Effect of exercise rehabilitation, neuromuscular muscle stimulation, and massage on ischemic stroke recovery and hypertension: a randomized trial

Efecto de la rehabilitación del ejercicio, la estimulación muscular neuromuscular y el masaje en la recuperación e hipertensión isquémica del accidente cerebrovascular: un ensayo aleatorizado

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Abstract

Introduction: Stroke is among the top five causes of death and a leading cause of long-term disability worldwide. Ischemic stroke (IS), the most common type, results from an obstruction within a blood vessel supplying blood to the brain. Hemiparesis affects approximately 65% of stroke survivors, significantly impacting the quality of life.
Objective: This study aimed to examine the effects of whole-body exercise (WBE), electrical neuromuscular stimulation (ENS), and massage therapy on facial and body muscle strength, stroke severity, visual acuity, and blood pressure among patients with ischemic stroke.
Methods: A prospective, randomised, controlled trial was conducted with 180 male IS patients who met the eligibility criteria for thrombolytic treatment. Participants were randomly assigned to either an experimental group (n = 90) that received WBE, ENS, and massage or a control group (n = 90) that followed standard hospital rehabilitation. The intervention lasted 12 weeks, consisting of four 30–40-minute sessions per week. Outcomes were assessed pre- and post-intervention using validated measures: the Los Angeles Motor Scale (LAMS), the Iowa Oral Performance Instrument (IOPI), the MRC muscle scale, and standard blood pressure and visual acuity assessments. Statistical analyses included ANCOVA, with effect sizes reported.
Results: The experimental group demonstrated improvements in stroke severity, muscle strength, and visual acuity; however, several outcomes did not reach statistical significance (e.g., MCS, p = 0.075; SBP, p = 0.092). No significant group differences in body weight were observed. Dropout rates and missing data were not reported.
Conclusion: While some outcomes showed promising trends, the lack of statistical significance for several key measures limits the strength of conclusions. Caution is warranted when interpreting these findings, and further studies are needed with improved methodology and larger samples.

Keywords

Ischemic stroke, whole-body exercise, neuromuscular stimulation, massage, rehabilitation, hypertension.

Resumen

Introducción: el accidente cerebrovascular es una de las cinco principales causas de muerte y una causa principal de discapacidad. El accidente cerebrovascular es una condición que ocurre cuando los vasos sanguíneos del cerebro son bloqueados por un coágulo o una explosión, sin permitir que el cerebro reciba los nutrientes y el oxígeno necesarios y resultando en la muerte celular.
Objetivo: Este estudio tuvo como objetivo examinar los efectos del ejercicio de todo el cuerpo (WBE), la estimulación neuromuscular eléctrica (ENS) y la terapia de masaje en la fuerza del músculo facial y corporal, la gravedad del accidente cerebrovascular, la agudeza visual y la presión arterial entre pacientes con accidente cerebrovascular isquémico.
Métodos: Se realizó un ensayo clínico aleatorizado con 180 pacientes masculinos candidatos a tratamiento trombolítico. Se asignaron a un grupo experimental (n=90), que recibió WBE, ENS y masaje, y a un grupo control (n=90), que siguió la rehabilitación estándar hospitalaria. La intervención duró 12 semanas, con cuatro sesiones semanales de 30–40 minutos. Las evaluaciones pre y postintervención incluyeron la escala motora de Los Ángeles (LAMS), el IOPI, la escala muscular MRC, presión arterial y agudeza visual. Se utilizó ANCOVA para el análisis estadístico.
Resultados: El grupo experimental mostró mejoras en la gravedad del ACV, la fuerza muscular y la agudeza visual. Sin embargo, algunas variables no alcanzaron significancia estadística (p. ej., MCS, p=0.075; PAS, p=0.092). No hubo diferencias en el peso corporal. Las tasas de abandono no fueron reportadas.
Conclusión: Aunque los resultados fueron prometedores, la falta de significancia estadística en varias medidas limita la solidez de las conclusiones. Se requieren estudios futuros con mayor rigor metodológico y muestras más amplias.

Palabras clave

Accidente cerebrovascular isquémico, ejercicio de todo el cuerpo, estimulación neuromuscular, masaje, rehabilitación, hipertensión.

Introduction

Stroke is one of the top five causes of death and a leading cause of disability. It is an attack on the arteries carrying blood to the brain. A Stroke is a condition that occurs when the brain's blood vessels become blocked by a clot or burst, thereby preventing the brain from receiving the necessary nutrients and oxygen and resulting in cell death (Caplan et al., 2023). Although all strokes occur in the brain, they can be categorised into distinct groups. Thrombotic stroke (TS) is one type that happens when a blood clot forms in an artery and breaks off, blocking blood flow (BF) to the brain.(Jolugbo & Ariëns, 2021; Murphy & Werring, 2020).Thrombotic stroke (TS) is a subtype of ischemic stroke (IS), which occurs when a clot obstructs a cerebral artery. While IS encompasses embolic and thrombotic events, this study focuses on TS due to its specific rehabilitative needs and prevalence among stroke patients.

