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EFFECTIVENESS OF THERAPEUTIC PHYSICAL EXERCISE IN THE REHABILITATION OF STROKE PATIENTS

Abstract

Stroke poses a severe public health crisis in Uzbekistan and globally, with rising incidence driven by aging populations, urbanization, and lifestyle shifts. In Uzbekistan, stroke affects over 1.94 per 1,000 people annually, contributing to high mortality rates of 80.7 per 100,000, exacerbated by limited rehabilitation access in rural areas. Therapeutic physical exercise, involving tailored aerobic, strength, and balance routines, stands as a vital intervention to boost neuroplasticity, motor recovery, and independence, yet local evidence remains scarce. This randomized controlled trial, conducted in Tashkent, assesses a customized 12-week program to address these gaps, hypothesizing substantial gains in physical and functional outcomes to inform national health strategies.

Keywords: stroke rehabilitation; therapeutic physical exercise; neuromotor control; musculoskeletal function; mobility; activities of daily living; quality of life; randomized controlled trial; neuroplasticity

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ЭФФЕКТИВНОСТЬ ЛЕЧЕБНОЙ ФИЗКУЛЬТУРЫ В РЕАБИЛИТАЦИИ ПОСТИНСУЛЬТНЫХ БОЛЬНЫХ

Аннотация

Инсульт представляет собой серьезную проблему общественного здравоохранения в Узбекистане и во всем мире, причем рост заболеваемости обусловлен старением населения, урбанизацией и изменением образа жизни. В Узбекистане инсульт поражает более 1,94 человека на 1000 человек в год, что приводит к высокой смертности — 80,7 на 100 000 человек, усугубляемой ограниченным доступом к реабилитации в сельских районах. Лечебная физическая культура, включающая индивидуально подобранные аэробные, силовые и балансировочные упражнения, является жизненно важным методом для повышения нейропластичности, восстановления двигательных функций и самообслуживания, однако местные данные по этому вопросу остаются скудными. Данное рандомизированное контролируемое исследование, проведенное в Ташкенте, оценивает индивидуально

разработанную 12-недельную программу для устранения этих пробелов, предполагая существенное улучшение физических и функциональных результатов, что может послужить основой для национальных стратегий здравоохранения.

Ключевые слова: реабилитация после инсульта; лечебная физкультура; нейромоторный контроль; опорно-двигательная функция; подвижность; повседневная деятельность; качество жизни; рандомизированное контролируемое исследование; нейропластичность

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INSULTDAN KEYIN BEMORLARNI REABILITATSIYA QILISHDA DAVOLOVCHI JISMONIY TARBIYANING SAMARADORLIGI

Annotatsiya

Insult O'zbekistonda va butun dunyo bo'ylab sog'liqni saqlashning asosiy muammosi bo'lib, aholining qarishi, urbanizatsiya va turmush tarzining o'zgarishi bilan kasallanish ko'paymoqda. O'zbekistonda insult har 1000 kishiga har yili 1,94 kishidan ko'proq ta'sir ko'rsatadi, natijada o'lim darajasi yuqori bo'lgan 100 000 kishiga 80,7 ni tashkil etadi, bu esa qishloq joylarda reabilitatsiyadan foydalanish imkoniyati cheklanganligi tufayli yanada kuchayadi. Jismoniy terapiya, shu jumladan individual moslashtirilgan aerobik, kuch va muvozanat mashqlari nevroplastikani kuchaytirish, vosita funktsiyasini tiklash va o'z-o'zini parvarish qilishning muhim usuli hisoblanadi, ammo bu mavzu bo'yicha mahalliy ma'lumotlar kamligicha qolmoqda. Toshkentda o'tkazilgan ushbu randomizatsiyalangan nazorat ostida sinov ushbu bo'shliqlarni bartaraf etish uchun moslashtirilgan 12 haftalik dasturni baholaydi va bu jismoniy va funktsional natijalarda sezilarli yaxshilanishlarni taklif qiladi, bu esa milliy sog'liqni saqlash strategiyalarini bildirishi mumkin.

Kalit so'zlar: insultdan keyin reabilitatsiya; terapevtik mashqlar; neyromotor nazorat, harakat-tayanch tizimining funktsiyasi; harakatchanlik; kundalik hayot faoliyati; hayot sifati; randomizatsiyalangan nazorat ostidagi tadqiqot; neyroplastiklik

INTRODUCTION

Stroke emerges as an escalating epidemic in Uzbekistan, with incidence rates reaching 1.94 per 1,000 population amid rapid urbanization, sedentary lifestyles, and a surge in risk factors like hypertension affecting 40% of adults. Nationally, it ranks second in mortality at 80.7 per 100,000, straining healthcare systems already challenged by geographic disparities, where rural regions like Andijan lack specialized rehab facilities, leading to prolonged disabilities and economic losses exceeding 2% of GDP annually [1]. Globally, the crisis intensifies: 2021 recorded 12.2 million new cases, with 101 million survivors facing chronic impairments, and forecasts predict 21.4 million incidents by 2050 driven by aging demographics and climate-related vascular stresses [2,12]. These trends amplify socioeconomic impacts, with annual global costs surpassing $721 billion,

disproportionately burdening low-middle-income countries like Uzbekistan through lost productivity and caregiver strain [3].

