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The Effect of Neuromuscular Control Exercises on the Rehabilitation of General Strength and Overall, Balance in Stroke Sequelae for Men with Temporary Hemiplegia Aged (50–55) Years

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Abstract

The study aimed to design neuromuscular control exercises for the rehabilitation of men aged (50–55) years with temporary hemiplegia and to identify the effect of these exercises on restoring general strength and overall body balance in stroke sequelae. The researcher hypothesized that there would be statistically significant differences between the pre- and post-test results of the experimental and control groups in general strength and overall body balance, as well as statistically significant differences in the post-test results between the two groups in favor of the experimental group. The experimental method was adopted using a two-group design (experimental and control) on a sample of (11) patients intentionally selected through a comprehensive sampling method (100%) from men aged (50–55) years with temporary hemiplegia who attended the physiotherapy department at Baghdad Teaching Hospital. After determining the research tests and preparing the rehabilitation exercises, the program was implemented for (8) weeks, comprising (40) daily rehabilitation sessions, excluding Fridays and Saturdays, for the experimental group. After completing the experiment and statistically analyzing the data using SPSS, the results indicated that neuromuscular control exercises are appropriate for rehabilitation sessions for men aged (50–55) years with temporary hemiplegia. Their application contributed to restoring general strength and improving overall body balance associated with stroke sequelae. The researcher recommended considering patients' capabilities and injury severity when designing neuromuscular control exercises, as well as promoting continuous collaboration between academic

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specialists in sports rehabilitation and physiotherapists to accelerate recovery from stroke-related impairments in this population.

Keywords: Rehabilitation exercises, neuromuscular control, general strength, overall balance, temporary hemiplegia.

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Introduction

In a healthy individual, there is a coordinated and balanced integration of the activities of different parts of the nervous system. The outcome of these neural activities at any given moment produces motor responses that reflect both the intensity and direction of this integration. In physical exercise, the role of the sensory system cannot be neglected, as it transmits information to the brain, in addition to receptors distributed throughout skeletal muscles—such as Golgi tendon organs and muscle spindles—which play protective and informational roles, as well as cutaneous receptors. The efficiency of these receptors facilitates joint movement to its maximum range. Furthermore, the vestibular balance system and reflexes responsible for maintaining balance operate through reciprocal muscular actions, such as crossed extension, withdrawal, and flexion reflexes, in addition to the biochemical processes that explain their mechanisms, including acetylcholine and sodium and potassium ions (Al-Nusairi & Naji, 2015).

Post-stroke neural dysfunction that affects voluntary muscles is an important characteristic of stroke. Symptoms can include incoordination, hyperactive or hypo active movements, and a combination of the two. Sensory disruptions and speech and language deficits might coexist with these conditions (Al-Shafie, 2010). Hemiplegia following stroke reflects an impairment of neuromuscular control in the complex neural system among men aged 50–55 years, where there is a loss of general strength and body balance, particularly at early stages after injury because of depressed neural activity and voluntary muscular control.

Hemiplegia is among the most frequent sequelae of stroke and refers to paralysis on one side of the body. It may also include lack of sensation and limited control over voluntary muscle movements, with treatment methods based on severity and location of the stroke as well as its impact on brain tissue (Kim & Lee, 2017). Temporary hemiplegia can be caused by any damage in the pyramidial tract from cerebral cortex to the segmental centre of spinal cord; and that may be accompanied with problems related to movement, posture or both because of central nervous system dysfunction (Al-Adrious, 2020). Stroke presents with a heterogeneous constellation of symptoms and impairments, which can be described in terms of a spectrum of motor disabilities (Lok, 2017).

Men aged 50–55 years are among the most vulnerable groups to stroke-related hemiplegia, and physical rehabilitation programs can be applied either after medical treatment or concurrently to restore neuromuscular control in affected body parts (Al-Ghanem, 2023). Given that this injury negatively affects the mechanical function of muscular contraction and the maintenance of balance, rehabilitation specialists must possess a sound understanding of functional neuromuscular anatomy.