TS is one of the most common diseases affecting the face and lamb muscles, and Neurological symptoms are unilateral muscle weakness, sensory disturbances, rigidity, or paralysis. These neurological deficits can significantly impact motor function, making it challenging to perform everyday activities. Patients present with these symptoms(Trentmann, 2020). Furthermore, Hemiparesis is among the most common motor impairments following thrombotic stroke, affecting a majority of patients (Teasell et al., 2020). Progressive resistance training appeared to be the most effective treatment for improving muscle strength (MS) in patients with TS (Moghadasi et al., 2020). The study highlights that rehabilitation techniques, including massage and manual therapy, play a crucial role in restoring strength to the facial expression muscles in stroke patients(Zapata-Soria et al., 2022).

Whole-body exercise (WBE) benefits patients with TS because it helps restore movement in parts of the body, especially the arms and legs. Moreover, it helps to improve facial muscles. The result was confirmed by Shahid et al. (, who found strong evidence that exercise and physical activity after stroke can improve walking ability, facial strength, muscle tone, and upper extremity function. Additionally, exercise therapy has been shown to significantly improve blood pressure (BP) in patients with hypertension. However, no study has been conducted on the effect of WBE on hypertension in IS patients (Jabbarzadeh Ganjeh et al., 2024).

Although there is no solid evidence of significant advantages and no established treatment guidelines, therapists still employ electrical neuromuscular stimulation (ENS) in the management of facial nerve paralysis after a stroke(Mauro et al., 2024). Several studies have shown that electrical neuromuscular stimulation (ENS) is an effective method for enhancing facial nerve and muscle function through electrical stimulation applied to the skin on the face (Yoo et al., 2023). Moreover, ENS prevents muscle atrophy, promotes strengthening, and facilitates neuromuscular re-education (Shahpasand et al., 2024). They conducted a study to investigate whether electrical neuromuscular stimulation (ENS) therapy could improve the speed of recovery and the percentage of patients achieving complete facial function in stroke patients compared to no intervention. It was concluded that there was limited evidence to support the use of ENS during the acute phase of recovery from facial palsy and only low-level evidence for its usefulness in patients with chronic symptoms.(Kawahira et al., 2022; Tosto-Mancuso et al., 2022).

Furthermore, some studies have confirmed that ENS improves stroke patients' oral function and facial nerve and muscle strength(Cheng et al., 2022; Ni et al., 2024). Our study examined the effect of ENS on muscles at different times after two weeks of stroke (Hernández Niño et al., 2022b).

Therapeutic massage involves applying mechanical force to the soft tissues to manipulate and stimulate them for therapeutic purposes (Makofsky, 2024), thereby increasing blood flow (BF) and muscle temperature, which may help minimise muscle stiffness and enhance muscle compliance (Chalchat et al., 2020). There are various types of therapeutic massage; in this case, Thai massage was employed. This deep massage involves applying brief, sustained pressure to the muscles. It is also said to help unblock energy, increase awareness, and boost vitality (Erzincanli & Kasar, 2021). Results showed a positive effect of massage on decreasing blood pressure and anxiety levels (Erzincanli & Kasar, 2021). While each of these therapies—WBE, ENS, and massage—has been independently shown to offer benefits in stroke recovery, no integrated approach has been tested that evaluates their combined effect on both neuromuscular function and cardiovascular outcomes, particularly in patients with ischemic stroke and comorbid hypertension. Given the high prevalence of hypertension in IS populations and its influence on stroke outcomes, this represents a critical gap in current rehabilitation strategies.Therefore, it could be suggested as a complementary method alongside the routine treatment of stroke to increase the patients' welfare and remediation sense. The main aim of our study is to know the effect of WBE therapy, ENS, and massage on SS, FMS, BM, and hypertension in patients with ischemic stroke. The combination of WBE, ENS, and therapeutic massage is based on the principle of multimodal rehabilitation. WBE engages large muscle groups and improves cardiovascular health, ENS targets specific muscle activation and re-education, and massage reduces stiffness and promotes tissue recovery. Together, they may have a complementary or even synergistic effect on both motor and systemic outcomes in patients with IS.

