher identified the research sample, consisting of students suffering from spinal deviation due to incorrect sitting posture or improper lifting of objects or functional issues only, not those affected by permanent or hereditary deformities. To obtain the sample, the researcher obtained (6) affected individuals, and randomly divided the sample into two experimental groups, with each group consisting of (3) affected individuals. The first group was rehabilitated through water exercises outside the aquatic environment, while the affected individuals in the second group were rehabilitated through qualifying exercises within the aquatic environment. The researcher then conducted homogeneity and equivalence tests as shown in Tables (1) and (2).

Table (1) shows the homogeneity of the research sample.

Variables	Experimental Mean 1		Experimental Mean 2		Levene's Test Value	Significance Level	Statistical Significance
	Mean	SD	Mean	SD			
Forward Body Flexion	7.167	0.764	6.733	0.252	3.141	0.151	Homogeneous
Backward Body Flexion	24.167	0.764	21.667	1.528	1.538	0.283	Homogeneous
Right Body Tilt	156.633	1.305	157.667	1.528	0.128	0.739	Homogeneous
Left Body Tilt	144.067	1.007	145.333	4.509	2.847	0.167	Homogeneous
Deviation Angle	44.667	4.509	48.667	1.528	1.906	0.240	Homogeneous
Force Sensing Right Muscles	77.167	0.764	77.567	0.404	1.346	0.311	Homogeneous
Force Sensing Left Muscles	75.267	0.702	76.667	1.756	1.651	0.268	Homogeneous

We notice from Table (1) that all significance levels are greater than (0.05), indicating no differences among the sample individuals and thus implying homogeneity of variances for all tests.

Table (2) shows the equality of the two research groups.

Variables	Experimental Mean 1		Experimental Mean 2		Levene's Test Value	Significance Level	Statistical Significance
	Mean	SD	Mean	SD			
Forward Body Flexion	7.167	0.764	6.733	0.252	0.933	0.403	Not Significant
Backward Body Flexion	24.167	0.764	21.667	1.528	2.535	0.064	Not Significant
Right Body Tilt	156.633	1.305	157.667	1.528	0.891	0.423	Not Significant
Left Body Tilt	144.067	1.007	145.333	4.509	0.475	0.660	Not Significant
Deviation Angle	44.667	4.509	48.667	1.528	1.455	0.219	Not Significant
Force Sensing Right Muscles	77.167	0.764	77.567	0.404	0.802	0.468	Not Significant
Force Sensing Left Muscles	75.267	0.702	76.667	1.756	1.282	0.269	Not Significant

The table (2) shows that all significance levels are greater than (0.05), indicating no differences between the two experimental groups and thus their equivalence in all tests.

Devices, Tools, and Data Collection Methods:

Data Collection Methods:

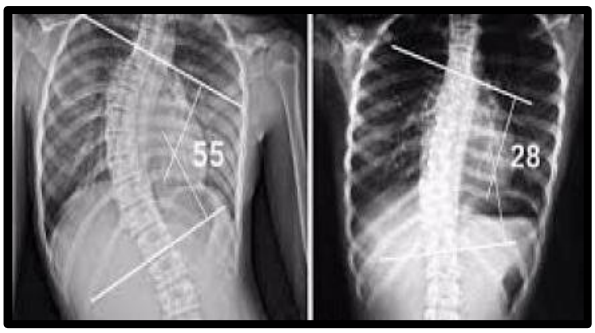
1. Personal interviews.
2. Tests and measurements.
3. Internet network.
4. Arabic and foreign sources.
5. Registration form.

Tools and Devices Used in the Research:

1. Measuring tape.
2. Elastic bands.
3. Various weights.
4. Medical rubber balls.
5. Plastic cushions.
6. Wooden box.
7. Goniometer device for determining spinal column movement angles.
8. X-Ray device to determine the degree of deviation.
9. Medical scale.
10. DELL laptop.

Injury Diagnosis:

The injury was diagnosed by a specialist doctor through clinical examination and Magnetic Resonance Angiography (MRA) and X-Ray imaging, where the deviation (scoliosis) in the lateral muscles of the spinal column in the area between the thoracic and lumbar regions was determined to be of a simple first-degree nature as shown below.



Identifying research variables.

1. Measurement of spinal deviation degree.
2. Measurement of muscular strength of the spinal muscles in the deviation area, both right and left sides.
3. Measurement of spinal range of motion (forward bending, backward bending, right lateral bending, left lateral bending).