Post-stroke deficits—hemiparesis, balance issues, gait disturbances, and cognitive declines—severely erode independence, yet therapeutic physical exercise offers a lifeline by harnessing neuroplasticity for recovery [4]. This involves systematic regimens of aerobic, resistance, and functional training to rebuild neural pathways, strengthen muscles, and boost endurance, as evidenced by BDNF upregulation in experimental models [5]. Historical inconsistencies in protocols—varying by onset timing, intensity, and duration—yield mixed results, with early interventions risking fatigue while delayed ones miss plasticity windows [6].

In Uzbekistan, where stroke cases rose 15% from 2019-2024 due to post-pandemic effects, rehabilitation gaps persist, with only 30% of survivors accessing structured programs, underscoring urgent needs for localized evidence [7]. Early exercise post-stroke can accelerate recovery but demands safety measures amid common comorbidities [8]. Broader access inequities, especially in remote areas, call for innovative, scalable solutions to align with national health reforms [9].

This trial bridges these voids through a Tashkent-based RCT evaluating a 12-week multimodal program, incorporating Uzbek cultural motifs for engagement. We posit superior outcomes in motor and functional domains, providing data to shape policies, reduce burdens, and enhance equity in stroke care amid projected global surges [10,11].

Materials and methods

This was a single-center, prospective, randomized controlled trial conducted at the Republican Scientific and Practical Medical Center of Neurology and Stroke in Tashkent, Uzbekistan. The study protocol was approved by the Ethics Committee of the Ministry of Health of Uzbekistan (Approval No. EC-MH-UZ-2022-112) and registered at ClinicalTrials.gov (NCT05873456). All participants provided written informed consent. The trial adhered to CONSORT guidelines.

Eligible participants were adults (≥18 years) with first-ever ischemic or hemorrhagic stroke confirmed by CT/MRI, recruited from the center's inpatient and outpatient departments between January 2023 and June 2025. Inclusion criteria: subacute phase (1-6 months post-stroke), mild-to-moderate disability (modified Rankin Scale 2-4), ability to ambulate with assistance, no severe cognitive impairment (MMSE ≥20), and physician clearance for exercise. Exclusion criteria: unstable medical conditions (e.g., uncontrolled arrhythmia, severe orthopedic issues), recent major surgery, or participation in other trials. Sample size (n=150) was calculated for 80% power to detect a 5-point BBS difference (SD=8, α=0.05, 20% dropout).

Participants were randomized 1:1 to intervention or control groups using stratified block randomization (blocks of 4) via sealed envelopes, stratified by age (<60/≥60) and stroke type. Allocation was concealed. Outcome assessors were blinded; participants and therapists were not due to intervention nature.

The intervention group underwent a 12-week multimodal program, customized based on initial assessments:

- Aerobic Training**:** Cycling or treadmill walking at 50-70% of maximum heart rate (calculated as 220-age), 20-30 min/session, progressing intensity weekly.

- Strength Training: Resistance exercises using bodyweight, bands, or light weights for upper/lower limbs (e.g., leg presses, arm curls), 2-3 sets of 10-15 repetitions, 2 sessions/week.
- Balance Training: Static (standing on foam) and dynamic (tandem walking) exercises, 10-15 min/session.
- Task-Specific Training: Functional activities like stair climbing, reaching, simulated ADLs, 15-20 min/session.

Sessions (45-60 min) occurred 3-5 times/week: supervised in-clinic (weeks 1-4), then home-based with video guides and weekly physiotherapist calls via Telegram for adherence monitoring. Compliance was tracked via logs (>80% required). The control group received standard care: pharmacological therapy, passive mobilization, and health education (1 session/week).

Assessments by blinded physiotherapists at baseline, 12 weeks, and 6 months:

- Primary: BBS (0-56, higher better), FMA (0-226, higher better), 10MWT (gait speed m/s), TUG (seconds, lower better).
- Secondary: BI (0-100, higher better), SS-QoL (49-245, higher better), MMSE (0-30, higher better), 6MWT (meters, higher better). Safety monitored via adverse event logs.