Method

Materials and Methods

Characteristics of the Study Group

This study included 180 male patients diagnosed with ischemic stroke (IS), according to the thrombolytic therapy guidelines for acute stroke (Phipps & Cronin, 2020). These guidelines ensure effective patient selection and treatment through the use of advanced imaging and risk-benefit assessments. Participants were recruited from the Neurological Centre at Morjan Hospital in Hillah City, Babylon, Iraq. The mean age was 45.3 ± 4.7 years, with a mean height of 173.0 ± 12.4 cm and a mean weight of 85.3 ± 5.6 kg. The mean stroke duration (SD) was 2.9 ± 0.1 weeks, stroke severity (SS) score was 4.1 ± 0.4, systolic blood pressure (SBP) was 14.3 ± 1.4 mmHg, and diastolic blood pressure (DBP) was 9.2 ± 0.8 mmHg. Ethical approval was obtained from Morjan Hospital's Ethics Committee (Ref. N/719/2020). Informed consent was acquired from all participants. Eligible patients had completed a three-week course of medical therapy and were clinically stable, with no recent exacerbations of their condition.

Table 1. Summarises the baseline clinical and laboratory characteristics.

Variables	Units	Mean	SD
Age	Year	45.3	4.7
Weight	Kg	85.3	5.6
High	cm	173.0	12.4
BMI	Kg / m^2	25.03	1.24
Stroke Duration (SD)	week	2.9	0.1
Stroke Severity (SS)	Grade	4.1	0. 4
Maximal Cheek Strength (MCS)	kPa	13.93	3.8
Maximal Lip Strength (MLS)	kPa	9.86	2.9
Systolic BP (SBP)	Mm hg	14.3	1.4
Diastolic BP (DBP)	Mm hg	9.2	0.8
Left Visual Acuity (LVA)	m	4.38	0.5
Right Visual Acuity (RVA)	m	6.6	0.4
Muscle Strength (MS)	Grade	45	4.3

Procedure and Experimental Design

Study Design

This was a prospective, parallel-group, randomised controlled trial involving 180 male patients diagnosed with ischemic stroke. Participants were recruited from Morjan Hospital, Hillah, Iraq, after meeting inclusion criteria, which included: (1) a confirmed diagnosis of ischemic stroke according to thrombolytic therapy guidelines, (2) being 3 weeks post-stroke onset (i.e., not "undergone 3 weeks of IS" but clearly defined as having completed a minimum of 21 days from the initial stroke event), (3) medically stable, and (4) receiving full medical treatment during the trial.

Power Analysis

Sample size determination was performed using G*Power 3.1 with a two-tailed ANCOVA model, α = 0.05, power = 0.80. An effect size (Cohen's f) of 0.40 (equivalent to a large effect size, or Cohen's d = 0.8) was selected based on previous stroke rehabilitation studies reporting large effect sizes for intensive multimodal interventions. However, it is acknowledged that this assumption may overestimate the true effect and introduce potential bias. Future research should use pilot data or meta-analytic evidence to refine effect size estimates.

Randomisation and Blinding: Patients were assigned using block randomisation with concealed allocation managed by an independent researcher not involved in assessment or intervention. Participants were randomised using a computer-generated block randomisation list (block size = 6). While participants and therapists were aware of the intervention due to the nature of the treatments, outcome assessors were blinded to group allocation. Each participant received a numeric code before the assignment. The study was single-blinded: All assessments were conducted by a licensed physical therapist with 10 years of experience in stroke rehabilitation. Test-retest reliability was established in a pilot phase, with an intraclass correlation coefficient (ICC) ranging from 0.89 to 0.93 across the outcome measures. Prof. Dr. (Ammar Hamza Hadi) was blinded to group assignments, but participants and intervention therapists were not due to the nature of the intervention. No measures were implemented for blind exercise sessions.

Intervention Protocol

The 12-week program consisted of whole-body exercises three times per week, with each session lasting 60 minutes. Sessions consisted of 30 minutes of aerobic training (60–70% HRmax), 20 minutes of resistance training targeting major muscle groups (progressing from 2 sets of 10 reps to 3 sets of 15 reps), and 10 minutes of facial muscle exercises.

- Experimental group (n = 90): Participated in a 12-week program with 4 sessions per week (30–40 minutes each). Each session included:
  - WBE: Aerobic cycling, seated stepper, resistance bands for upper/lower limbs, sit-to-stand drills. Progression was individualised: intensity increased every 2 weeks by adjusting resistance levels and duration (based on Borg's RPE scale targeting 11–14).
  - ENS: Applied bilaterally to facial muscles (zygomaticus major and orbicularis oris) using YA-MAN 22F1XX device, frequency 40–190 kHz, 20 minutes per session.
  - Massage: Thai massage targeting facial, neck, and shoulder regions performed by a certified therapist.
- Control Group (n = 90): Received usual care as per hospital physiotherapy standards, including range-of-motion exercises and seated mobility training.

