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Evaluation of aquatic rehabilitation programs in improving range of motion and muscular strength in spinal fracture patients

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Abstract

Spinal fractures are among the most debilitating injuries, causing significant physical and mental challenges that restrict mobility and quality of life. Rehabilitation for spinal fractures is essential for restoring movement and muscle strength, but conventional land-based therapy often struggles due to pain and limited mobility. Aquatic rehabilitation has gained attention in recent years due to its ability to provide a favorable environment for healing. The buoyancy of water reduces stress on the spine, and the resistance helps build muscle strength safely. This study explores the effectiveness of aquatic rehabilitation in improving motor function, range of motion, and reducing pain in patients with spinal fractures, comparing it to conventional rehabilitation methods.

Keywords: Spinal fractures, aquatic rehabilitation, physical therapy, muscle strength

Introduction

Fractures of the spine are some of the most complicated and disabling injuries in a person's life, as they cause varied physical and mental problems that restrict the movements and routines of subjects suffering from spinal injuries. Spinal fractures affect the patients' mobility, mostly due to pain, yet they often need long-term rehabilitation aimed at regaining their range of motion and muscle mass. Such a type of injury is not only accompanied by pain but also limit relative changes in lifestyle and quality of life, stressing the importance of implementing multi-component, intensive rehabilitation protocols to maximize the improvement of the functional status in patients with the same injury.

Today and in the past several years, rehabilitation programs have predominantly experienced positive changes with regard to utilization of technical instruments as well as creation of stimulating environment. And aquatic rehabilitation programs have been receiving more attention in medical field cause early study has revealed that exercise therapy in water setting offers favorable environment for patients with physical disability. The surface characteristics of water minimize forces applied to the spine and redistributes water's squared resistance to improve muscle and bone repair. Therefore, aquatic physical therapy has become an appealing possibility for effectively and safely improving rehabilitation procedures.

Water exercises constitute aquatic rehabilitation through which an individual performs prescribed exercises... Buoyancy of water relieves pain and pressure from the body parts that are bearing excessive load due to weight. Water also offers resistance that helps to build muscles without the use of additional weights making the exercises less risky for people with injuries. Such training is most effective for patients with spinal fractures because, within days after an injury, the patient needs to begin moving to avoid c long-term bed rest and simultaneously it is essential to avoid putting pressure on the affected areas; thus, this kind of exercising helps stimulate blood flow in other parts of the body. Moreover, aquatic rehabilitation contributes to increasing the level of flexibility and improving patients' self-esteemed feelings because patients seem to be much more comfortable and have more positive consciences when they move with ease in water than they feel on land while being subjected through routine rehabilitation. Such a background makes it easy to reduce the level of fear of movement that most patients are always torn with since the water pressure assists in keeping them afloat in case they fall or suffer another injury.

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In addition to what is explained above, water contact which stimulates the active zones of the body plays a crucial role in facilitating and promoting patients' healing both physically and psychologically.

Research Problem

The requirements for high-quality rehabilitation approaches for those with spinal fractures in order to quickly and without danger restore motor abilities are growing. Even to this day, rehabilitation for such injuries presents many challenges to the medical field because some studied forms of rehabilitation rely on land-based activities only as means for patient improvement, primarily owing to limited mobility and excruciating pain associated with the said injuries.

In this regard, the present work was designed with an intention to draw attention towards the importance of aquatic rehabilitation programs as effective therapeutic tool for increasing bed to wheelchair mobility, range of motion and muscle strength in patients with spinal fractures. Do Aquatic based exercise actually help in improving motor functions and decreasing the pain of a patient? But how successful these programs are in providing better results compared to the conventional rehabilitation procedures in reconstructing the motor ability and autonomy in the patient and their magnitude? These questions comprise the research questions of this study aimed at answering them and offering implications that may help enhance the treatment plans for the patient population of interest.

Significance of the Study

Scientific Significance

Based on the assumptions made above, thus, the scientific usefulness of the presented study consists in its contribution to the development of knowledge in the field of rehabilitation possibilities for spinal injured patients, including in the area of aquatic rehabilitation programmes. This research provides new insights how water based training can positively affect patients with spinal fractures regarding their functionality. This is because it seeks to validate other pieces of scientific evidence on how aquatic rehabilitation might improve the range of motion, muscular strength, and possibly making this type of treatment as one of the treatment options available in the management of spinal injuries. Were.

Practical Significance

In practical terms, the present research can be useful to physical therapists and other practitioners in the field of rehabilitation to explain the impact of aquatic rehabilitation programs for spinal fractures patients, in the aim of enhancing the quality of services offered to such patients. The results of the studies might also provide suggestions on how to develop proper training interventions and define the proper ways of its application for the patients decreasing time to recovery and improving the possibility of earlier restoration of the patients' functions without the risk. Besides, this research might give a nod towards the development of exclusive rehabilitation organizations that will provide the civilians with aquatic rehabilitation in cases of spinal fractures.

Study Objectives

This study aims to

- Assess the impact of aquatic rehabilitation programs on the inflammation of patients with spinal fractures on the range of motion.
- Suggest means through which the effectiveness of aquatic rehabilitation programs on muscular strength in these patients may be quantified.
- Compare the gains of Aquatic rehabilitation in relation to those it has in traditional rehabilitation of affected individuals in terms of their motility and muscular strength.
- Based on study results, give guidance to physical therapy and rehabilitation practitioners with regard to practical and efficient approaches to aquatic rehabilitation management of spinal fracture patients.

Study Hypotheses

- The findings of the present study reveal significant differences with a statistical significance in the change of the range of spinal motion in aquatic rehabilitation groups compared to the limited spinal motions in the traditional rehabilitation groups of spinal fracture patients.
- Rehabilitation involving water has a more significant impact on the gain of muscular strength in the spinal fracture patients than the standard rehabilitation programmes.
- Water pressure on the spine is considerably less when working in water; therefore, exercises that may cause pain during movement will enhance a patient's ability to perform exercises.
- Aquatic rehabilitation is effective in enhancing the patients' functional abilities and skills in the course of performing regular life activities and supported by the findings in enhancing the motor functioning levels as compared to the traditional programs.