The nervous system is composed of varying types of neurons projecting from the brain and spinal cord which are myelinated or unmyelinated with structural properties affecting the efficacy of neural conduction (Al-Ali & Hussein, 2016). Once the neural impulse arrives at the neuromuscular junction and acetylcholine is released, sodium ions flow into individual muscle fibers creating an action potential that propagates down the muscle membrane. Calcium ions are subsequently released from sarcoplasmic reticulum, leading to actin and myosin interaction,

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which results muscle contraction (Guyton & Hall, 2020). The strength of the response is proportional to the strength of stimuli because muscle fibres differ in this property; some fibres are sensitive to weak stimuli (high excitability) and other require strong stimulus (low excitability) to respond (Jalal Al-Din, 2007).

Various rehabilitation programs have been implemented for functional deficits due to nonfatal stroke-induced temporary hemiplegia. Rehabilitation should be effective by combining more than one therapy modality within a session, designing exercises depending on the type of lesion, taking into account that recovery is slow and paying attention to patient individual differences. Rehabilitation regimes should not use very high training loads or ask patients to complete tasks beyond their capacity (Al-Ghalib, 2024). Furthermore, muscle strength cannot be increased without proper resistance to match the nature of injury and rehabilitation aims (Bhatt et al., 2015). The role of sports rehabilitation is to strengthen muscles, preserve joint flexibility, prevent muscular atrophy and stiffness as well as restore tissue vitality to aid recuperation process (Kamel, 2017).

The importance of studying stroke sequelae associated with temporary hemiplegia in men aged 50–55 years lies in both theoretical and practical aspects.

Theoretical significance

- Directing academic attention in sports rehabilitation toward the importance of neuromuscular control exercises in rehabilitating stroke-related hemiplegia.
- Enriching the literature in sports rehabilitation and supporting researchers by highlighting the value of neuromuscular control exercises for this population.

Practical significance

- Providing structured neuromuscular control exercises for rehabilitating stroke sequelae in men aged 50–55 years with temporary hemiplegia.
- Guiding professionals in the Physiotherapy Department at Baghdad Teaching Hospital and supporting the requirements necessary for implementing such rehabilitation exercises.

Through reviewing stroke-related impairments in this population and the role of physical therapy in restoring movement by improving muscular strength and overall body balance—two key indicators of recovery—the researcher observed, during visits to the Physiotherapy Department at Baghdad Teaching Hospital, a noticeable delay in restoring general strength and balance. This delay is attributed to the complexity of neuromuscular recovery processes, which require repeated practice with low resistance and specialized neuromuscular control exercises to support rehabilitation efforts for this group of patients.

Accordingly, the study aimed to design neuromuscular control exercises for men aged 50–55 years with temporary hemiplegia and to identify their effect on improving general strength and

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overall body balance in stroke sequelae. The researcher hypothesized that there would be statistically significant differences between the pre- and post-test results of both the experimental and control groups in general strength and overall balance, as well as significant differences between the post-test results of the two groups in favor of the experimental group.

Methods and Procedures

The experimental method was adopted using a pre- and post-test design with two equivalent groups (experimental and control) under controlled conditions.

The research population consisted of men aged (50–55) years with temporary hemiplegia resulting from stroke sequelae who attended the Physiotherapy Department at Baghdad Teaching Hospital, Medical City. The total number of patients was (11), all of whom were intentionally selected using a comprehensive sampling method (100%). They were then divided into two groups according to the requirements of the experimental design. One group was randomly assigned as the experimental group (5 patients), while the other served as the control group (6 patients). The selection was based on their direct representation of the research problem population. Procedurally, the sample included patients who had experienced stroke within (4–6) days, were non-athletes by nature, and had no previous medical history of other diseases, as confirmed by MRI examinations for each participant.

To ensure internal validity, the homogeneity of the sample was statistically verified in several extraneous variables, as shown in Table (1).

Table 1. *Homogeneity of the main research sample in selected extraneous variables*

Extraneous variables	Unit	N	Mean	SD	Skewness
Body Mass Index (BMI)	kg/m²	11	21.55	1.214	0.692
Chronological age	Years	11	52.18	1.601	0.892
Duration of injury	Days	11	4.91	0.701	0.123
Type and severity of injury	Mild; participants at the physiotherapy stage				

BMI = body mass (kg) / height squared (m²); skewness values ranged within acceptable limits (±1).