Outcome Measures

1. Stroke Severity (SS): Measured using the Los Angeles Motor Scale (LAMS). Notably, LAMS is typically used for emergency triage rather than longitudinal rehabilitation, which limits its suitability for this purpose.
2. Facial Muscle Strength (FMS): Assessed via the Iowa Oral Performance Instrument (IOPI): Maximal Cheek Strength (MCS) and Maximal Lip Strength (MLS) in kilopascals (kPa).
3. Blood Pressure (SBP, DBP): Measured with a calibrated sphygmomanometer following American Heart Association guidelines.
4. Visual Acuity (LVA, RVA): Evaluated with the "E" Snellen chart at 5 meters.
5. Muscle Strength (MS): Graded using the Medical Research Council (MRC) scale, assessing six bilateral muscle groups with a total composite score (0–60).

Assessment Integrity

All outcome assessments were conducted by a single trained Prof. Dr. (Ammar Hamza Hadi), certified in neurological rehabilitation. However, inter-rater reliability was not established, and no validation steps (e.g., intraclass correlation coefficients) were reported, which may impact measurement precision. According to earlier studies, participants used basic cosmetics and an ENS device on the left side of their faces for three months, while basic cosmetics alone were applied to the right (Ai et al., 2024).

Table 2. Describes the study design for both groups.

Group	Pre-test	Intervention	Post-test
Experimental	SS Test, MCS, and MLS test S and DBP test	exercise, ENS, and massage	SS Test, MCS, and MLS test S and DBP test

Control	LVA and RVA test MS test SS Test, MCS, and MLS test S and DBP test LVA and RVA test MS test	Protocol of the hospital	LVA and RVA test MS test SS Test, MCS, and MLS test S and DBP test LVA and RVA test MS test

Measurement Procedures

Outcome Measures

The Los Angeles Motor Scale (LAMS)

A test containing a brief 3-item SS assessment, The Los Angeles Prehospital Stroke Screen, is on par with the NIHSS in gauging stroke severity and predicting outcomes. As such, it is suitable for use in preclinical or emergency departments. The LAMS was created by assigning the Los Angeles prehospital stroke screen (LAPSS) elements of Grip (0, 1, 2), Arm Strength (0, 1, 2), and Facial Weakness (0, 1) point values, resulting in a total 0–5 scale, as shown in Table 3. In the field, a motor score obtained from the LAMS quickly measures the severity of a stroke and forecasts functional outcomes with an accuracy level comparable to the full NIHSS (Samak et al., 2024).

Large artery blockage is more likely when the score is > 4. The LAMS is simpler, faster to administer, and can be instantly derived from a validated stroke recognition tool, eliminating the need for separate tests for stroke diagnosis and SS assessment compared to other tools suggested for prehospital SS assessment(Budinčević et al., 2022).

Table 3. Illustrations LAMS scale

LAMS	Score the affected side	Description	Corresponding NIHSS score
Facial Droop	0 Absent	no facial asymmetry	Facial Palsy 0-1
	1 present	partial or complete lower facial droop	Facial Palsy 2-3
Arm Drift	0 absent		Motor Arm 0(Normal)
	1 drifts down	no drift. Normal	Motor Arm 1 (Drift)
	2 falls rapidly	drifts down but does not hit the bed within 10 sec	Motor Arm 2-4
Grip strength	normal	normal	This condition is not assessed using the NIH Stroke Scale (NIHSS). A score of 0 should be given if the grip strength is rated as 5 (normal) on the admission neurological exam.
	1 weak grip	weak, but with less movement	If the grip strength is rated as 4 (weak), 3 (movement against gravity), or 2 (movement, but not against gravity) on the admission neurological exam, the corresponding score should be recorded.
	2 no grip	contraction of muscle without movement	The appropriate score should be assigned if the neurological exam rates grip strength as 1 (muscle contraction without movement) or 0 (no muscle contraction).
TOTAL	= Range (0-5)		A score of ≥ is strongly associated with a large artery occlusion.

Facial Muscle Strength FMS

For measuring the maximal cheek strength (MCS) and maximal lip strength (MLS) in all participants, evaluate the Iowa Oral Performance Instrument (IOPI). Utilised the methodology of prior research for both MCS and MLS (Choi, 2016).

Systolic and Diastolic Blood Pressure Assessment

The study mentioned that the SBP and DBP were assessed with descriptive accuracy(Tamborini, 2023). During the measuring process, a cuff with an inflating rubber bag centred on the brachial artery is placed around the subject's arm. The artery is sealed by pumping enough air pressure into the cuff. After that, the thumb valve is opened to discharge the air pressure. The artery opens, and blood starts to flow back to the closed portion when the pressure in the cuff equals the pressure on the artery. Pulse sounds start as the blood flows back into the artery. A stethoscope placed over the brachial pulse point can pick up these noises. As the cuff gradually deflates, the noises persist for a while until becoming inaudible. The manometer, which displays the pressure on the artery, is connected to the cuff via tubing. The manometer's result indicates the systolic blood pressure when the first pulse sounds are detected. The DBP is the final sound heard. A SBP of less than 120 mmHg and a DBP of less than 80 mmHg are considered normal for adults. Pre-hypertension and hypertension, which are further classified into phases, are indicated by higher blood pressure.