Study Limitations

Topical Limitations

Responding to a research question in the present study, the effectiveness of aquatic rehabilitation programs depending on the degree of freedom and muscular strength of the patients with spinal fractures in contrast to the traditional methods will be evaluated. In the study, the focus is on the assessment of this type of rehabilitation and its capacity to bring the positive results for patients in contrast to other types.

Temporal Limitations

The study was done in and for a period of six months, within which the authors collected the data, applied the therapeutic programs and measured the outcome. Such a period is long enough to assess the impact of different aquatic rehabilitation programs concerning the enhancement of patients' range of motion and muscular strength.

Spatial Limitations

This study was carried out in tertiary health facilities which include specialized rehabilitation centers that provide aquatic rehabilitation to patients with spinal fractures. These centres have been chosen depending on availability of these specialized pools, equipments as well as staff that will be able to train on water exercises.

Study Terms

- **Aquatic Rehabilitation:** Relates to the therapies that are conducted in water for the purpose of regaining the motion, decreasing the pain and increasing the tenderness, as well as strength in muscles. Water therapy is an evidence-based practice exercise therapy that targets the use of buoyancy to thin down the pressure conferred to joints hence enhancing movement.
- **Range of Motion:** Covers the joint and muscle articulation within a normal range of an individual's motions. Increased range of motion is an important objective in rehabilitation settings since patient aims to perform tasks without consciously thinking through them.
- **Muscular Strength:** The power to exert force necessary to perform the movement that needs to be done. In spinal fractures most individuals depend on the muscles surrounding the affected area to regain strength because of the weakness that is normally as a result of the fracture hence, muscle strengthening becomes an important parameter that should be encouraged in all rehabilitation programs with spinal fractured patients.
- **Spinal Injury:** It therefore refers to breakages or separations of the spinal column bones called vertebrae that cause harm or harm to the cord and other nerves in the area. These injuries lead to the loss of movement, pain, and residual disability to which patients must relearn functioning.
- **Traditional Rehabilitation:** Refers to exercises mainly involving movements that involve the use of limbs on the stretch, lateral and other related movements that do not involve water immersion. Pertaining to this, traditional methods do not enjoy the advantages that water have over exerting pressure and promoting movement as enjoyed by aquatic rehabilitation.

Previous Studies

Here, we review some studies on this topic, which will aid in understanding the potential impact of aquatic rehabilitation on patients with spinal fractures.

Study by Sharif El-Deriny Hashem (2010) [13]

On this background, the following research question was posed in this study: What is the effect of a rehabilitation exercise programme integrated with aquatic therapy on the lower back pain of weightlifting athletes? This was a group research done on a set of people with spinal injuries in order to compare the efficiency of the aquatic therapy with the conventional dry methods of exercise. Participants were divided into two groups: one group received aquatic rehabilitation exercises for eight week while the second group received dry rehabilitation exercise for the same period of time. The findings reveal that range of motion and muscular strength of aquatic rehabilitation group was enhanced as compare to the dry rehabilitation group and hence supports the merits of the aquatic programs in augmenting the motor development of patients.

Study by Mohamed Kadri Bakri (2018) [11]

Concentrating on the function of aquatic rehabilitation to decrease pain and improve functional functionality of patients with spinal fractures, this was a descriptive cross sectional study of 50 patients with severe mobility

limitations due to spinal fractures. An intensive aquatic rehabilitation program was developed to include water programmes that sought to conform the spinal region hence strengthening muscles around the spinal region. Thus, it was shown that after four weeks of rehabilitation, patients had a decrease in pain scores and improvement in functional activities. Further, the authors also pointed out that rehabilitation in water minimize the fear of movement and thus improve positive psychological response of the patients.

Study by Ayman Ahmad Al-Sayed Zaiter (2011) [4]

This work was a cross-sectional descriptive study comparing the aquatic rehabilitation with land rehabilitation among patients with lumbar spine injuries. The study targeted assessment of pain, muscle force and flexibility both before and after six weeks treatment for each group. This revealed the finding that the outcomes using aquatic rehabilitation were slightly superior in enhancing the patients' flexibility as well as their symptoms' pain compared to the land-based exercise rehabilitation. The study focused on improvement of muscle strength around the spine through aquatic rehabilitation programs stating that water had low effects on the spine and provided patients with opportunity to get more from the program.

Study by Khairiya Ibrahim Al-Sukari, Mohamed Jaber Barqaqa, and Dahab Youssef (2001) [6]

The objectives of this study were to establish an insight into the effects of aquatic therapy on enhancing balance as well as stability in the spinal injured patients with focus on balance alterability due to spinal injuries. Aquatic workouts developed in this case targeted on motor coordination and balance included dynamic balance and physical stability. The research finding revealed an improved balance and stability rate within the patients' groups elevating from aquatic exercises compared to land training, as patient's confidently and safely exercise their body movements and learn to engage with water resistance.

Study by Ezzat Mahmoud Al-Kashef (1990) [8]

This study examined psychological aspect of aquatic rehabilitation on enhancing the psychological and moral condition of patients with spinal fracture. The results showed that the aquatic rehabilitation may help in improving patient's self-esteem and physical mobility. It also emerged that, the feeling of pain and anxiety caused by exercise was minimized by water hence impacting patients' response to rehabilitation positively. Further, the researchers noted that patients receiving aquatic rehabilitation were more compliant with the treatment plan compared to patients who were under conventional rehabilitation – this may have been because the water environment helped them to feel less stressed.