Description of the tests used in the research:

Firstly, Measurement of spinal deviation degree.

- Objective of the measurement: To determine the extent of deviation in the spine.
- Tools used: X-ray.

- Test description: The patient is examined in a specialized clinic by a doctor using an X-ray machine to determine the degree of deviation.

Secondly, Range of motion test for the spine (forward bending, backward bending, right lateral bending, left lateral bending).

1. Measurement of spinal range of motion for forward bending.

- Tools used: Numbered wooden box (1 to 20 degrees).
- Performance description: The patient sits on the ground with legs extended forward, touching the box. The examiner bends the trunk forward while extending the hands towards the markings on the box (1 to 20 cm).
- Recording the degree: By measuring the numbered distance reached by the examiner's fingertips.

2. Measurement of spinal range of motion for backward bending.

- Tool used for measurement: Measuring tape.
- Performance description: The patient lies on the stomach with hands placed under the thighs and legs held by a colleague. Upon signal, the examiner raises the trunk upwards while keeping it stable. The distance between the lower end of the chin and the ground is measured using the measuring tape.
- Recording the degree: The distance in centimeters between the chin and the ground is calculated.

3. Measurement of spinal range of motion for right lateral bending.

- Tool used for measurement: Goniometer.
- Performance description: The examiner stands straight with hands by the sides of the body. The goniometer is placed on the lumbar spine region, with both ends fully extended (180 degrees). After instructing the examiner to bend the body to the right while maintaining a straight position, the lower end of the goniometer is fixed, and the upper end is moved along with the examiner's lateral bending.
- Recording the degree: The angle shown on the goniometer is calculated.

4. Measurement of spinal range of motion for left lateral bending.

- Tool used for measurement: Goniometer.
- Performance description: The examiner stands straight with hands by the sides of the body. The goniometer is placed on the lumbar spine region, with both ends fully extended (180 degrees). After instructing the examiner to bend the body to the left while maintaining a straight position, the lower end of the goniometer is fixed, and the upper end is moved along with the examiner's lateral bending.
- Recording the degree: The angle shown on the goniometer is calculated.

Main experiment

Pre-test

The researcher conducted pre-tests for the research sample during the period from February 17, 2023, which was the date of the first patient, to March 9, 2023, which was the date of the pre-test for the last patient. The first day involved measuring the deviation angle by the specialized doctor using X-rays (COBB ANGEL), and on the second day, the range of motion

of the trunk (right lateral bending and left lateral bending) was measured using a goniometer. Muscle strength was measured using a force sensor.

Rehabilitation program

The rehabilitation exercises were implemented from Saturday, February 25, 2023, to Sunday, June 19, 2023. The researcher included the following elements in the rehabilitation exercises:

- The application of the rehabilitation program lasted for 12 weeks, with three rehabilitation sessions per week.
- The research sample was divided into two experimental groups. The first group consisted of three patients who were rehabilitated through exercises outside the aquatic environment, while the second group consisted of three patients who were rehabilitated through exercises in the aquatic environment.
- The researcher ensured diversity in the rehabilitation exercises.
- At the beginning of the training sessions, the exercises were performed using body weight, and then additional weights were added to ensure proper technique.
- The rehabilitation sessions were conducted by the researcher for both experimental groups in the main section, immediately after warm-up, to ensure that the participants were physically prepared and had neuromuscular coordination to achieve the goals of the proposed exercises.
- The repetitions, intensity, and rest periods were determined based on the opinions of experts after reviewing the prepared rehabilitation exercise program and conducting a pilot survey on one of the research sample members before starting the pre-tests.
- The rehabilitation exercises included exercises with the movement direction of the spine primarily to achieve two main goals: improving range of motion and strength of the muscles surrounding the deviation area. The exercises also included auxiliary tools such as rubber balls, ropes, supports, plastic sticks, platforms, and benches.
- The aquatic exercises were performed in a swimming pool and included a set of exercises performed with the patient's own body weight without any auxiliary tools, as well as exercises performed with the assistance of tools such as noodles, rubber cushions, and wrist weights.

Post-test

The researcher conducted post-tests for the research sample during the period from May 27, 2023, which was the date of the post-test for the first patient, to June 19, 2023, which was the date of the post-test for the last patient. The first day involved measuring the deviation angle by the specialized doctor using X-rays (COBB ANGEL), and on the second day, the range of motion of the trunk (right lateral bending and left lateral bending) was measured using a goniometer. Muscle strength was measured using a force sensor.