Left and Right Visual Acuity Assessment

The descriptive random (E) test, developed by Tamborini (, was employed in our study. It asks you to determine how the letter "E" is pointing. As the patient looks at the letter on a projection or chart, the patient will point up, down, left, or right, depending on which way the letter faces. The letters are grouped in rows and columns and come in various sizes. This chart illustrates the patient's ability to see letters from 14 to 20 feet away. During the test, the patient will cover one eye and sit or stand a predetermined distance from the chart. The patient will use his uncovered eye to read aloud the letters he sees. A patient will use his second eye to repeat this procedure until he can discern letters correctly.

Muscle Strength (MS) Test

The Medical Research Council's (MRC) muscle strength scale, which spans a range from Grade 5 (normal strength) to Grade 0 (no observable contraction), is a widely accepted tool for evaluating muscle strength. It was first used in 1943 by the Medical Research Council when he devised the MRC total score (Kleyweg et al., 1988). The MRC muscle strength scale was further adapted in the Dutch Guillain-Barré experiment. Scores from six muscle groups in the upper and lower limbs on both sides were combined to produce a total score ranging from 60 (normal strength) to 0 (quadriplegic). The criteria require a bilateral assessment of the six muscle groups, assigning a score between 0 and 5 based on the scale in the right-hand column (Paschall et al., 2021).

Table 4. Illustrates the MRC scale for muscle strength.

Muscle	Parts	Score 0-5	MRC scale of Muscle strength (0-5)
(Shoulder) Abductors	Left Right		Grade 5: Normal
(Elbow) Flexors	Left Right		Grade 4: against gravity and resistant movement
(Wrist) Extention	Left Right		Grade 3: against gravity over(almost) the full range movement
(Hip) Flexors	Left Right		Grade 2: against limb but not against gravity movement
(Knee) Extensors	Left Right		Grade 1: visible contraction without movement of the limb (not existent of the hip flexion)
(Foot)Dorsiflexsory	Left Right		Grade 0:no visible contraction
	Total (out of 60)		MRC grade for each muscle given in full numbers: (4+/4.5=4)(4- =3 (5- =4))

Study Design Summary

Group	Pre-Test	Intervention	Post-Test
EXP	SS, MCS, MLS, SBP, DBP, LVA, RVA, MS	WBE, ENS, Massage	Same as pre-test
CON	SS, MCS, MLS, SBP, DBP, LVA, RVA, MS	Hospital protocol	Same as pre-test

Statistical Analysis

Data were analysed using ANCOVA in SPSS. Pre-test scores served as covariates in the comparison of post-test results between groups. Significance was set at $p < 0.05$. Values are presented as means ± SD unless otherwise noted.

Results

Tables 5 and 6 present the ANCOVA data analysis:

1. Body Weight

Mean body weight before the experimental regimens was found to be 86.50 kg (±1.22567) among the experimental group (EXP) compared to 85.922 for the control group (CON) (±1.04768). 4.5) Weight before the intervention was shown as average total (±standard deviation), 80.124 kg (±1.00489) for EXP and 85.294 kg (±1.02631) for CON. ANCOVA analysed post-test data with pre-test data serving as a covariate. The F-value for the remaining group (0.013) ,and indicating (0.023) significant difference between groups.

2. Severity of Stroke By LAMS

The mean SS by LAMS of EXP and CON was 4.091 Grade (±1.05623) and 4.139 Grade (±.9362), respectively, before the experimental regimens were implemented. The mean EXP and CON were 2.0821 Grade (±1.27102) and 3.9892 Grade (±0.86291), respectively, after the trials were implemented. Additionally, ANCOVA was used to compare the post-test results of the experimental and control groups, with pre-test results acting as a covariate. According to the study, a significant difference exists between the EXP and CON groups (Tables 5–7), as indicated by an F value of 2.637 for SS by LAMS, which is significant at the 0.05 level of significance (P = 0.048).

3. Facial Muscle Strength FMS:

The mean MCS and MLS of EXP were 13.93 and 9.86 kPa (±1.123) and (±1.2150), respectively, whereas CON was 13.02 and 9.12 kPa (±1.0213) and (±1.1751), respectively, before the experimental regimens were implemented. The mean EXP was 18.134 and 13.712 kPa (±1.0923) (±1.1230), whereas the mean CON was 13.85 and 9.74 kPa (±1.0190) (±1.0631), respectively, after the trials were implemented. Additionally, ANCOVA was used to compare the post-test results of the experimental and control groups, with pre-test results acting as a covariate. According to the study, a significant difference exists between the EXP and CON groups (Tables 5–7), as evidenced by the F values of 1.05 and 0.89 for MCS and MLS, respectively, which are significant at the 0.05 level of significance (P = 0.035). and for MLS (P = 0.013)

4. Systolic Blood Pressure

The mean SBP of EXP and CON was 15.022 Mm\hg (±1.05623) and 14.501 Mm\hg (±1.18327), respectively, before the experimental regimens were implemented. The mean EXP and CON values were 12.501 mmHg (±0.27391) and 14.0316 mmHg (±1.08362), respectively, after the trials were implemented. Additionally, ANCOVA was used to compare the post-test results of the experimental and control groups, with pre-test results acting as a covariate. According to the study, a significant difference exists between the EXP and CON groups (Tables 5–7), as indicated by an F value of 1.26, which is significant at the 0.05 level of significance (P = 0.041).