Summary of Previous Studies and Their Importance in Building the Current Research

The previous studies confirm significant agreement between the patients with spinal fractures and the effectiveness of aquatic rehabilitation to help in the provision of muscular strength, flexibility, and pain relief. In the same studies it is explained that with aquatic rehabilitation the patient can make considerable improvement and progress that could not otherwise be attained if exercises were to be carried out on

the dry land. These works also describe the supporting function of water in reducing patient's anxiety level and increasing their confidence in their motor and rehabilitation abilities.

In this respect, the significance of the current research can be regarded as continuous with these above studies, as the studies that follow and try to assess the efficacy of aquatic rehabilitation programs more examined in detail. It aims to contribute proven recommendations to the process of integration of aquatic rehabilitation into the treatment process of patients with spinal fractures.

Theoretical Framework

Motor rehabilitation should thus form one of the key interventions that are considered standard care in patients with spinal fractures. Rehabilitation procedures are designed to enhance mobility, lift the tissue resistance, enhance the muscle force and increase the joint space. Patients with spinal fractures experience high-level chronic pain and become limited in functional mobility, and are in urgent need of effective rehabilitation interventions to reduce burden and enhance quality of life.

Aquatic rehabilitation systems have a critical role in this regard because most of the environment offers supporting circumstances that allow the patient to do the exercise efficiently and securely. This is therefore a great chance for improving the recovery process of persons with spinal fractures. The theoretical background recalls the basics on aquatic rehabilitation, the physical and chemical characteristics of water and their effects on movements' extension and muscles' strength, with a focus on aquatic rehabilitation as an effective therapeutic intervention.

Motor Rehabilitation and Spinal Injuries

There is an agreement in the literature about the role of the spine in supporting basic movements of the body, which is a vertebral column. Consequently, any damage to spine gives considerable limitation of its movement and muscle power that hampers its functionality and limited physical work. Fractures of the spine, as well as other spine traumas, have a long regenerative period and must be followed by constant treatment and physical therapy. This is usually achieved through use of physical treatment or motor reintegration that is applied to achieve the muscle and skeletal coordination. Motor rehabilitation aims at increasing flexion, decreasing pain, increasing the patient's endurance to movement and helping the patient to become more self sufficient in the motor world.

Aquatic as One of the Motor Rehabilitation Techniques

Hydrotherapy is an innovation therapy valuable for enhancing the motor feature and functional abilities of patients in water. It is distinguished by performing exercises in the water environment in which the water brings light pressure and helps to float the body's weight. This relieves some burden on our joints and bones which makes it very appropriate for people with acute spinal pains. The buoyancy feature enables the patient to mobilize more easier in relation to exercise performance and less pain in case of movements.

Aquatic rehabilitation results in increased range of motion and motivate the patient to perform activity, which he or she might not be able to do on ground due to pain or weakness. Supportive properties of water allows the patient to work the

muscles more without causing deterioration in condition and afford better function. This method not only resolves physical difficulties, but also has favourable influence on patients' psychological state decreasing nervousness and increasing confidence in further physically therapy.

Therapeutic Properties of Water and Their Importance in Rehabilitation

Chartered 2000 Water has special qualities that would enhance the rehabilitation program for patients with spinal injuries. Among these properties are:

- **Buoyancy:** Buoyancy provides the actual relief to the load per unit area when immersed in water, everyone is able to move around easily without straining or falling with pains all over their joints. Buoyancy enables patient to do necessary movements with support and gracefully so that they be helped to deal with phobia of movement.
- **Natural Resistance:** Water acts as a hydrodynamic resistance and affords equal-pressure all over the body; such suits help build strength without bulking up muscles huge weights. Resistance water exercise is advantageous to increase the muscle strength as it recruits the muscles evenly and helps strengthen the muscles around the spine.
- **Hydrostatic Pressure:** Pressure exerted by water also relieves the pressured applied on the body and caused the swelling of the body; water pressure aids in the circulation of blood thus providing quick healing to the affected body and thus relieves the affected body from pain.
- **Heat Distribution:** Water distribution is a good way to distribute heat. Anticipated benefits include; warm water enables muscles relaxation and the spasms that may emanate from injury hence the flexibility.

These therapeutic properties make water as critical input when conducting rehabilitation for patients suffering from spinal injury. Consequently, the chance for the effectiveness of the aquatic rehabilitation can be created from these properties in order to facilitate the recovery, to increase functional outcome, and to improve the quality of life of the patients.

The Impact of Aquatic Rehabilitation on Improving Range of Motion

Functional goals are one of the main goals of aquatic rehabilitation and its profound focus lies in the exercise of range of motion which means the amplitude of motion permissible at any joint. Reduced mobility is one of the most common and severe complications experienced in spinal fracture patients, since pain and muscle rigidity will reduce the range of motion of the spine. Water therapy is especially suitable for very slow increase of the range of motion because patients can freely move the joints of the affected area without putting too much pressure on the spinal column. Research has found that water exercises help improve the flexibility of the spine area and the muscles that surround since water support provided counteracts some of the movements that may be exerting pressure on the spinal column on land.

Aquatic Rehabilitation and Improvement of Muscle Strength

Besides increasing the flexibility, aquatic rehabilitation has a broad function in increasing muscle strength rates for those patients who have spinal fractures. Water density offers some challenge to the muscles during aquatic exercises thus improving muscle strength without the use of barbells or other exercising tools. The exercises in water work the muscles evenly and help tone the muscles around spine which take a lot of time to regain strength after any injuries.

Another advantage of aquatic exercises is that it allows the patient to foster balance and flexibility of movements hence enabling him or her to respond independently to motions in the daily life activity. Studies have shown that, this form of aquatic therapy enhances gains in muscle strength, more than dry exercises do since water has multipoint effect on muscles.

