

Original Article



Assessment of balance status and neurophysiological assays in patients with ischemic stroke

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Abstract

Introduction: Stroke is the third most common cause of death and most common debilitating neurological disease with balance disorder as one of its major clinical manifestations. The purpose of this study is to investigate the balance and related neurophysiological measurements in ischemic stroke patients.

Methods: Stroke patients with 0 or 1 modified Rankin Scale (mRS) level and National Institutes of Health Stroke Scale (NIHSS) below 10 was involved in this study. Balance measuring device (BSS), Pittsburgh Sleep Quality Index (PSQI) Questionnaire, Vienna Test System (VTS), paraclinical measurements including transcranial Doppler and MRI were used to evaluate the condition.

Results: In evaluation of 58 patients with acute stroke, the average score of the overall stability index was 3.38 ± 1.75 . The left-right average was 8.93 ± 67.90 and front-back average was 7.58 ± 133.50 . The mean reaction time was 659.64 ± 197.72 milliseconds, which was 17.31 in terms of percentage rank. Also, average movement time was 337.77 ± 146.44 , which was equal to 9.18 in terms of percentage rank. Total score was 2.78 ± 4.27 , its average percentile rank is 13.27 and time for correct answers was 6.70 ± 1.83 , and average percentile rank is 22.50. Sleep quality score of the patients indicated low.

Conclusion: Balance, reaction time, follow-up, and sleep disturbance among the studied stroke patients were significantly worse than the community average and in poor range. In addition, it was shown that several factors are effective in balance of stroke patients, and thus paying attention to those factors can be effective in improving the balance.

Introduction

Stroke is the third most common cause of death and most common debilitating neurological disease that occurs following ischemia or hemorrhage and changes the motor function of the body.¹ Cerebral ischemia is a complication caused by lack of oxygen supply to the brain. This complication can be transient (for example, transient cerebral ischemia caused by constriction of cerebral vessels) or permanent (such as infarction or stroke caused by clotting or embolism in one of the main arteries of the brain). Symptoms of ischemia depend on the areas involved. Long-term ischemia causes the death of brain cells. The most common disability caused by stroke is hemiparesis.² Although the severity and variety of disorders in hemiparesis and cerebral ischemia depend on the location and extent of the lesion, balance disorder is considered as one of the most important clinical manifestations in supratentorial strokes.³

Balance is a person's ability to limit body sway and maintain the body's center of gravity within the reliance level. Balance includes three components: symmetry, static and dynamic stability, which is arranged by controlling the state of organs. When there is an external or internal balance-disrupting stimulus, the relative position of the center of gravity and the reliance level change accordingly and prevent the person from falling down.⁴ The ability to maintain basic balance in chronic stroke patients is very important to improve walking,⁵ which is essential for successful performance of almost all daily movements.⁶ Due to the importance of balance in individual life, previous reports also emphasize the reduction of the quality of life of stroke patients due to the reduction of movement abilities.⁷ In addition to balance disorder, supratentorial stroke patients also suffer from sleep disorder, which collectively increase the probability of trauma and accidents such as traffic

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accidents. Therefore, one of the purposes of this study is to investigate sleep disorders in supratentorial stroke patients. The appropriate pattern of muscle activity at any moment depends on two external (threats) and internal factors (sensory and motor processes).⁸ The actions of the muscles of the limbs and trunk are coordinated by movement processes. Sensory processes organize sensory inputs from somatosensory, visual, and vestibular nerves.⁹ Also, spatial perception also plays an important role in balance.⁸ Stroke patients have difficulty in acquiring and maintaining the pattern of symmetrical standing.⁹ This asymmetry exists not only in the position of the limb, but also in the amount and timing of muscle activity on the affected and healthy side, and is a sign of the transfer of body weight to the side of the healthy limb.¹⁰ Many brain structures, such as the cerebellum, basal ganglia, and cerebral cortex, are involved in improving limb position after stroke.⁸ Laterality is the acquisition of special abilities based on the structures on each side. Laterality of the brain is a sign of the high capacity of each side of the brain to acquire special skills. Based on this theory, previous studies have shown that the right posterior parietal cortex plays a major role in the development of spatial cognition. A review of the articles also shows that the imbalance of the limb position is more in the right hemisphere lesions.⁴ Contrary to this theory, Chen et al showed that balance performance in patients with right hemisphere stroke is better than left hemisphere stroke.¹⁰⁻¹²

Based on this, measuring the balance status of stroke patients and the variables affecting it can be an important step in improving the quality of life of these patients. As very few studies have been conducted on the reaction time and balance status of stroke patients, need for further studies is felt in this field. Based on this, the present study was conducted with the aim of investigating the balance status and reaction time in supratentorial ischemic stroke patients who had no balance disorder in the usual clinical examinations and had a low National Institutes of Health Stroke Scale (NIHSS) and modified Rankin Scale (mRS) score.

