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Quantitative Assessment of H Reflex and F Response Values in Healthy and Paralyzed Limbs and Their Correlation with the Prognosis of CVA Patients

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ABSTRACT

Quantitative and objective evaluation of stroke patients with limb paralysis provides valuable insights into functional decline and treatment prognosis. The present study aims to quantitatively assess the H reflex and F response values in both healthy and paralyzed limbs and their relationship with the prognosis of recovery in paralyzed limbs of stroke patients. This descriptive-analytical study was conducted on 60 stroke patients hospitalized at Valiasr Hospital in Qaemshahr during 2022-2023. H reflex and F response values were measured using EMG-NCV for both healthy and paralyzed limbs at the onset of the disease, three months later, and six months later. The results were analyzed using the repeated measures test with SPSS software. The mean age of patients was 65.47 ± 8.57 years, with 58.3% (35 individuals) being male. The results revealed significant differences in Min F latency, Min M latency, and Min H latency in F response, as well as Max H amplitude in H reflex between healthy and paralyzed limbs (P<0.05). However, there were no significant differences in H reflex and F response values across different time points (baseline, three months, six months) (P>0.05). H reflex and F response measurements offer valuable insights into patient recovery and the therapeutic management of stroke patients with paralyzed limbs.

Keywords: *H reflex, F response, stroke, EMG*

1. Introduction

Stroke is a clinical syndrome characterized by the sudden onset of a focal neurological deficit attributed to vascular events, such as necrosis or hemorrhage, within the central nervous system. It is recognized as one of the leading causes of disability and mortality worldwide, frequently resulting from ischemic events or intracranial hemorrhages. Given its prevalence predominantly among middle-aged and elderly individuals, stroke has a significant impact on disability and mortality rates in these age groups. The condition can lead to loss of physical and cognitive abilities, declining quality of life, and increased healthcare costs (1).

Motor impairment is among the most common and well-documented disabilities resulting from stroke, manifesting as a loss or restriction of muscle control, movement, or overall mobility. Such impairments typically affect one side of the body, involving facial, hand, and leg movements (2). Approximately 80% of stroke survivors experience motor disabilities, with nearly two-thirds presenting with initial motor deficits. Even six months post-stroke, over 30% of survivors are unable to walk independently. As such, a significant focus of rehabilitation efforts centers on restoring physical independence and enhancing functional capacity in daily activities, with the ultimate goal of improving gait function, balance, and movement coordination (3).

Human interaction with the environment depends not only on sensory and muscular strength but also on complex, coordinated motor behavior. This motor behavior is regulated by networks of central pattern generators (CPGs) within the spinal cord, interconnected through neural circuits (4). The components of CPGs include descending systems, propriospinal pathways, sensory inputs, and segmental interneurons, with control centers modulating neuronal excitability. Damage to the spinal cord or disruption of these systems can alter segmental reflexes, which can be measured through muscle recordings. Parameters such as H-reflexes and F-responses are used to assess the functionality of motor neuron pools, quantifying approximately 20–100% and 1–5% of motor neuron activity, respectively (5).

The H-reflex serves as an indicator of alpha motor neuron (αMN) excitability under conditions where presynaptic inhibition and intrinsic αMN excitability remain constant. This measurement can be utilized to assess the nervous system’s response to various neurological conditions, musculoskeletal injuries, therapeutic interventions, pain, exercise, and motor tasks. The amplitude of the H-reflex during different phases of gait cycles is recorded using quantitative electromyography (EMG) in both healthy individuals and patients. However, research on H-wave latency during gait cycles in patients and healthy individuals remains limited (6).

The F-wave represents a motor response typically recorded from a muscle following stimulation of a peripheral nerve trunk. It is believed to result from the "backfiring" of motor neurons in response to antidromic conduction from the stimulation point of the peripheral nerve (7). The F-wave occurs subsequent to the compound muscle action potential (CMAP). However, as the stimulation point moves proximally along the nerve, the CMAP latency increases, while the F-wave latency decreases, indicating that the generating pulse of the F-wave first travels toward the spinal cord before returning to the distal muscles. Generally, the shortest F-wave latency is determined by measuring at least eight consecutive discharges (8).