Statistical Methods

The researcher used the Statistical Package for the Social Sciences (SPSS) to obtain the data and utilized the following:

1. Mean.
2. Standard Deviation.
3. Levene's Test.
4. Pearson's Correlation Coefficient.

5. Self-Efficacy Coefficient.
6. Paired Samples T-Test.
7. Independent Samples T-Test.

Presenting and Analyzing Results:

Displaying and Analyzing Pre and Post-Test Results for the First Experimental Group and Discussing them.

Table (3) Shows the differences between pre and post-test scores in the Kinetic Range Test and Deviation Degree for the first experimental group.

Variables	Pre-test		Post-test		M	S	Calculated t	Significance Level
	Mean	SD	Mean	SD				
Forward Body Flexion	6.733	0.252	18.667	1.155	-11.933	0.929	22.245	0.002
Backward Body Flexion	21.667	1.528	40.667	1.155	-19.000	1.000	32.909	0.001
Right Body Tilt	157.667	1.528	170.333	0.577	27.333	2.082	22.743	0.002
Left Body Tilt	145.333	4.509	150.667	0.577	117.667	4.509	45.197	0.000
Deviation Angle	48.667	1.528	28.333	0.577	20.333	1.528	23.056	0.002

Discussion of the results of the range of motion values for the first experimental group:

The researcher believes that the rehabilitation exercises used outside the aquatic environment led to the activation of the muscles surrounding the deviation area after a lack of movement. The exercises helped stimulate the muscle and return it to its normal position, resulting in a rapid recovery rate. It should be noted that the participants were children in the muscle growth phase, as the type of deviation affected around 90% of the muscles, with only 10% of the spinal column being affected. The use of exercises resulted in an increase in strength, indicating that exercise therapy yielded better results compared to the exercises performed within the aquatic environment for the second group. This led to a noticeable improvement in the range of motion for the first experimental group. Additionally, the deviation area gained sufficient strength and flexibility, which in turn improved the angle of deviation. The joint's mobility increases as the flexibility of the muscle working on that joint increases.

"Obtaining sufficient flexibility for specific muscles, tendons, ligaments, or a group of joints in a specific movement or activity depends on the amount and intensity of exercises that cover a wide range of motion, as well as the individual's previous acquired flexibility" (Wadi Yassin, 2020, p. 111). The researcher also believes that the exercises used played a role in developing the angle of the deviation for each movement, and following a gradual increase in exercise intensity within one week was an important factor that accelerated the good and noticeable development in the area affected by the deviation. "Each increase in training load through intensity and volume is met with an increase in the functional capacity of the organic systems, ensuring their growth and development" (Abd Ali, 2021, p. 98). The main goal is to develop the

flexibility of the trunk and abdominal muscles, and exercises that lead to acquiring the necessary flexibility for a specific task should be done by developing and training the specific muscle groups for that task, focusing on flexibility. Stick and medicine ball exercises contribute to flexibility development. "The connective tissues determine the degree of joint flexibility, in addition to the bones" (Jamil Hanna, 2019, p. 55). Therapeutic exercises lead to muscle stretching, and this stretching, in turn, leads to increased flexibility in the spinal column. The rehabilitation exercises resulted in the development of the range of motion in the deviation area, and this comes from the continuity of training and not interrupting it throughout the program. In the case of not training, the cartilaginous tissues lose their elasticity, becoming rigid and contracted, which limits their movement. This highlights the positive contribution of rehabilitation exercises in developing the range of motion compared to the second group.
Presentation, analysis, and discussion of the strength test results for the back muscles:

Table (4) shows the differences between the pre and post-tests in the strength values of the back muscles for the first experimental group.