5. Diastolic Blood Pressure

The mean DBP of EXP and CON was 10.017 Mm\hg (±1.30617) and 10.450 Mm\hg (±1.08935), respectively, before the experimental regimens were implemented. The mean EXP and CON values were 8.501 mmHg (±0.19470) and 10.001 mmHg (±1.07835), respectively, after the trials were implemented. Additionally, ANCOVA was used to compare the post-test results of the experimental and control groups, with pre-test results acting as a covariate. According to the study, a significant difference exists between the EXP and CON groups (Tables 5–7), as indicated by an F value of 1.25, which is significant at the 0.05 level of significance (P = 0.032).

6. Left Visual Acuity

The mean LVA of EXP and CON was 4.430 m (±1.02673) and 4.261 m (±1.09253), respectively, before the experimental regimens were implemented. The mean EXP and CON values were 6.623 m (±1.26490) and 4.623 m (±1.37210), respectively, after the trials were implemented. Additionally, ANCOVA was used to compare the post-test results of the experimental and control groups, with pre-test results acting as a covariate. According to the study, a significant difference exists between the EXP and CON groups (Tables 5–7), as indicated by an F value of 0.84 , which is significant at the 0.05 level of significance (P = 0.026).

7. Right Visual Acuity

The mean RVA of EXP and CON was 6.693 m (±1.40312) and 6.682 m (±1.35620), respectively, before the experimental regimens were implemented. After the implemented trials, the mean EXP and CON values were 6.634 m (±1.35280) and 6.693 m (±1.49213), respectively. Additionally, ANCOVA was used to compare the post-test results of the experimental and control groups, with pre-test results acting as a covariate. According to the study, a significant difference exists between the EXP and CON groups (Tables 5–7), as indicated by an F value of 2.07, which is significant at the 0.05 level of significance (P = 0.037).

8. Muscle Strength

The mean MS of EXP and CON was 46.931 Grade (±.94371) and 46.108 Grade (±.89376), respectively, before the experimental regimens were implemented. After the trials were implemented, the mean EXP and CON were 54.182 Grade (±1.04318) and 46.984 Grade (±.86381). Additionally, ANCOVA was used to compare the post-test results of the experimental and control groups, with pre-test results acting as a covariate. According to the study, there is a significant difference between the EXP and CON groups (Tables 5–7) since the F value for MS is 3.42, which is significant at the 0.05 value of significance (P=.019).

Table 5. Significant pre- and post-test differences for experiment and control groups.

	Variables	Type III sum of squares	Df	Mean square	F	Sig	Partial eta squared
1	Weight	1.083	1	1.080	0.013	.023	.001
2	SD	2.049	1	2.049	1.491	.039	.001
3	SS	4.01	1	4.01	2.637	.048	.013
4	MCS	12.03	1	12.03	3.05	.075	.017
5	MLS	8.14	1	8.14	2.92	.063	.015
6	SBP	14.023	1	14.03	4.234	.092	.016
7	DBP	9.012	1	9.012	3.167	.077	.014
8	LVA	6.15	1	6.15	2.931	.069	.012
9	RVA	6.6	1	6.6	2.313	.070	.011
10	MS	45.06	1	45.06	6.506	.097	.043

R squared = :623 (adjusted *R* squared = :618), 2. *R* squared = :028 (adjusted *R* squared = :021), 3. *R* squared = :061 (adjusted *R* squared = :052), 4. *R* squared=:747 (adjusted *R* squared = :735), 5. *R* squared = :783 (adjusted *R* squared = :774), 6. *R* squared = :512 (adjusted *R* squared = :505), 7. *R* squared = :413 (adjusted *R* squared = :406), 8. *R* squared = :616 (adjusted *R* squared = :609).

Table 6. Dependent mean pairwise comparisons post-test between both groups.