Methods

The present study is a cross-sectional study and was conducted in 2022. 58 patients with acute stroke were selected according to the available method from the acute stroke patients hospitalized in the stroke wards of Imam Reza and Razi hospitals in Tabriz. The ethical principles based on the declaration of Helsinki were observed in this study.

Inclusion and exclusion criteria

Diagnosed acute stroke by a neurologist and based on ICD 10 codes, having written consent to participate in the study; Being at least 18 and at most 70 years old, having mRS one, zero or two and NIHSS below 10, having Glasgow Coma Scale (GCS) equal to 15, having a stroke in

the supratentorial region of the brain were our inclusion criteria. Suffering from hearing and vision disorders, those with major psychiatric and cognitive disorders, severe balance disorder that caused the patient to be unable to stand, and suffering from cerebellar or brainstem were our exclusion criteria.

Procedure

The sample of stroke patients with mRS level of zero, one or two and NIHSS below 10, which was diagnosed and evaluated by a neurologist, was selected from the stroke patients admitted to the men's ward of Razi or Imam Reza hospital in Tabriz. Balance measuring device (BSS), Pittsburgh Sleep Quality Index (PSQI) Questionnaire, Vienna Test System (VTS), paraclinical measurements including MRI were used to evaluate the type and location of stroke in all patients and finally were used to obtain the results of the study.

Demographic questionnaire

This questionnaire includes questions about age, gender, education level, social and economic status, which were completed by self-report or direct questions from illiterate patients.

Disease history questionnaire

This questionnaire includes questions about the time of infection, length of hospitalization, history of stroke, history of other diseases through medical records or direct questions from patients.

Balance measuring device

In this balance evaluation system, a round base plate is used that can move simultaneously in the anterior-posterior (A-P) and medio-lateral (M-L) axes. In addition, the balance of the plate is changed by changing the resistive force acting on it. Based on the degree of tilt in AP and ML axes, the device calculates mediolateral balance index, anterior posterior balance index and total balance index. Higher scores on the BSS indicate balance problems and lower scores indicate a better ability to maintain balance.

Pittsburgh Sleep Quality Questionnaire

PSQI¹³ is a self-report tool used to measure sleep quality. The scoring of PSQI is such that higher scores indicate poor sleep quality. A score of 5 or more indicates that the person has trouble sleeping. The total score is between 0 and 21. The PSQI has 7 subscales of subjective sleep quality, sleep delay, sleep adequacy, sleep duration, sleep disturbance, use of sleeping pills, and daily functioning. Buysse et al¹³ have reported the internal consistency of the original version of the PSQI sleep quality index using Cronbach's alpha coefficient of 0.83. Saeedi et al obtained the test-retest reliability of this questionnaire at 0.78 and the internal consistency at Cronbach's alpha of 0.85.¹⁴ Aghajanloo et al. reported Cronbach's alpha coefficient of

0.86 for this questionnaire.¹⁵

Vienna Test System

The VTS is one of the first computerized psychological, neurological, transportation and sport assessment tools. VTS guarantees the highest degree of objectivity and accuracy possible despite the fact that these aspects cannot be measured with ordinary paper-pen tests. VTS Scoring test results are quick and accurate and the implemented software provides clear communication instructions for the user to easily run the tests, score the results, and record client information. VTS wide range of functions enables the creation and execution of a variety of test suites. VTS covers a wide range of new tests and has flexible methods that can be applied according to the requirements of different assessment conditions. This system includes both computerized versions of common paper-pen tests and a wide range of adaptive, multimedia and listening tests. Its special input device allows for precise performance measurements which are not possible with a conventional mouse and keyboard. This device includes a response screen and a control handle that are used to measure action speed, reactive stress tolerance, and sensorimotor coordination. It also includes an optical pen and other auxiliary tools for special tests. In the research, reaction time test (to tone of voice and yellow color) was used. In reaction time test, the response speed of a person to tone of voice and yellow color and their movement reaction are evaluated. In order to measure the reaction time (to tone of voice and yellow color), first, the patient is placed in front of the VTS device. In the reaction time test, the person reacts by simultaneously seeing yellow color and also hearing tone of voice (pressing the black key). The duration of time he performs due to this action is calculated as his reaction time.