Variables	Measurement Unit	Pre-test		Post-test		M	S	Calculated t	Significance Level
		Mean	SD	Mean	SD				
Force Sensing for Right Side Muscles	Newton	75.567	0.404	85.333	4.041	23.233	3.656	11.008	0.008
Force Sensing for Left Side Muscles	Newton	76.667	1.756	88.333	2.887	-11.667	1.756	11.508	0.007

Discussion of the results of the pre-test and post-test values for the first experimental group
The development that occurred in the variables under investigation did not happen by chance, but rather as a result of the nature of the prepared methodology and its inclusion of the use of exercises in the rehabilitation program. This contributed to the development and growth of strength, accompanied by a decrease in the degree of deviation in the coherence of the prepared methodology's components in terms of the use of different exercises. This had a clear impact on the development of strength, which increases with the use of rehabilitation exercises. "The development of strength is achieved by selecting different and varied exercises performed during the rehabilitation program to achieve better results in developing the strength attribute" (Keffry E. Lkel: 1986: 79). Furthermore, improving strength does not necessarily have to be a mental design, but it can be based on the efficiency of the nervous system in activating and improving muscular function. The increase in strength here is due to the coordination of the working, assisting, and opposing muscles as a result of neural adaptation. Therefore, any effort exerted must be accompanied by a period of rest that allows it to return to its natural state. This is consistent with what was confirmed by (Mukhtar Salem, 1987) that "the muscle needs a certain period of rest, which is a natural and physiological reaction to the need for nourishment after exertion" (Mukhtar Salem: 1987: 22). The researcher agrees with

what is mentioned by (Mofti Ibrahim) that the more coordination there is between the muscles involved in motor performance on one hand, and the muscles performing the movement and the opposing muscles on the other hand, the greater the production of muscular strength. The improvement that occurred on the left side in the strength variable was greater than on the right side. The researcher attributes this to the fact that all the individuals in the sample had a deviation angle of the spine towards the right, which leads to weakness in the muscles on the right side as they have limited movement compared to the left side, which had good movement. This resulted in the selected exercises being effective, as the physical rehabilitation exercises played an active role in acquiring sufficient strength and flexibility during the rehabilitation period. This makes them prepared to withstand the intensity they will be exposed to, in line with their current condition. Strength increases with the use of physical exercises, and the correct and scientific progression in the given intensities leads to the development of strength (Mofti Ibrahim: 2018: 37). "The development of mental strength is achieved by selecting specific exercises performed during the training program to achieve better results in developing the strength attribute" (Jeffry E. Falkel: 1986: 76).

Presentation of the pre-test and post-test results for the second experimental group and their analysis and discussion

Presentation of the results of the range of motion test and its analysis and discussion

Table (5) shows the differences between the pre-test and post-test values in the range of motion and the degree of deviation for the second experimental group.

Variables	Pre-test		Post-test		M	S	Calculated t	Significance Level
	Mean	SD	Mean	SD				
Forward Body Flexion	7.167	0.764	13.667	1.528	-6.500	2.179	5.166	0.035
Backward Body Flexion	24.167	0.764	32.000	2.646	-7.833	3.014	4.502	0.046
Right Body Tilt	156.633	1.305	142.667	2.517	13.967	2.214	10.925	0.008
Left Body Tilt	144.067	1.007	128.333	2.887	15.733	3.164	8.612	0.013
Deviation Angle	44.667	4.509	36.667	1.528	8.000	3.000	4.619	0.044

Discussion of the results of the range of motion values for the second experimental group

The rehabilitation exercises applied to the individuals in the second group within the aquatic environment were effective in improving the degree of deviation in the spinal column. The aquatic environment is considered one of the important natural means in the field of comprehensive rehabilitation of injuries. The researcher relied on diversity in the rehabilitation exercises, which matched the type of injury and diagnosis, in order to accelerate the recovery of the affected part to its pre-injury condition and enhance its mobility according to natural measures as quickly as possible. Regarding determining the intensity of the applied rehabilitation exercises, this determination is related to the range of motion of the spinal column that the muscles work on. The larger this range (which occurred in the results of the

post-tests), the greater the motor task of the working muscles. Therefore, it is possible to train the muscle fibers at the required speed and strength within the range of motion according to the resistance that these fibers are subjected to. This intensity must be compatible with the resistance used during the exercise (Gideon Ariedi: 1994, 37). Training in water is considered an effective method, and increasing the number and types of available exercises for the individual, continuously and with gradually increasing intensity, can be used to benefit from the effects of training in water to reduce the time needed to improve and accelerate the injured area. Water is the best natural environment, as it acts as a supportive medium for a sense of relaxation. Increasing water resistance works to raise and improve the functional level of the individual. Its real importance is evident in improving the imbalance between different muscle groups and improving joint movement mechanics. One of the properties of water is also making the body weightless, and the density of water is heavier than the density of air. When moving the arms or legs in water, they encounter significant resistance. This resistance can be used to strengthen the muscles and increase the range of motion in the joint. When the speed of their movement increases, the resistance increases, and the training becomes more difficult and gains more strength. Positive and negative therapeutic exercises are considered one of the means of motor rehabilitation, and they are among the most important steps in the motor treatment of the injured individual. Rehabilitation exercises play an important role in maintaining the health and fitness of the injured individual, and the psychological impact on the injured individual (Jaddi Al-Husseini: 1997, 212).