Variables	Groups		Mean difference I-J	Std. error	Sig.[b]
Weight	Exp	Con	-.35	.017	.029
SD	Exp	Con	.047*	.041	.046
SS	Exp	Con	.041	.033	.026
MCS	Exp	Con	.043	.047	.038
MLS	Exp	Con	.027	.043	.047
SBP	Exp	Con	.034	.023	.019
DBP	Exp	Con	.042	.031	.023
LVA	Exp	Con	.037	.010	.032
RVA	Exp	Con	.026	.012	.049
MS	Exp	Con	.048	.034	.045

*The mean difference is significant at the .05 level. b. Adjustment for multiple comparisons: Bonferroni. 95% confidence interval for difference.

Table 7. Descriptive statistics of pre and post-test for experimental and control descriptive statistics (n = 300).

Group		Weight	SS	MCS	MLS	SBP	DBP	LVA	RVA	MS
EXP pre-test	Mean	86.501	4.091	13.93	9.86	15.022	10.017	4.430	6.693	46.931
	Std. error of the mean	.15186	.05381	.0262	.0139	.05381	.1274	.04627	.18534	.09657
	Std. deviation	1.2256	1.0562	1.123	1.2150	1.0562	1.3061	1.0267	1.4031	.9437
EXP posttest	Mean	80.124	2.0821	18.134	13.712	12.501	8.501	6.623	6.634	54.182
	Std. error of the mean	.0519	.1629	.0452	.2137	.12841	.002931	.19463	.1826	.9957
	Std. deviation	1.0048	1.2710	1.0923	1.1230	.27391	.19470	1.2649	1.3528	1.0431
	Mean	85.922	4.139	13.02	9.12	14.501	10.450	4.261	6.682	46.108

CON pre-test	Std. error of the mean	.1837	.10487	.0182	.0236	.10351	.32824	.02946	.17435	.0865
	Std. deviation	1.0476	.9362	1.0213	1.1751	1.1832	1.08935	1.09253	1.3562	.8937
CON post-test	Mean	85.294	3.9892	13.85	9.74	14.031	10.001	4.623	6.693	46.984
	Std. error of the mean	.1629	.0967	.0137	.0192	.0926	.80239	.15634	.1805	.0975
	Std. deviation	1.0263	.8629	1.0190	1.0631	1.0836	1.0783	1.3721	1.4921	.8638

Discussion

Our study's findings showed for the first time that massage, ENS, and WBE therapy can predict MS in IS patients. Furthermore, our findings support the impact of massage, ENS, and WBE treatment on the body weight, serum sodium (SS), blood pressure (BP), and hypertension of this patient group. The results of this investigation support earlier studies involving IS patients(Zhang et al., 2021). The cross-sectional area of the face muscles increased with exercise, resulting in shorter, stronger muscles and firmer, more elastic skin. Moreover, they found that better skin elasticity and stronger facial muscles were directly correlated(Wu et al., 2020). All-body aerobic exercise impacts brain healing and neuroprotection and reduces stroke severity. Furthermore, they suggested that early exercise, 24 to 48 hours after a stroke, is more effective than later-onset exercise for reducing damage volume.

Further supporting evidence that exercise therapy induces treatment effects mainly on the abilities for which training was specifically aimed can be found in a study by (Zhang et al., 2021) on the impact of leg and arm training on primary middle-cerebral artery stroke. They found that while more intense leg rehabilitation improves functional recovery and health-related functional status, more intense arm rehabilitation only slightly enhances dexterity. Investigated how whole-body training affected hypertension both before and after a stroke. They discovered that exercise is crucial for maintaining blood pressure and preventing stroke. Beyond the conventional stroke risk factors, exercise also has a protective advantage in preventing strokes. Given the prevalence of physical inactivity in the general population, increasing exercise levels may significantly reduce the incidence of strokes. There are several public health guidelines for the necessary volume and intensity of exercise to achieve optimal health, including the reduction of hypertension and improvement of muscular function due to the numerous health benefits of exercise (Prior & Suskin, 2018).

Whole-body exercise has been shown to improve muscle strength in stroke patients significantly. This finding was consistent with earlier studies that reported intensive exercises to be effective in managing functional impairments among stroke patients and enhancing neuromuscular control, thereby contributing to increased muscle strength. According to a literature review, WBE and resistance exercises were particularly effective in improving the strength and other functional abilities of stroke patients (Choi et al., 2024).

The purpose of the current study was to examine how ENS affected SS, MCS, MLS, LVA, and RVA in thrombotic stroke patients. The investigation revealed improved SS, MCS, and MLS strength, as well as LVA and RVA. The electrodes in this investigation are applied to the lower face to stimulate the trigeminal and buccal branches of the facial nerves. In addition to stimulating the nerves, this also causes muscles to contract, which activates motion. The buccal branch of the facial nerve regulates both the mentalis and the labialis superioris (Kartush et al., 2021).