To measure the dependent variables representing recovery from stroke sequelae, guidance from physicians at the Physiotherapy Department in Baghdad Teaching Hospital was adopted. General body strength was assessed using a handgrip strength test (Appendix 1) for both clinical and normal cases, employing a hydraulic electronic dynamometer measured in kilograms, appropriate for the apparent weakness in finger flexor muscles associated with the condition (Sayed, 2019).

Overall body balance was assessed using the Berg Balance Scale, a standardized clinical test with a total score ranging from (0–56) (Al-Ansari, 2009).

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Protocol for preparing and implementing neuromuscular control exercises

Rehabilitation responsibility lies with the sports rehabilitation specialist, who is required to design, implement, and supervise rehabilitation programs, as well as possess adequate competence to provide appropriate care following injury (Abdel Nabi & Hashoush, 2018). Accordingly, the following steps were undertaken in preparing neuromuscular control exercises for men aged (50–55) years with temporary hemiplegia:

- Reviewing numerous relevant scientific studies and specialized references related to stroke sequelae and temporary hemiplegia.
- Conducting preparatory steps prior to designing the rehabilitation exercises by examining the types of physiotherapy exercises currently provided to patients in the Physiotherapy Department at Baghdad Teaching Hospital.
- Determining the specific objective of each exercise in rehabilitating patients and restoring their general strength and overall body balance.
- Ensuring continuity of comprehensive medical care and periodic evaluation by physicians in the Physiotherapy Department.
- Determining the difficulty level of neuromuscular control exercises by calculating the longest duration of balance and dynamic stability and identifying the highest tolerable light resistance, based on the principle of progression from simple to more complex exercises.

Muscle strength and overall body balance were considered key indicators of recovery from stroke sequelae. The proportion and intensity of exercises across rehabilitation sessions were structured based on the concept that neuromuscular control depends largely on strengthening muscular contraction and coordination, as illustrated in Figure (1).

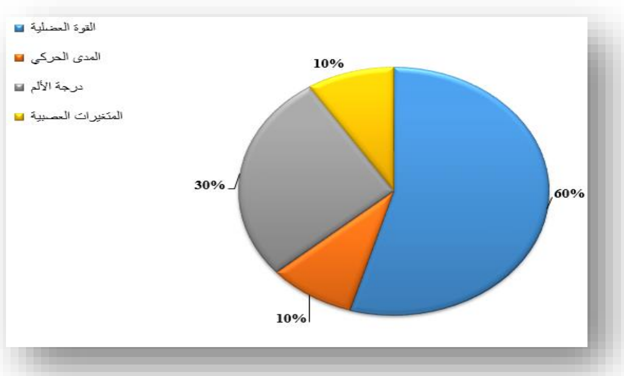

Figure 1. *Distribution of percentages across different neuromuscular control rehabilitation exercises*

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The researcher applied a pilot on the (4) patients extracted in the same sample of this study patients, 2 from each group at Baghdad Teaching Hospital/ Physiotherapy Department on Tuesday (19/11/2024). No notable difficulties were encountered.

The duration of implementing the neuromuscular control rehabilitation exercises in each session ranged from (25.32) to (29.24) minutes. Five sessions were conducted per week on (Sunday, Monday, Tuesday, Wednesday, and Thursday), with (4) exercises in each session. The program continued for (8) consecutive weeks, resulting in a total of (40) rehabilitation sessions, as shown in Appendix (2).

The content of the neuromuscular control rehabilitation exercises, organized according to the three stages of rehabilitation, included the following:

- Exercises involving attempts to move the affected arm toward nearby points without resistance, alternated with movements of the affected leg (5 sessions).
- Exercises involving grasping nearby objects (5 sessions).
- Light-resistance pulling exercises using a spring attached to the bed (5 sessions).
- Light-resistance isometric contraction exercises using an elastic band (level 1), holding for a specified duration according to the patient's ability (5 sessions).
- Light-resistance dynamic contraction exercises using an elastic band (level 1) (5 sessions).
- Light-resistance dynamic contraction exercises using kettlebells and dumbbells weighing (0.5 kg) (5 sessions).
- Static balance and dynamic stability exercises (5 sessions).
- Dynamic balance exercises (5 sessions).