Presentation of the results of the differences between the two experimental groups in the post-test and their analysis and discussion

Presentation of the results of the range of motion test, their analysis, and discussion

Table (6) shows the differences in the post-test values of the range of motion between the first and second experimental groups.

Variables	Pre-test		Post-test		M	S	Calculated t	Significance Level
	Mean	SD	Mean	SD				
Forward Body Flexion	7.167	0.764	13.667	1.528	-6.500	2.179	5.166	Significant
Backward Body Flexion	24.167	0.764	32.000	2.646	-7.833	3.014	4.502	Significant
Right Body Tilt	156.633	1.305	142.667	2.517	13.967	2.214	10.925	Significant
Left Body Tilt	144.067	1.007	128.333	2.887	15.733	3.164	8.612	Significant
Deviation Angle	44.667	4.509	36.667	1.528	8.000	3.000	4.619	Significant

Discussion of the results of the post-test measurements of the range of motion for the two experimental groups, the first and second groups.

The researcher used rehabilitation exercises with the first group, which consisted of a selected set of exercises aimed at rehabilitating the muscles surrounding the deviation area. These

exercises were characterized by diversity and progression in order to help the deviation return to its natural state by improving the range of motion of the spine. The intensity of the exercises used was appropriate and within the physical capabilities of the affected children. Through this, there was an improvement in the range of motion. "Obtaining sufficient flexibility for a specific joint muscle, its tendons, ligaments, or a group of joints in a specific movement or activity depends on the amount and intensity of the exercises that lead to a wide range of motion, in addition to the previous acquired flexibility of the individual" (Jumaa, 2020: 321).

As for the second group, which performed the rehabilitation exercises in the aquatic environment, the researcher believes that the aquatic environment provided ease for the nervous system to perform motor tasks. This additional task contributed to the improvement of the nervous system's function, or in other words, "adaptation occurs in the function of this system, which is directly responsible for the coherence of sensory and motor information" (Haus, 2017: 66). The research results obtained for the sample of the study in terms of the measurements of the range of motion showed significant differences between the pre-test and post-test, in favor of the post-test. In these tests, it is observed that the sample individuals practiced the rehabilitation program, which included various exercises. The results above indicate that the development of the range of motion for the deviation area was consistent in all directions that the spine works on. Furthermore, exercising in groups greatly helps encourage patients to adhere to exercise. Some experts recommend that patients exercise three to four days a week for 30 minutes, and this duration can be divided into parts. The research sample performed the exercises in the aquatic environment, which is characterized by spontaneity, ease, repetition, and endurance mechanism that suited the capabilities of the sample. The method used to implement the rehabilitation unit had an effective impact on raising the level of the test results for the range of motion of the spine for the individuals in the research sample. "Swimming pools are considered ideal places for muscle and joint injuries. The buoyancy provided by water helps reduce the load on the joints during exercise, which facilitates movement. If the water level is at the waist, the water carries half the person's weight, and if the water level is at the neck, in this case, the water carries 90% of the person's weight, where appropriate exercises were used for the age level of the sample and also for the type of injury."

CONCLUSIONS

The researcher concluded, based on the results obtained, that:

1. The contribution of the rehabilitation exercises used outside the aquatic environment in improving the deviation of the spine through the obtained results.
2. The rehabilitation exercises used outside the aquatic environment have an effective role in improving the deviation of the spine through the results related to the angle of deviation variable.
3. The rehabilitation exercises used in the aquatic environment have an effective role in improving the deviation of the spine through the results related to the angle of deviation variable.

RECOMMENDATIONS

The researcher recommends:

1. The use of rehabilitation exercises for their effective role in improving the range of motion and strength of the deviation area in the spine.
2. The need to follow up with patients with spinal deviation throughout the rehabilitation program.
3. Paying attention to the rehabilitation exercises applied in the aquatic environment for all patients with deviation, while also focusing on their psychological aspect to help them overcome their fear factor.

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