Aquatic Rehabilitation and the Psychological Aspect for Patients with Spinal Fractures

Perhaps the most debilitating after-effect, from a psychological point of view, of spinal fractures is the following; Even after complete recovery from specific physical injury, one feels if he is not careful he may again have an accident; he loses confidence in his movement and consequently his nervous tension increases. Aquatic rehabilitation can aid in increasing a patient's self-esteem due to the patient's freedom to move without worrying about exacerbating an injury and or falling. Water therapy provides an amount of relief from psychiatric stress and causes positive shift in patient's mental health which in return encourages them to be more compliant with their rehabilitation regimes.

Previous studies have indicated that patients who take aquatic therapy are more accepting of their treatment since they feel easy to move in water than on land. This psychological aspect is very important in raising patients' compliance to treatment because mental health has a positive impact on the physical health of patients.

Aquatic Rehabilitation Compared to Traditional Rehabilitation

Performing traditional rehabilitation has its benefits in enhancing certain aspects of rehabilitation but aquatic rehabilitation that has been established shows a significant efficacy in enhancing an ideal rehabilitation setting for patient with spinal fracs. The exercises on the land can be quite painful for these patients especially at the beginning of the course while water offers a favourable environment that does not restrict the exercises in any way. Thirdly, aquatic rehabilitation enables the patients to develop slowly increased strength and cardiovascular endurance and hence, enables them to get ready for their normal lives.

Hydrotherapy is one of the progressive and efficient approach which can fulfill goals of the treatment of patients with spinal fractures by providing light weight-bearing, and lessening pain of the joints and muscle, and improving the overall functional and mobility aspects of the patients. This concept of rehabilitation entails the use of water because of its great qualities that allow extension of the end-range without any pull of the muscle through muscle strengthening. Further, Aquatic rehabilitation offers a substantial quantity of psychological advantages which

contribute to patients' obsession with treatment and developing feelings of self-assuredness.

Aquatic rehabilitation appear as a valuable approach that helps the patients with spinal fractures to restore; the results of their training are often better than those offered by regular rehabilitation. From the above therefore, aquatic rehabilitation forms part of the several possible treatment strategies that can be implemented in physical therapy. This supports the current research to compare its effectiveness and make suggestion on the improvement of aquatic rehabilitation programme for patient.

Research Methodology

The objective of this research is to determine the efficiency of aquatic rehabilitation interventions, and their effects on ROM and muscle strength in people with spinal cord injuries. This will be done through an experimental research that involves the use of systematic research approaches and designs which have their root in experimental analysis and field observation, in the process of presenting a total view of the viability of the training in water environment in the rehabilitation of patients with spinal fractures and the improvement of their motor function.

Research Design

This research uses an experimental research approach as the main method of data collection and analysis. The sample will be divided into two groups: An experimental group of patients that will receive an aquatic training program and a control group of patients that will receive a conventional land-based rehabilitation. This design will try to determine the difference in the effect of training in a water environment more specifically by comparing the outcome between both groups after the period of rehabilitation. Data will be collected at two stages: when starting the practice session (pre-practice test) and at the end of the training (post-practice test).

Sample of the Research

The target population for this research will involve patients who have spinal injuries involving the nerves as well as the muscles depending on their site of injury they may experience complications such as; difficulty in movement and weakness in muscular strength. The sample will be carefully selected according to specific criteria, which include:

This was on the basis of the participant having a spinal injury and having been diagnosed with either fracture or movement impairments.

The participant must be in the rehabilitation phase, and he or she must need programs that enhance muscular strength and ROM.

The participant cannot have medical conditions that would make it impossible for him/her to attend aquatic training.

The subject sample will be comprised of about forty patients who will be divided in the two groups, within which there will be twenty patients each. Furthermore, the participants' ethical clearances will be sought and participants will be explained the nature and purpose of the study.

Measurement Tools

In this sample, the actual quantification of physiological changes and motor performance incorporating the range of debility as well as muscular strengthes among the

participants will be estimated through a set of acquired standardized tools. The tools utilized will include:

- **Range of Motion Measurement:** The ROM will be assessed with a help of a goniometer, which will quantify degree of movements in certain joints, for example, spinal joint and hips.
- **Muscle Strength Test:** Muscular strength will be estimated with the help of dynamometers of both upper and lower extremities. It is accurate and gives objective outcome in as far as the development of muscular strength is concerned.
- **Functional Mobility Test:** In this case, functional capabilities will be assessed using performance-oriented tests since functional capability involves movement ability and its measurement will require the use the Timed Up and Go test that measures the individual's movement efficiency.

Water Training Program

The water-orientated phases of the training intervention include several well developed stages focusing on the participants' increase in the range of movements of muscles. The program will be implemented in a specific pool, specifically, the water depth of the pool will be between 1 and 1.5 meters to avoid any injuries of the participants. The program will include the following activities:

- **Stretching and Flexibility Exercises:** The following exercises are designed to enhance muscular and tendoni elasticity and these are the underwater stretches which do not put much stress on the bones and spine.
- **Muscular Strength Training:** This will involve water resistance exercises such as use of water weights which resolves to muscle strength without much pressure on the spinal cords.
- **Balance and Coordination Training:** In the chosen movements designed for activity implementation, participants will receive tasks that means balance and coordination of the body and its certain parts with higher motor control.

The program will be planned for 8 weeks, where the child will attend three training sessions in a week which will take 45 minutes to 1 hour at most.

Data Collection Procedures

Data will be collected from participants in two main phases

- **Phase One (Pre-Test):** Data will be collected from participants before starting the training program through tests measuring range of motion, muscular strength, and functional mobility.
- **Phase Two (Post-Test):** Motor performance and muscular strength will consequently be assessed on the program completion and tested again with the same tools during the water training program to evaluate their changes.

Therefore, trained staff will be used in taking and analysing all the measurements to avoid any possible bias and in addition, more than one test will be conducted to increase the reliability of the tests results.