The research experiment began with administering the pre-tests to the participants aged (50–55) years, totaling (11) patients. These tests were conducted at Baghdad Teaching Hospital / Physiotherapy Department at 10:00 a.m. on Wednesday (20/11/2024).

Neuromuscular control rehabilitation exercises were applied to the experimental group during their physiotherapy treatment at Baghdad Teaching Hospital / Physiotherapy Department from Sunday (24/11/2024) to Thursday (16/1/2025). The control group continued receiving the standard rehabilitation program followed at the same hospital.

Post-tests were administered to both research groups on Sunday (19/1/2025), after completing the neuromuscular control rehabilitation program.

After completing the experiment, the researcher statistically analyzed the data using the SPSS software package to extract the percentage, mean, standard deviation, skewness coefficient, and paired-samples t-test values.

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Results

Table 2. *Pre-test results between the two research groups*

Variables and unit of measurement	Group (N)	Mean	SD	Levene	Sig	t	Sig	Difference
General body strength (kg)	Experimental (5)	0.55	0.071	0.048	0.831	0.237	0.818	Not significant
	Control (6)	0.56	0.069					
Berg overall body balance (score)	Experimental (5)	4.8	3.633	0.602	0.458	0.692	0.506	Not significant
	Control (6)	6.17	2.927					

Baseline equivalence was confirmed, as no statistically significant differences were found between the two groups (Sig > 0.05, df = 9).

Table 3. *Pre- and post-test results for each research group*

Variables	Group (N)	Comparison	Mean	SD	t	Sig	Difference
General body strength (kg)	Experimental (5)	Pre	0.55	0.071	26.151	0.000	Significant
		Post	30.28	2.54			
	Control (6)	Pre	0.56	0.069	38.486	0.000	Significant
		Post	24.243	1.563			
Berg overall body balance (score)	Experimental (5)	Pre	4.8	3.633	28.562	0.000	Significant
		Post	54.6	0.894			
	Control (6)	Pre	6.17	2.927	27.129	0.000	Significant
		Post	45.17	3.656			

Differences were statistically significant (Sig < 0.05) at a degree of freedom of (n−1) and a significance level of (0.05).

Table 4. *Post-test results between the two research groups*

Variables and unit of measurement	Group (N)	Mean	SD	t	Sig	Difference
General body strength (kg)	Experimental (5)	30.28	2.54	4.851	0.001	Significant
	Control (6)	24.243	1.563			
Berg overall body balance (score)	Experimental (5)	54.6	0.894	5.585	0.000	Significant
	Control (6)	45.17	3.656			

The differences were statistically significant (Sig < 0.05) at a degree of freedom of (9) and a significance level of (0.05).

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Discussion

A review of the results presented in Table (3) indicates that participants in both the experimental and control groups showed improvements in general body strength and overall balance in the post-tests compared with the pre-tests. However, the results of Table (4) demonstrate that the experimental group outperformed the control group in both general strength and overall body balance, which are key indicators of recovery from stroke sequelae among men aged (50–55) years with temporary hemiplegia.

This researcher stated that this betterment and superiority in the experimental group is due to applying neuromuscular control exercises, which were safe, compatible with patients' capabilities and without extremely difficulty or pressure on the nervous system it). The progression of the exercises was controlled and their contents were varied: repetitions depended on each patient's tolerance indicating that individual differences might be more important. Both sensory–motor stimulation of peripheral nerves and functional movement patterns in variable positions for the muscles involved were included. Most important, the fact that a low level of resistance was used in both isometric and dynamic contractions should be considered safe, but also very useful as part of resuming general strength and balance in people who have experienced stroke.

The improvement observed in the experimental group can be explained by the integration of these factors, which placed patients in rehabilitation situations characterized by simplicity, progression, and frequent repetition. This facilitated the recovery of neural functions related to neuromuscular control and the reorganization of motor programs governing the contraction of muscles in the affected limbs, particularly the arms and legs.

Rehabilitation in patients with hemiplegia need to consider some points, especially during the exercise, a sense of security and should not put pressure on affected nerve or submitting the patient to exercise he is unable to make it (Khadam 2022). Physical therapy for stroke-induced hemiplegia generally includes muscle strengthening and movement exercises to improve the posture of affected extremities (Rudy, 2018). Management modalities will vary based on the features and severity of disease, including motor rehabilitation, physiotherapy, medical treatment and possibly surgery (Al-Hajilan, 2019).