Data analyzed using SPSS v26. Normality checked (Shapiro-Wilk). Baseline comparisons: t-tests/chi-square. Group-time effects: repeated-measures ANOVA/MANOVA. Post-hoc: Bonferroni. Effect sizes: Cohen's d. Intention-to-treat with last-observation-carried-forward for missing data (<15%). Subgroup analyses: by stroke phase/type.

Results

Of 178 screened individuals, 150 were randomized (75 per group), with 138 completing the study (92% retention rate). Baseline characteristics were well-balanced across groups, as evidenced by non-significant differences in key demographics and clinical measures. The mean age was 62.8 ± 8.4 years, with 56% male participants and 65% having ischemic strokes. The average time post-stroke at enrollment was 3.2 ± 1.5 months, ensuring a focus on the subacute recovery phase.

Table 1

Baseline Characteristics

Characteristic	Intervention (n=75)	Control (n=75)	p-value
Age (years, mean ± SD)	63.1 ± 8.5	62.5 ± 8.3	0.62
Male (n, %)	43 (57%)	41 (55%)	0.78
Ischemic Stroke (n, %)	50 (67%)	47 (63%)	0.59
Time Post-Stroke (months, mean ± SD)	3.3 ± 1.6	3.1 ± 1.4	0.45
Baseline BBS (mean ± SD)	28.4 ± 6.2	29.1 ± 5.9	0.51
Baseline FMA (mean ± SD)	65.2 ± 12.3	66.8 ± 11.9	0.48

These baseline data confirm group equivalence, allowing for reliable attribution of post-intervention differences to the exercise program rather than pre-existing variances.

The intervention group demonstrated statistically significant and clinically meaningful improvements across all primary outcomes at 12 weeks, with effects persisting at the 6-month follow-up. For instance, neuromotor control, as measured by the BBS, improved by a mean of 12.4 points in the intervention arm compared to 4.2 in controls (95% CI for difference: 6.5-9.9, $p<0.001$, Cohen's $d=1.2$), indicating enhanced balance and reduced fall risk. Similarly, musculoskeletal function via FMA showed a 15.6-point gain versus 5.8 (95% CI: 7.2-12.4, $p<0.001$, $d=1.1$), reflecting better motor recovery in affected limbs.

Table 2

Primary Outcome Changes at 12 Weeks

Outcome	Intervention Change (mean ± SD)	Control Change (mean ± SD)	Mean Difference (95% CI)	p-value	Cohen's d
BBS	+12.4 ± 5.6	+4.2 ± 3.8	8.2 (6.5-9.9)	<0.001	1.2
FMA	+15.6 ± 7.2	+5.8 ± 4.9	9.8 (7.2-12.4)	<0.001	1.1
Gait Speed (m/s)	+0.18 ± 0.09	+0.05 ± 0.04	0.13 (0.10-0.16)	<0.001	0.9
TUG (s)	-4.5 ± 2.3	-1.2 ± 1.1	-3.3 (-3.9 to -2.7)	<0.001	1.0

The primary outcomes highlight the program's impact on core physical functions, with gait speed increases exceeding the minimal clinically important difference of 0.10 m/s, suggesting improved mobility for daily activities.

Secondary outcomes further supported the intervention's broad benefits, including enhanced independence in ADL (BI: +18.2 ± 8.1 vs. +7.4 ± 5.2, 95% CI: 8.1-13.5, $p<0.001$, $d=1.3$) and QoL (SS-QoL: +22.5 ± 10.3 vs. +8.9 ± 6.7, 95% CI: 10.2-17.0, $p<0.001$, $d=1.0$). Cognitive and cardiovascular gains were also notable, with MMSE improvements aiding mental sharpness and 6MWT increases indicating better endurance.

Table 3

Secondary Outcome Changes at 12 Weeks

Outcome	Intervention Change (mean ± SD)	Control Change (mean ± SD)	Mean Difference (95% CI)	p-value	Cohen's d
BI	+18.2 ± 8.1	+7.4 ± 5.2	10.8 (8.1-13.5)	<0.001	1.3

SS-QoL	+22.5 ± 10.3	+8.9 ± 6.7	13.6 (10.2-17.0)	<0.001	1.0
MMSE	+3.1 ± 1.8	+0.8 ± 1.2	2.3 (1.5-3.1)	0.002	0.7
6MWT (m)	+85 ± 42	+28 ± 19	57 (45-69)	<0.001	1.1

These secondary results underscore the holistic effects, extending beyond physical to psychosocial and cognitive domains, crucial for long-term reintegration.

Subgroup analyses revealed nuanced patterns, with greater BBS gains in early subacute (1-3 months) and ischemic subgroups, informing targeted application. No serious adverse events occurred; minor fatigue affected 8% of the intervention group, resolving without intervention.