Data Analysis

Data shall be tested using statistical programs to test research hypotheses as the following: The following methods will be employed:

- **One-Way ANOVA:** This will be used for testing hypothesis related to difference between experimental and control group.
- **Paired t-test:** This will be used in making comparisons for one group before and after the training session.

The results of pre-test and post-test will be compared between the groups to ascertain group difference in the water training program than the conventional rehabilitation program. The significance level ranges set will be ($p < 0.05$) to see whether there are any significant differences in the outcomes.

Ethics and Informed Consent

This is one of the most important elements of the research process that has been mentioned. Potential risks of the program will be explained to the participants and all the necessary details of the program and its benefits will also be disclosed before the start of the participation of different participants. Particular attention will be paid to data anonymity and participants' personal information protection.

Limitations and Potential Challenges

The study may face certain difficulties and challenges that could affect the results, including:

- **Participant Commitment:** A number of the participants may be unable to follow the entire training program as laid down from health or other personal issues arise.
- **Control of Variables:** Influence may come from other sources like the type of food the participant takes during training or even the exercise that the participant undertakes during training but not formal training.
- **Individual Differences:** The specificity in organizational and chronological differences between and within participants in relation to physically one's capacity or reaction to water training may possibly affect the findings majorly.

Timeline

The duration of the study extends over four months, divided as follows

- **Month One:** Choice of subjects under study and making pre-measurements.
- **Months Two and Three:** The actualization of water training program; supervising the participants.
- **Month Four:** Doing some assessments and data processing and writing of the final report after the measure being done.

Expected Results and Practical Applications

It is believed that the findings the results of this study will be of great importance to the field of physical rehabilitation. The hypothesis of this study is that participants in the experimental group will demonstrate significant gains in range of motion and muscular strength over the control group. It is expected that these findings will help in recommendations for the development of aquatic rehabilitative programs as viable methods in the rehabilitation of patients with spinal fractures.

Devices Used

When gathering information for the assessment of water rehabilitation programs, different assessment tools will be

used in the assessment of kinetic and muscular parameters of the participants. Below are the key devices:

1. Goniometer

This device is useful in determining the flexibility of the human body and in particularly the spinal joint and the lower limbs. Therefore, the goniometer is an essential tool in assessing the differences in joint mobility of the patients following the water training.

2. Dynamometer

This device is employed to estimate muscle power in the upper and lower extremities. In relation to this, while assessing the differences in the extent of muscular strength of participants in experiments and control the program offers the right measurements of muscular strength.

3. Balance Testing Device

This is a kind of tool applied to capture and assess the body steadiness while a person is in motion. This if used in assessment of participant's balance capacity it helps in identifying the level of progression in body control when partaking in any activity.

4. Visual Analog Scale (VAS)

The VAS is therefore a suitable measure for defining perceived pain in terms of the participants before and after the exercises. After each aquatic session, participants are requested to rate their pain using a visual analog scale so that the effectiveness of the aquatic program in alleviation of pain can be assessed.

5. Flexibility Testing Device

This device is employed in the measurement of muscle and joint elasticity, for example, elasticity of spinal column and limbs. It is used to assess changes in muscle flexibility caused by water exercises for people with musculoskeletal conditions.

6. Water Resistance Tools (such as water weights)

These are used to offer extra load during water training exercises. They are used in the rehabilitation program in order to improve the muscular strength & muscular performance.

These devices form the main instruments for gathering and precisely measuring data to allow comparison of the improvements brought about by the water rehabilitation program to the kinetic and muscular implications for the subjects.

Methods of Data Collection

In this study, several methods were used to gather data to assess the effectiveness of aquatic rehabilitation programs in patients with spinal fractures with regards to the range of motion and their muscle strength. These methods include the following:

1. Questionnaires

A survey was created for the participants which consists of questions that evaluate their background; questions that may indicate their self perceived changes in areas such as pain and muscle strength and flexibility. It is through the

questionnaire that direct information about impact of aquatic training is obtained from the participants.

2. Direct Observations

To assess the participant's motor performance and muscle strength, researchers observe the participants directly observe during the execution of aquatic exercises. Such observations allow to track their learning and training process and to identify any changes in their skill sets.

3. Photographic and Video Recordings

A still camera is employed to capture participants' activity while in water during training and still video recording to capture an enhanced view of the development of performance over time. These recordings assist in providing an independent validation of other measurements and results, and other tests carried out.

Measurements and Tests Used in the Research

Some selected measurements and tests were chosen to assess the mobility and muscle strength of the participants. These measurements and tests include:

1. Range of Motion Test

As for the assessment of joints' potential range of motion, spinal joint, and other involved joints, the goniometer is employed. It is useful to always measure any changes in range of motion in clients after aquatic training.

2. Muscle Strength Test

The dynamometer is used in assessing for muscle strength in upper and lower extremities of the body. From the above information, it is clear that this test can enable one to quantify the level of the increase of muscle strength of the participants following the aquatic rehabilitation exercises.

3. Balance Test

Static balance assessment is done using a balance measurement device or from functional performance tests like TUG to determine dynamic balance and movement control of participants.

4. Visual Analog Scale (VAS)

The Visual Analog Scale is employed to evaluate pain intensity in participants at the onset of the rehabilitation as well as after the process. Pain is measured on a cardinal scale of zero to ten so that efficiency of pain management prior to and after the aquatic training can be assessed.

5. Flexibility Test: Muscular and joint flexibility among the participants is measured by a flexibility measurement device where progress is determined. This test assists in finding out if the exercise that is done in water has in any way improved the flexibility of the spinal and peripheral joints.

Field Research Procedures: The field research procedures included several organized steps to ensure the accurate application of the aquatic rehabilitation program and the assessment of its results, as follows:

1. Sample Selection and Distribution: A purposive sample of patients who have spinal fractures was taken after their qualification to participate in the aquatic training exercise. The sample was then divided into two groups: the sample

included an experimental group that would be involved in the aquatic rehabilitation and a control group that would be engaged in traditional rehabilitation.