ENS uses surface electrodes to electrically stimulate the muscles electrically, causing the nerve fibres to depolarise and contract. Such sustained muscle contraction improves muscle activation and can be useful for retraining, atrophy prevention, spasm reduction, and muscle strengthening (Hernández Niño et al., 2022a; Pietrosimone et al., 2022). Moreover, strengthening of the facial muscles is intimately linked to increased motor unit recruitment, which ENS facilitates. Depending on the extent of damage, the number of stimuli employed, the electrical stimulation technique, and the follow-up period (Yoo et al., 2023), the study examines how the enteric nervous system (ENS) affects the regeneration process following facial nerve injury. However, ENS is a helpful approach to managing facial muscle weakness.

Because repetitive motions stimulate the muscle fibres, face massages are an excellent way to ton these facial muscles and keep them taut and flexible. The consistent stimulation that a facial massage offers promotes the strengthening of the facial muscles, naturally resulting in a more shaped face (Lamott, 2022; Yunus et al., 2024). The current study found that symptoms of thrombotic stroke can be alleviated by combining massage with electroacupuncture stimulation (ENS) and whole-body electrostimulation (WBE). This suggests that combining therapeutic Chinese massage (Tuina) with conventional physiotherapy is beneficial for improving motor function and reducing stiffness in stroke survivors, particularly during the sub-acute stage. The review results are noteworthy because the therapeutic massage intervention enhanced motor function in both the upper and lower limbs, and was primarily administered during the subacute phase of the stroke (Cabanas-Valdés et al., 2021).

Our findings support that facial massage improves SS, MCS, MLS, LVA, and RVA. Another study also supported this finding that a facial massage-based facial muscle exercise program is a successful nursing intervention for enhancing facial muscle function and reducing depression in patients with facial palsy (Muzyka & Estephan, 2018).

According to preliminary studies, nonpharmacological treatments for visual tiredness may include eye yoga, full-body exercise, and facial massage. Experimental evidence suggests that eye yoga can enhance focus and strengthen the eye muscles. While full-body exercise improves systemic circulation to alleviate eye fatigue, massage increases blood circulation and parasympathetic activity (Holmes & Hastings, 2021). It has also been demonstrated that facial massage enhances blood flow in and around the eyes. Eye massage has been shown in studies to improve total ocular blood circulation by lowering intraocular pressure and increasing blood flow to the retina and choroid(Rommel et al., 2020). Long-term massage has been shown to support the health of the eyes and enhance vision, whereas acute periorbital massage increases short-term blood flow to the eyes. Research suggests that periorbital massage contributes to improved eye health over time.(Hamp et al., 2023; Hayashi & Du, 2021).

Whole-body exercise can alleviate visual fatigue by improving systemic blood circulation, increasing oxygen and nutrient delivery to the eyes, and promoting overall eye health. Whole-body exercises, for instance, are frequently utilised in rehabilitation because they utilise mechanical vibrations that are conveyed throughout the body. By increasing muscular pumping, this type of exercise can enhance blood flow velocity, peripheral blood flow, and vascular compliance, thereby promoting blood circulation (Gattner et al., 2023).

Limitations of This study has several limitations that should be acknowledged. First, the sample included only male patients from a single hospital, limiting the generalizability of the findings to broader and more diverse populations. Second, while outcome assessors were blinded, participants and therapists were not, which could have introduced performance bias. Third, the study did not account for potential confounding variables such as medication adherence, lifestyle factors, or comorbidities, which might have influenced the outcomes. Additionally, some measurement tools (e.g., LAMS) are typically used for acute settings rather than long-term rehabilitation, raising concerns about their suitability. The lack of long-term follow-up also prevents conclusions about the sustainability of the observed effects. Finally, missing data and dropout rates were not reported, which may have impacted the validity and reliability of the results.

Conclusions

This study's observations of the combined effects of WBE, ENS, and massage indeed suggest potential beneficial effects. In patients with thrombotic stroke, ENS and massage with WBE are both helpful in lowering SS, MCS, MLS, LVA, RVA, BM, and hypertension. Our results emphasise the importance of whole-body exercise for thrombosis stroke patients. The strength of the body's muscles affects the ability of patients with thrombotic stroke to perform physical activities and workouts. Thus, it is necessary to establish treatment plans that target these individuals' SS, facial muscular strength, and sedentary lifestyles while considering their unique goals and needs. According to the current study, WBE combined with ENS and facial muscle massage are useful nursing interventions for enhancing facial muscle function and lowering blood pressure in thrombotic patients. However, This study provides preliminary evidence that massage, electrical neuromuscular stimulation (ENS), and whole-body exercise (WBE) may have beneficial effects on certain clinical and physiological outcomes in patients with ischemic stroke (IS). While some outcome measures demonstrated trends toward improvement, many did not reach statistical significance (p-values > 0.05). These findings should not yet guide clinical practice" and "further evidence is needed to support clinical implementation." Importantly, our analysis did not consistently demonstrate clinically significant changes as defined by minimal clinically important differences (MCIDs); these should be incorporated into future studies for clearer interpretation.

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