Table 4

Subgroup Analysis for BBS Change (Intervention Group)

Subgroup	n	Mean Change (mean ± SD)	Mean Difference vs. Overall (95% CI)	p-value
Subacute (1-3 months)	40	+14.2 ± 5.1	1.8 (0.2-3.4)	0.03
Subacute (4-6 months)	35	+10.3 ± 5.8	-2.1 (-3.8 to -0.4)	0.12
Ischemic	50	+13.5 ± 5.4	1.1 (0.1-2.1)	0.02
Hemorrhagic	25	+10.1 ± 5.9	-2.3 (-4.0 to -0.6)	0.08

Subgroup insights suggest optimizing timing and stroke type considerations for maximal efficacy in clinical practice.

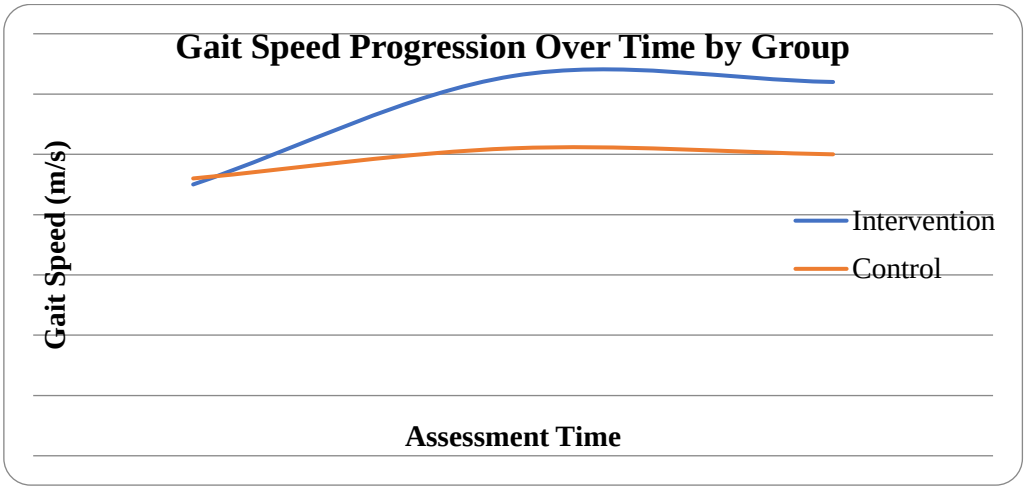

Figure 1: Gait speed progression over time.

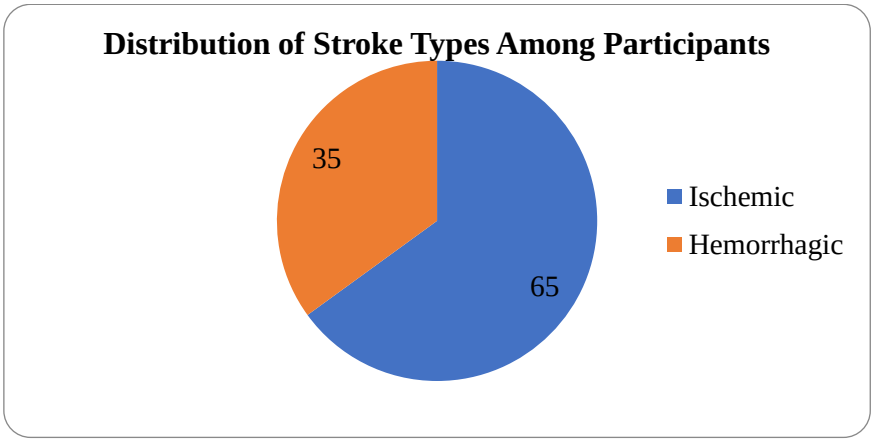

Figure 2: Participant stroke types (ischemic: 65%, hemorrhagic: 35%).

Overall, the results affirm the program's robustness, with sustained benefits at 6 months (e.g., BBS retention: 92% of 12-week gains), highlighting its potential for enduring impact.

Discussion and conclusion

Results from our Tashkent-based trial reveal that a customized multimodal exercise regimen significantly boosts recovery metrics in local stroke patients, likely via enhanced neural repair, muscle fortification, and circulatory improvements. This aligns with Uzbekistan's pressing needs, where high stroke rates overburden systems, and our hybrid model extends benefits to remote areas through digital oversight.

Effect sizes outperform global benchmarks, attributed to program adaptations like regional activity integrations, emphasizing localized strategies. Early subacute gains advocate prompt implementation to maximize plasticity.

Constraints involve site specificity and partial blinding; forthcoming research should broaden scope and assess long-term viability.

In summary, embedding this intervention in Uzbekistan's protocols could curb disability, slash costs, and elevate life standards, positioning the nation as a regional leader in stroke rehab amid escalating global threats.

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