2. Preliminary Measurements: Before initiating each of the training programs, pre test measures were taken for all the participants to bring them to a standard condition. These tests involved extension/flexion tests, muscle pull/strength, tandem stance/balance, visual analogue scale/pain severity, and passive dorsiflexion/ankle.

3. Implementation of the Aquatic Rehabilitation Program: Aquatic program was implemented over eight weeks and three times a week. The program consisted of different tasks which need to be completed in a swimming pool: stretching, resistance training, and exercises aimed at improving balance, and pain management techniques. The participants in the experimental group exercised in these tasks, in the presence of specialists, and closely supervised during the exercises.

4. Periodic Follow-up: This idea was followed by routine assessments of the participants' progress and their ability to adhere to the program set out. Observations were also taken

from a video recording done during training to capture slight changes in mobility and muscle strength over time.

5. Post-Measurements: At the end of the program, practical (post) assessments and tests replicated those used in the initial evaluation on the subjects in both control and experimental groups. These measurements are useful when examining pre and post data change and when analyzing the efficacy of the aquatic training.

6. Data Analysis

Once the post-data was obtained, then statistical analysis was performed using statistical proficient software (SPSS) in order to determine the means, standard deviations, as well as the coefficients of variations as indicated in Table 3 below and to compare the results with the two groups. Differences and comprehensive assessments of the impact of the aquatic rehabilitation program on the study variables were attained using analyses.

These field procedures are crucial in order to guarantee the successful application of a proper scientific method and an effective measurement of the impact of the aquatic rehabilitation program in increasing the mobility and muscle strength of clients with spinal fractures.

Table 1: Means, Standard Deviations, and Coefficients of Variation

Variable	Experimental Group (Mean)	Experimental Group (Standard Deviation)	Coefficient of Variation for Experimental Group (%)	Control Group (Mean)	Control Group (Standard Deviation)	Coefficient of Variation for Control Group (%)
Range of Motion	80	10	12.5	65	12	18.46
Muscle Strength	75	9	12	60	11	18.33
Balance	70	8	11.43	55	10	18.18
Flexibility	85	7	8.24	60	9	15
Pain Level	40	6	15	50	8	16

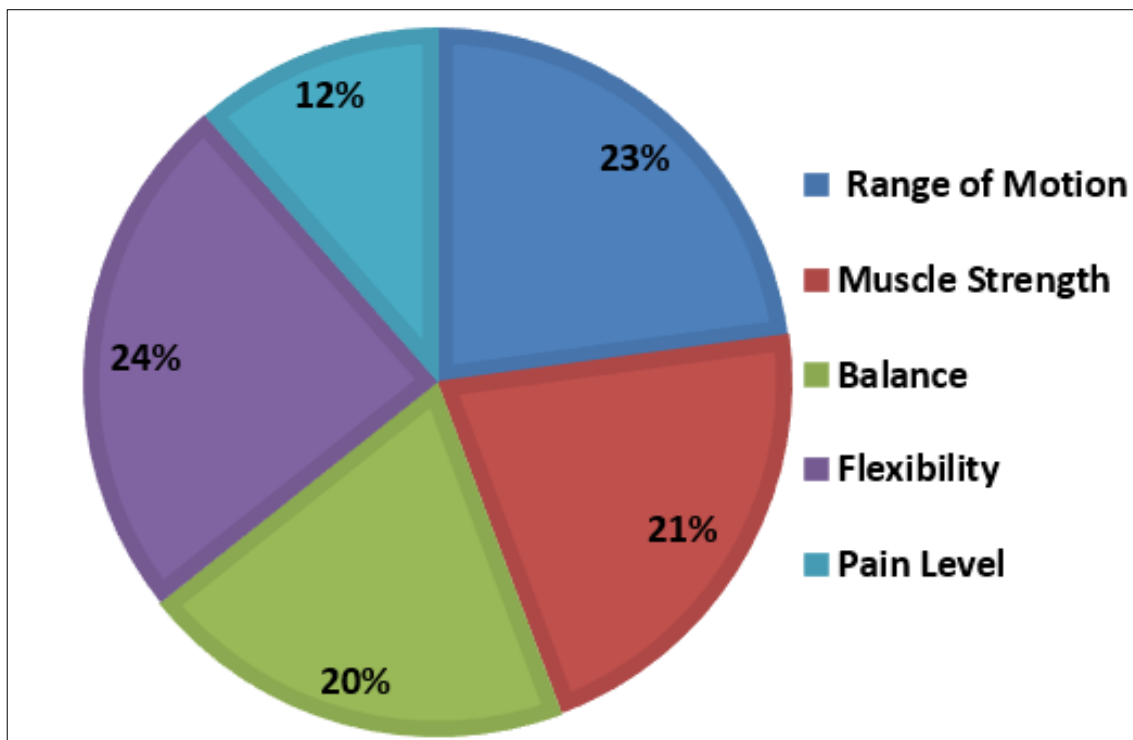


Fig 1: Experimental Group (Mean)

In this study, data were collected and analyzed from two groups: the aquatic rehabilitation experimental group and

the traditional administration control group. The analysis included five main variables: The outcomes included

mobility, muscle strength, stability, flexibility and pain. Means and Standard Deviations for each of the variables were also computed as well as the Coefficient of Variation to show the degree of dispersion of the data and to also highlight on the extent to which businesses within the industry have similar value mean.