Statistical analysis

All research data were analyzed using STATA version14 software. Descriptive statistics (mean, standard deviation, frequency and percentage) were used to describe the research variables. Logistic regression was used to investigate clinical factors predicting balance in stroke patients. In order to control disturbing/confounding variables, by identifying these disturbing variables, they were eliminated or controlled. Closed and open questions were used to identify confounding variables. During the implementation of the research, enough accuracy was done to identify disturbing/confounding variables and it was controlled by adopting appropriate research and statistical methods. If necessary, disturbing variables were included in the study as independent variables. A p-value less than 0.05 was considered as a significant level.

Results

In the present study, there were 58 patients with acute stroke, among them 50 (84%) were men and 8 (16%) were women. Based on the data obtained from the Biodex

device, the average score of the overall stability index is 3.38 with a standard deviation of 1.75. This index evaluates a person's inability to maintain balance. The left-right average was 8.93 with a standard deviation of 67.90. The front-back average was 7.58 with a standard deviation of 133.50 (Table 1).

Based on the obtained data and comparing it with the Biodex balance system software data, the results showed that in terms of the balance status, 10 of the patients (16.9%) had scores below the cut off point in the overall stability index score, in other words, their performances were above the social average (good balance). 21 patients (35.6%), were in the normal range (normal balance). Also, 28 patients (47.5%), were above the cut-off point, meaning that their performances were lower than social average (poor balance) (Table 1).

Status of reaction time in stroke patients

Among the patients participating in the study, 22 people were measured in terms of reaction time using the VTS. The results showed that the average reaction time was 659.64 with a standard deviation of 197.72 milliseconds, which was 17.31 in terms of percentage. Also, the average movement time was 337.77 with a standard deviation of 146.44, which was equal to 9.18 in terms of percentage rank. According to the percentage rank, the findings indicate that the average reaction time and the average movement time in patients are very weak compared to the general population of healthy people (Table 1).

Line tracking status in stroke patients

Among the patients participating in the study, 23 people were measured in terms of line tracking using the VTS. The results showed that the average total score is 2.78 with a standard deviation of 4.27, and its average percentage rank is 13.27. Also, the average time for correct answers is 6.70 with a standard deviation of 1.83, and the average percentage rank is 22.50. According to the percentage rank, the findings indicate that the average reaction time and the average movement time in patients are very weak compared to the general population of healthy people (Table 1).

Status of sleep quality in stroke patients

In this study, the PSQI Questionnaire was used to measure the sleep quality of patients. According to the indicators and also the interpretation of scores, each patient's score in each scale can be between zero and three, in which zero, one, two, and three scores indicate patients with no sleep problem, moderate sleep problem, serious sleep problem, and very serious sleep problem, respectively. Also, obtaining a total score higher than 5 in the whole questionnaire means poor sleep quality.¹³ In the current study, the scores of 59 patients in the indices of subjective quality of sleep, sleep duration, sleep efficiency, use of sleep-inducing drugs, and daily functional disorders were

Table 1. Description of investigated variables in ischemic stroke patients (Data are presented as mean±standard deviation (minimum, maximum) or number (percentage %))

Variables		mean±SD
Balance status	Overall stability index	3.38±1.75 (0.50, 7.50)
	Overall stability of the criteria index	1.42±0.71 (0.41, 3.90)
	left right	8.93±67.90 (-204.54, 198.59)
	Back and forth	-7.58±133.50 (-344.27, 438.07)
	Below cut off point (good balance)	10 (16.9%)
	Normal range (normal balance)	21 (35.6%)
	Above cut off point (poor balance)	28 (47.5%)
	Average reaction time	659.64±197.72
reaction time	Average movement time	337.77±146.44
	Number of correct responses	135.95±59.09
	Unanswered number	55.90±35.85
	Number of incomplete answers	15.54±0.73
	Number of correct answers	0.31±0.56
line-tracking	total score	2.78±4.27
	Average time for correct answers	6.70±1.83
	Number of correct answers	14.60±4.74
	Number of image views	18.17±0.49
	Time taken for the test	2.20±0.83
PSQI sleep quality index	subjective quality of sleep	0.37±0.76
	Delay in falling asleep	1.35±1.09
	sleep duration	0.71±0.72
	Sleep efficiency	0.33±0.86
	sleep disorders	1.18±0.47
	Use of sleeping pills	0.54±0.89
	Daily functional disorders	0.77±0.89
	Total sleep quality	5.28±2.76