In addition, motor rehabilitation exercises have been demonstrated to promote neural growth and increase the generation of neurotrophic factors necessary for nerve development. Research also suggests the ability of physical activity to promote better cerebral blood flow and increasing cognitive function (Ludyga et al., 2016). It is, therefore, widely regarded that sports rehabilitation as a purposeful and goal-oriented process performed by professionals to increase the functional capacity of the injured body part and subjecting it back to pre-injury conditions with minimal chance of any deformity or dysfunction (Bunwan, 2019).

Physical responses of the body as seen in tissue growth and function are the result of muscle resistance training. Rehabilitation of the injured muscle, on the other hand is not same as training healthy muscles and should be done based on injury type and severity with slow increase in intensity, in a progressive manner without excessive load that can lead to further damage. It is thus imperative that practitioners who are rehabilitating athletes use a safe, scientifically sound

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approach to resistance application versus one of commercial vanity (Thabit, 2018). Repetition is one of the significant factors that have been regarded as essential elements of rehabilitation exercise load, it enhances neural function and promotes neuromuscular control required for restoring natural movement patterns (Jwan, 2023).

Improvements in muscular strength and balance on both sides of the body form the foundation for proper posture and contribute to correcting body alignment, while strength training in different positions enhances balance through repeated exposure and the equalization of dynamic moments (Al-Qatt, 2020; Jack, 2016).

Conclusions

Neuromuscular control exercises are appropriate for rehabilitation sessions for men aged (50–55) years with temporary hemiplegia.

1. The application of neuromuscular control exercises contributes to restoring general strength following stroke-related impairments in this population.
2. Neuromuscular control exercises help restore overall body balance in patients with temporary hemiplegia after stroke.
3. It is essential to consider the capabilities and severity of injury among men aged (50–55) years with temporary hemiplegia when designing neuromuscular control rehabilitation exercises.
4. Continuous collaboration between academic specialists in sports rehabilitation within colleges of physical education and sports sciences and therapists in rehabilitation departments is necessary to accelerate recovery from stroke sequelae among men aged (50–55) years with temporary hemiplegia.

Appendix 1. *Description of the Handgrip Strength Test*

- **Test objective:** To measure handgrip strength.
- **Equipment and tools:** An electronic dynamometer with a measurement range of (0–150) kg (Figure 2).
- **Test description:** The patient holds the electronic device in the grip of one hand (right or left) and then squeezes the device as forcefully as possible.
- **Instructions and test conditions:**

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- The arm holding the device must not touch any external object or the patient's own body.
- Avoid swinging or pendulum movements of the arm during performance.
- Three attempts are performed, and the best attempt is recorded.
- The measurement display must be reset to zero after each attempt.

- **Recording:** The best value obtained from the three attempts is recorded for the patient.
- **Unit of measurement:** Kilograms (kg).

Figure 2. *Image of the handgrip strength measuring device*

Appendix 2. *Examples of selected rehabilitation exercises*

Rehabilitation session (21):

1. Contraction exercise using a 0.5 kg dumbbell:
- Sitting on a chair at a 90° angle or standing with feet shoulder-width apart.
- Hold the dumbbell in the affected arm directed downward with arms extended at the sides.
- Gradually flex the affected arm at the elbow to the maximum possible contraction.
- Hold for 5 seconds, then slowly return to the starting position.

2. Dynamic contraction using a level (1) elastic band:

- Stand with feet shoulder-width apart and hold the elastic band handle in the affected hand.
- Gradually flex the affected arm at the shoulder (without bending the elbow) until the band reaches shoulder height while maintaining body stability.
- Hold for 5 seconds, then slowly return to the starting position.

3. Reverse contraction using a 0.5 kg kettlebell:

- Stand with feet shoulder-width apart and hold the kettlebell in the affected hand.
- Gradually raise the affected arm laterally from the shoulder until the kettlebell reaches shoulder height.
- Hold for 5 seconds, then slowly return to the starting position.

4. Elastic band contraction with coordinated arm and leg movements:

- Combine arm exercises with leg movements such as pulling, extending, and contracting (e.g., backward pulling), while stabilizing the non-affected leg.

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