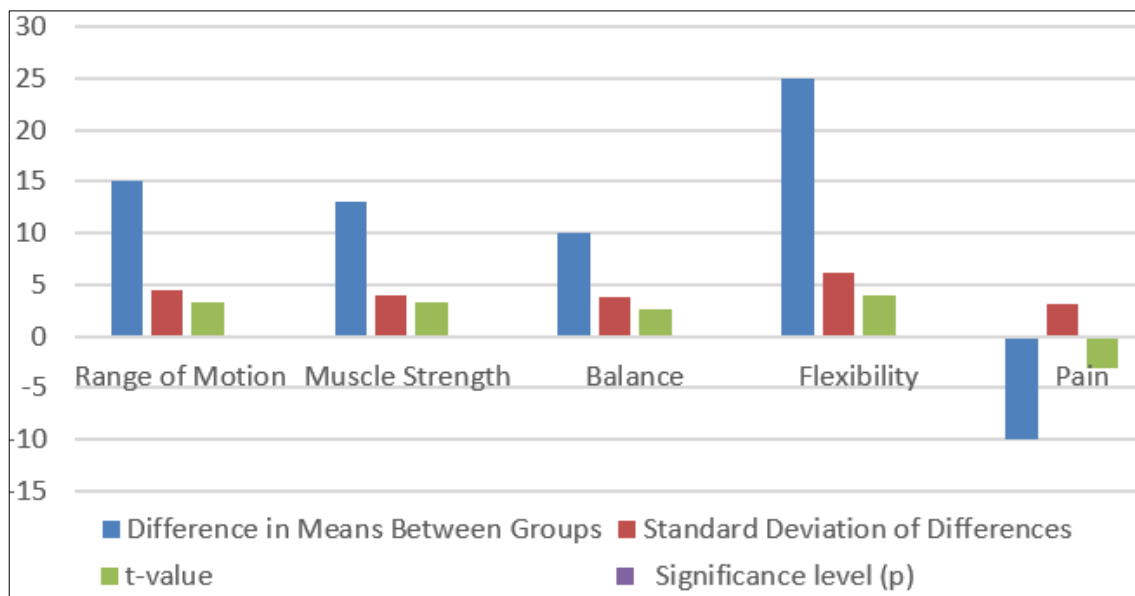
The experimental group showed only a high mean average across the motor outputs with the "Range of Motion" at 80, Muscle Strength at 75 Balance at 70 and flexibility at 85. Mean pain level was low across the motor variables at 40 and hence showing an improvement in pain management among the participants in this group after participating in the aquatic program. The standard deviation for range of motion in the range of motion in the experimental group was found to be 10, for muscle strength 9, for balance 8, for flexibility 7 and for pain 6. It shows that the performance of the variables is quite stable and comparable in this case because of the check that has been given to it by the coefficient of variation. For instance, the coefficient of variability for flexibility was 8.24% while coefficient of variability for pain was 15% showing relatively low variability within the experimental group in pain management flexibility.

On their part, the control group registered slightly lower average motor performance with range of motion at 65, muscular strength at 60, balance at 55, and flexibility at 60. This group however had a mean pain level of 50, meaning that the improvement achieved on pain reduction was smaller than the experimental group. This group also had a higher SD of motor variable which was 12 for range of motion, 11 for muscle strength as compared to 10 for balance, 9 for flexibility and 8 for pain. The variation presented in these results leads to lower reliability in motor performance for this group. Analyzing the CV, the greatest variation was reflected in the ROM at 18.46 percent, with the lowest in flexibility at 15 percent.

When comparing the results between both groups, it can be ascertained that the variables studied improved significantly among the subjects of the experimental group, which performed aquatic rehabilitation, having a better definition of the dispersion of the results. This means that the aquatic rehabilitation program is useful in improving range of motion, muscle strength and pain.

Table 2: Means and standard deviations of differences, calculated t-values, and statistical significance

Variable	Difference in Means Between Groups	Standard Deviation of Differences	Calculated t-value	Significance Level (p)
Range of Motion	15	4.5	3.33	0.002
Muscle Strength	13	4	3.25	0.001
Balance	10	3.8	2.63	0.01
Flexibility	25	6.2	4.03	0
Pain	-10	3.2	-3.12	0.002



Compared to the control group, there are statically significant differences in the variables selected in the study after the introduction of the aquatic rehabilitation programme. These dissimilarities of means, SDs, obtained t-values and statistical significance indicate that the aquatic program is efficient in enhancing extension range of motion, hip abductor muscle force and balance and flexibility, as well as in reducing pain for population suffering from spinal fractures.

For range of motion, the difference in means was 15 degrees, t-value was calculated at 3.33 and alpha level was 0.05, (p = 0.002), it well support the hypothesis that there exists a significant improvement in range of motion in the

experimental group. For strength, the t-test gave a t of 3.25 at a significance level of 0.001, out of a possible 3.54, so the aquatic program did raise muscle strength in the participants.