less than one, indicating the absence of sleep problems. However, in the index of delay in falling asleep and sleep disorders with a score higher than one, comparing the group t-tech test, it showed that the average score of the patients was significantly higher than one ($P<0.001$) indicating a moderate and slightly more than moderate sleep problem. Also, the results of the group t-tech test with an average score of 5.28 (significantly higher than 5; $P<0.001$) means moderate and slightly poor sleep quality (Table 1).

Effective factors in the balance status of stroke patients

The results of simple regression analyses for two scores of the overall stability indices and the standard deviations of the overall stability indices showed that factors including female gender, NIHSS score, average movement time, motor time dispersion, mean time spent for correct answer in line tracking, the total time spent in line tracking, the quality of psychological sleep, had a direct and significant relationship with the overall stability index. While, the

relationship between the overall stability index and the factors of education level, smoking, average total score, the number of correct answers in line tracking, the median percentage rank of the time spent for correct answers in line tracking was significantly indirect (Table 2).

In the final multiple regression model, in the best case, the average movement time with a beta coefficient of 0.53 and the overall quality of sleep with a beta coefficient of 0.61 were obtained as predictors. In the case of controlling the effect of two variables, namely age and gender, the significance of the above two variables was maintained, so that in total, the two variables average movement time and general sleep quality explain 48% of the variance of the overall stability index. In other words, by increasing the average movement time and also by increasing sleep quality problems, it is possible to predict 48% of the variance of the balance status of stroke patients (Table 3).

Discussion

Balance is the ability to maintain the line of gravity at the base of support with minimal postural fluctuation.⁹ Human balance control is a comprehensive process that depends on the integration of visual, vestibular, and somatosensory inputs to the central nervous system. According to the underlying disorder in stroke patients, the prevalence of balance disorders in these patients has been reported to be high. Impaired balance is characterized by short support times and differences in activity between the two sides of the body and slow walking speed, which may increase the risk of falling.¹⁶ Therefore, considering the importance of the topic, the purpose of this study was to investigate the balance status and related neurophysiological measurements in ischemic stroke patients. However, in this study, only patients who had low NIHSS and mRS scores despite having supratentorial stroke, which significantly increases the possibility of balance disorder, and did not have balance disorder in the usual clinical examinations for stroke patients were studied. For this purpose, the sample of patients with supratentorial stroke with mRS level of zero, one or two and NIHSS below 10, which was diagnosed and evaluated by a neurologist, was selected from the stroke patients admitted to the men's ward of Razi or Imam Reza Hospital in Tabriz. BSS, PSQI, VTS, paraclinical measurements including MRI were used to evaluate the condition of all patients and finally were used to obtain the results of the study. A total of 58 patients were included in this study. According to the data obtained from the Biodex device, the average score of the overall stability index was 3.38 with a standard deviation of 1.75. The left-right average was 8.93 with a standard deviation of 67.90. The front-back average was -7.58 with a standard deviation of 133.50. In terms of balance status, the scores of 10 patients (16.9%), were below the cut-off point in the overall stability index score, in other words, they were above the social average (good balance). the scores of 21 patients (35.6%), were in the normal

Table 2. The results of simple regression analysis of factors affecting the balance status of stroke patients