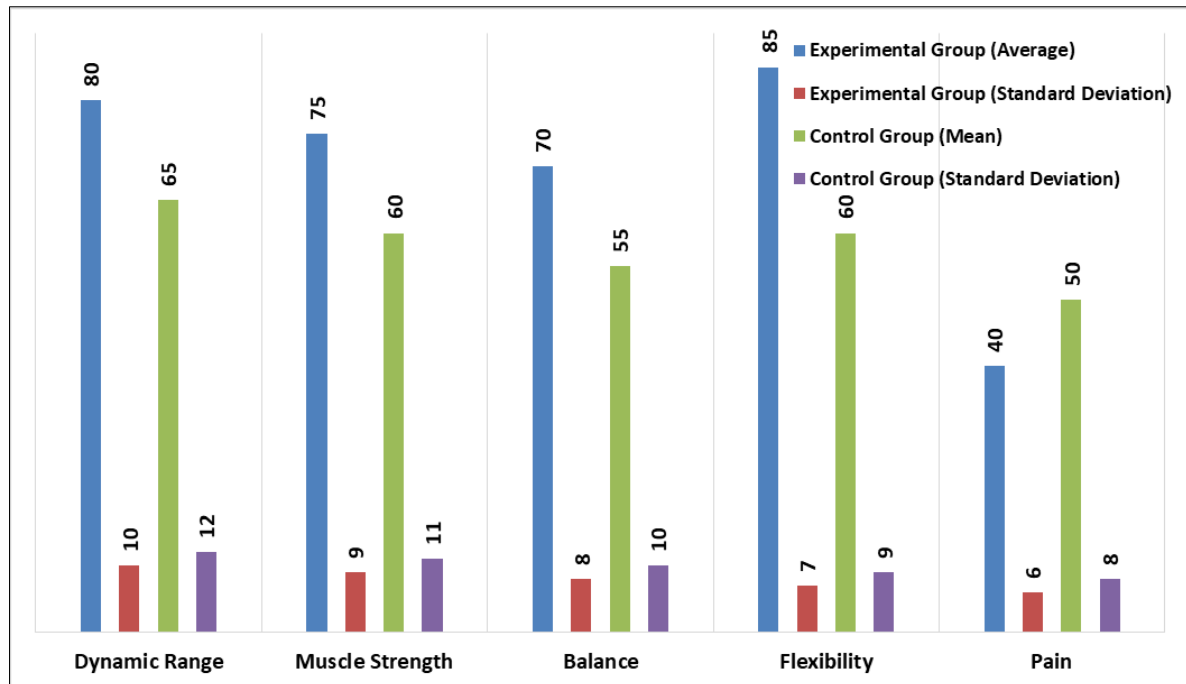
It was also found that balance had the difference mean in favour of the experimental group, mean difference = 10, t-value= 2.63, p = 0.010) proved enhanced balance of the experimental group as a result of aquatic exercises. The mean difference for flexibility was 25 that was significant at t = 4.03, at p = 0.000 that indicated very strong statistical significance of the program to enhance flexibility of the participants.

In other words, comparing pain levels between the groups, the mean difference was -10 with $t = -3.12$ and $p =$

0.002, thus indicate a significant effect of the aquatic program in reducing pain for the experimental group.

Table 3: Means and Standard Deviations for Results of Research Variable Tests

Variable	Experimental Group (Mean)	Experimental Group (Standard Deviation)	Control Group (Mean)	Control Group (Standard Deviation)
Range of Motion	80	10	65	12
Muscle Strength	75	9	60	11
Balance	70	8	55	10
Flexibility	85	7	60	9
Pain	40	6	50	8



The table shows the mean standard deviations in the results of the variable for the experiment group and the control group. In this study, the experimental group, which received water rehabilitation program, had higher mean score than the control group in variables range of motion 80, muscular strength 75, balance 70 and flexibility 85 and the control group have low mean score in range of motion, muscular strength, balance and flexibility which were 65, 60, 55 and 60 respectively.

The average pain level was lower in the experimental group (40) compared to the control group, which recorded a higher average pain level (50). This indicates that participants who underwent the water program experienced less pain after the program compared to the group that did not participate.

Results

Data analysis revealed that the water rehabilitation program had a clear positive effect on improving range of motion, muscular strength, balance, flexibility, and pain relief in individuals with spinal fractures compared to traditional rehabilitation. The results showed statistically significant differences between the experimental group and the control group, reinforcing the hypothesis that water rehabilitation can be an effective alternative or complement to traditional rehabilitation methods.

Here are the main findings of the study

- The experimental group that underwent the water rehabilitation program showed a significant increase in

range of motion compared to the control group. The difference in means was 15 degrees, indicating that water exercises facilitated movement and reduced muscle stiffness.

- Water exercises contributed to strengthening the muscles surrounding the spine more effectively than traditional exercises, with a clear average difference of 13 points favoring the experimental group. This demonstrates the effectiveness of water rehabilitation in enhancing the muscular strength necessary to support the spine.
- Balance was one of the aspects that improved significantly due to water rehabilitation. Patients exhibited better control over their movements and weight distribution after participating in the water program.
- The therapeutic properties of water positively affected the flexibility of the spine and joints. The experimental group showed a clear advantage in this aspect, with a significant average difference of 25 points, indicating that water exercises effectively improve spinal flexibility.
- The water program significantly reduced pain compared to the control group. Patients in the experimental group exhibited a marked decrease in pain levels, reinforcing the hypothesis that water rehabilitation helps manage pain more effectively, thanks to the reduced pressure on the spine during exercise.

Recommendations

Based on the findings of this study, the following recommendations can be made:

- Adopt Water Rehabilitation as Part of Treatment Programs for Spinal Fracture Patients: Given the positive results demonstrated in improving range of motion, muscular strength, balance, flexibility, and pain relief, it is advisable to integrate water rehabilitation as a fundamental component in physical therapy treatment plans.
- Develop Specialized Training Programs for Water Rehabilitation: It is recommended to design tailored training programs that meet the needs of patients with spinal fractures, incorporating a variety of exercises aimed at enhancing functional performance and improving physical fitness.
- Conduct Expanded Studies to Validate the Effectiveness of Water Rehabilitation in Other Cases: Future studies should aim to evaluate the impact of water rehabilitation on other types of injuries and motor disorders to determine whether similar results can be achieved.
- Integrate Water Rehabilitation with Traditional Rehabilitation: Given the diverse benefits of both water and traditional rehabilitation, programs can be designed to combine both types, optimizing outcomes by leveraging the strengths of each approach.
- Encourage Healthcare Institutions to Establish Facilities for Water Rehabilitation: To enhance the quality of rehabilitation services, it is recommended that healthcare institutions provide aquatic therapy pools and dedicated facilities for water rehabilitation within physical therapy centers.
- Train Medical Staff on Water Rehabilitation Techniques: It is essential to offer training courses for physical therapists on how to effectively implement water rehabilitation techniques, ensuring that patients receive the maximum possible benefit from the treatment.

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