Variables		Overall stability index		Standard deviation of the overall stability index	
		β	P value	B	P value
Demographics	Age	0.34	<0.01*	0.32	0.01
	Sex (reference: female)	0.40	<0.01*	-0.21	0.09
	Education level (reference: diploma)	-0.32	<0.05*	-0.21	0.10
	smoking	-0.28	<0.05*	0.08	0.52
	mRS	0.01	0.94	0.10	0.53
	mRS 0	-0.17	0.19	-0.22	0.17
	mRS 1	0.31	0.05	0.26	0.09
	mRS 2	-0.17	0.29	0.06	0.70
	NIHSS	0.28	0.07	0.33	0.03
reaction time	Average reaction time	0.10	0.66	0.05	0.82
	Average movement time	0.48	0.02*	0.55	<0.01*
	Dispersion motor time	0.54	0.01*	0.58	<0.01*
	Reaction time percentage rating	-0.28	0.21	-0.31	0.17
	Movement time percentage rating	-0.13	0.56	-0.31	0.16
line-tracking	total score	-0.46	0.03*	-0.44	0.04
	Average time for correct answers	0.46	0.02*	0.54	<0.01*
	Number of correct answers	-0.48	0.02*	-0.37	0.08
	Time taken for the test	0.52	0.01*	0.67	0.01
	Percentage ranking of the total score	-0.24	0.29	-0.34	0.13
	The percentage rank of the average time spent on correct answers	-0.69	<0.01*	-0.48	0.02
PSQI sleep quality index	Psychological sleep quality	0.27	0.05	0.06	0.62
	Total sleep quality	0.13	0.34	0.01	0.93
conners test	Attention Deficit Scale (Index A)	0.31	0.02*	0.14	0.29
	Total index (index C)	0.24	0.08	0.06	0.66

Table 3. The results of multiple regression analysis of factors affecting the balance status of stroke patients

Variables	Overall stability index		Standard deviation of the overall stability index	
	β	P value	β	P value
Average movement time	0.53	0.02	0.71	<0.01*
Total sleep quality	0.61	0.03	0.56	0.02
Age	0.12	0.45	0.10	0.60
Sex (reference: female)	-0.24	0.38	-0.64	0.02

range (normal balance). Also, the scores of 28 patients (47.5%) were above the cut-off point, in other words, they suffered from a lower than average social condition (poor balance). Several studies such as the present study have shown balance disorders in the majority of stroke patients. Another study reported that about 83% of stroke survivors suffer from balance disorders.¹⁶ In addition to underlying pathology and numerous disorders in coordination between nerves and muscles, which are effective in causing balance disorders in these patients, the fear of falling in these patients increases the risk of losing balance and falling down.¹⁷ This disorder is important because it increases the risk of trauma and thus increases the probability of hospitalization and increases

the costs imposed on the patient.¹⁸ Reaction time has been reported as another important dimension affected in stroke patients.¹⁹ Among the patients participating in the study, 22 people were examined in terms of reaction time using the VTS. The average reaction time was 659.64 with a standard deviation of 197.72 milliseconds, which was 17.31 in terms of percentage rank. Also, the average movement time was 337.77 with a standard deviation of 146.44, which was equal to 9.18 in terms of percentage rank. According to the percentage rank, the findings indicate that the average reaction time and the average movement time in patients are very weak compared to the general population of healthy people. Although few studies have been conducted in this regard, findings have shown that balance and the probability of falling are closely related to reaction time.¹⁹ This functional aspect in stroke patients not only plays a role in maintaining balance, but is also known to be effective in doing daily tasks such as driving.²⁰⁻²³ It has been reported that longer reaction time in stroke patients is associated with an increased risk of road accidents. Various studies have shown that there is a doubt in the ability to drive in most stroke patients, and driving requires a driving test again²⁴ and without performing nerve rehabilitation exercises,

the ability to drive in stroke patients can be very difficult to improve.^{24,25}

Among the patients participating in the study, 23 people were measured in terms of line tracking using the VTS. The average total score is 2.78 with a standard deviation of 4.27, and its average percentage rank is 13.27. Also, the average time for correct answers is 6.70 with a standard deviation of 1.83, and the average percentage rank is 22.50. According to the percentage rank, the findings indicate that the average reaction time and the average movement time in patients are very weak compared to the general population of healthy people. One of the important aspects in creating a disturbance in this test is the visual impairment of stroke patients, which has been mentioned in many studies.^{21,22}

In this study, the PSQI Questionnaire was used to measure the sleep quality of patients. Based on the scores of 59 patients (less than one) in the indices of subjective quality of sleep, sleep duration, sleep efficiency, use of sleep-inducing drugs, and daily functional disorders which scores, patients had no sleep problems. However, in the index of delay in falling asleep and sleep disorders with a score higher than one, comparing the group t-tech test, the average score of the patients was significantly higher than one ($P < 0.001$) indicating a moderate and slightly more than moderate sleep problem. Also, the results of the group T-Tech test with an average score of 5.28 compared to a score of 5 showed that the average score of the patients was significantly higher than 5 ($P < 0.001$) and the total score means moderate and slightly poor sleep quality. Sleep disorder in stroke patients is not a new finding and it has been mentioned in different studies.²⁰⁻²² However, the presence of sleep disorder in these patients is important as this disorder along with balance disorder significantly increases the probability of trauma and accidents such as traffic accidents, which are preventable by early diagnosis. In addition, the present study showed a relationship between sleep disorder and balance status in which 48% of the variance of the balance status of stroke patients is predictable by measuring the average movement time and sleep quality problems. Therefore, with a simple examination in terms of sleep disorder with routine and prepared methods in the clinic, such as the PSQI Questionnaire, it is possible to find out the balance disorder in these patients and possible future accidents and thus prevent them with proper treatment and rehabilitation. In a new review study, Cai et al showed that stroke patients suffer from various sleep disorders such as insomnia, hypersomnia, breathing-related sleep disorders, and parasomnias.²⁰ In addition, it has been shown that sleep disorders themselves are effective in the occurrence of stroke.²¹ Hasan et al's study showed that sleep disturbances following stroke or transient ischemic attack (TIA) are very common over time. They showed that the prevalence of sleep-related breathing disorders varies from 31% to 67% depending on the severity of

the disorder and the post-stroke phase.²³ In addition, the effective factors on the balance status of the patients were evaluated and based on the simple regression model, the factors of female gender, NIHSS score, average movement time, motor time dispersion, the average time spent on correct answers in line tracking, the total time spent in line tracking, the quality of psychological sleep were directly related to the patients' balance status. Meanwhile, the factors of education level, smoking, average total score, the number of correct answers in line tracking, the median percentage rank of the time spent in following the correct answers had an indirect relationship with the balance status in patients. In the final multiple regression model, in the best case, the average movement time with a beta coefficient of 0.53 and the overall quality of sleep with a beta coefficient of 0.61 were obtained as predictors. In the case of controlling the effect of age and gender variables, the significance of the above two variables was maintained, so that in total, the two variables average movement time and general sleep quality explain 48% of the variance of the general stability index. In other words, by increasing the average movement time and also by increasing sleep quality problems, it is possible to predict 48% of the variance of the balance status of stroke patients. Paying attention to each of these factors in the treatment of stroke patients can play a significant role in improving the quality of life and reducing their treatment costs. These findings show that performing more advanced investigations along with routine examinations and NIHSS and mRS scores can be effective in preventing accidents in these patients. In general, the present study showed that the balance status among patients with supratentorial stroke who did not have balance disorders in the usual clinical examinations and had a low NIHSS and mRS score was lower than the average of the society and was at a weak level that could be determined by more advanced tools and thus prevent occurring more problems in these patients. Also, the reaction time and line tracking in these patients were very poor compared to the healthy population. Sleep disorders were less common in these patients compared to other cases, and thus the sleep quality of stroke patients was moderate and slightly poor compared to the normal population.

Conclusion

The examined stroke patients' balance, response time, follow-up, and sleep disruption were all much worse than the community norm and in the poor range. Furthermore, this research demonstrated that a number of factors influence stroke patients' ability to balance, therefore focusing on these issues may help patients become more balanced.

Authors' Contribution

Conceptualization: Behnaz Ahmadi, Salman Abdi, Hamed Azar, Homayoun Sadeghi-Bazargani, Mehdi Farhoudi, Daryoush Savadi

Study Highlights

What is current knowledge?

- Stroke frequently impairs balance control, even when motor deficits are mild.
- Conventional clinical exams may overlook subtle balance or reaction-time impairments.
- Sleep disturbances and neurophysiological changes are common secondary issues after ischemic stroke.

What is new here?

- Quantitatively showed that patients with low NIHSS/mRS scores still have poor balance, delayed reaction time, and reduced movement accuracy.
- Identified sleep quality and movement time as significant predictors explaining nearly half of the variance in balance performance.
- Combined Biodex Stability System (BSS), Vienna Test System (VTS), and sleep assessments to link neurophysiologic measures with functional balance after mild ischemic stroke.

Oskouei.

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Competing Interests

None.

Ethical Approval

The ethics committee of Tabriz University of Medical Science reviewed and approved the study protocol (Ethics code: IR.TBZMED.REC.1400.209).

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