The study of F-waves is predominantly employed to assess nerve conduction velocity and proves particularly beneficial for evaluating conduction abnormalities in proximal segments of nerves. The F-wave pathway involves the antidromic stimulation of all activated motor axons traveling toward the spinal cord, followed by the reactivation of a small subset of anterior horn cell axons and the orthodromic action potentials transmitted along one or more motor axons toward the muscle (9).

The absence of an F-wave response from stimulation of the median, ulnar, or tibial nerves, despite the presence of normal CMAPs elicited from the same muscle, suggests a conduction block or axonal loss (less than 5–8 days post-onset) at a point proximal to the nerve trunk stimulation site. Various parameters of the F-wave are used in the diagnostic evaluation of peripheral nerve disorders, serving as a sensitive indicator for axonal polyneuropathy and radiculopathy (10). This response is also utilized in the diagnosis of conditions such as diabetic peripheral neuropathy (DPN), Guillain-Barré syndrome (GBS), and amyotrophic lateral sclerosis (ALS), as it aids in the early detection of motor nerve fiber abnormalities. In the upper limb, the minimum F-wave latency for the median nerve is approximately 34.4 milliseconds in men and 31 milliseconds in women. An asymmetry exceeding 2 milliseconds between the right and left sides is considered abnormal. The dispersion time, defined as the difference between the maximum and minimum latencies, is highly sensitive for detecting demyelinating neuropathy. F-wave stability, which is calculated by dividing the number of F-wave responses by the number of stimulations, varies depending on the muscle assessed (11).

Given the critical medical significance of stroke and the potential for increased knowledge about its diagnostic methods to enhance disease awareness, this study aims to quantitatively determine H reflex and F response values in healthy and paralyzed limbs and to assess their relationship

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with the prognosis of CVA patients within a three- to six-month period at Valiasr Hospital in Qaemshahr.

2. Methods and Materials

The present study is descriptive and analytical. Patients were selected using a non-probability, convenience sampling method, with a total of 60 patients diagnosed with CVA meeting specific inclusion criteria. These patients were selected from Vali-Asr Hospital in Qaemshahr between March 2023 and September 2024. The required data, including demographic information (age, gender, height, weight) and ECG-NCV findings, were collected using a researcher-developed checklist for statistical analysis relevant to the study's objectives. Both the healthy and paralyzed limbs of all patients underwent EMG-NCV assessment conducted by a neurologist using a specialized device. The variables of H-reflex and F-response were recorded. Patients were evaluated at three time points: at the onset of the disease, three months later, and six months after the onset.

Inclusion criteria for the study were a diagnosis of CVA with hemiparesis or hemiplegia, along with the willingness to participate in the study. Exclusion criteria included the presence of transient ischemic attack (TIA) and the unwillingness to continue participation in the study.

Data were analyzed using SPSS version 22. Descriptive statistics, including mean ± standard deviation and frequency (percentage), were used to summarize the data. To compare within-group (time effects) and between-group (healthy vs. paralyzed limbs) differences, repeated measures analysis of variance (ANOVA) and Bonferroni post-hoc tests were employed. A p-value of less than 0.05 was considered statistically significant for all tests.

3. Findings and Results

In this study, a total of 60 patients were evaluated. The mean age of the patients was 65.47 years with a standard deviation of 8.57 years. Of the participants, 58.3% (35 individuals) were male. The mean height of the patients was 166.85 cm with a standard deviation of 7.80 cm, and the mean weight was 69.86 kg with a standard deviation of 12.15 kg. The mean body mass index (BMI) of the patients was 25.16 kg/m² with a standard deviation of 4.27 kg/m². The results of these measurements are presented in Table 1.

Table 1

Within and between-group comparison of the H reflex and F response variables at different time points in two groups

Variables		Paralyzed limb*			Healthy limb*			Within-group significance level**	Between-group significance level**
		Early stage	Third month	Sixth month	Early stage	Third month	Sixth month		
Paralyzed limb function		*	On the mend	On the mend	*	*	*	*	*
F Response	Min F latency	41.88±4.89	41.87±4.95	42.29±5.37	51.23±5.66	52.22±3.64	52.33±3.01	0.147	<0.001
	Min M latency	11.20±2.91	11.39±2.75	11.56±2.52	10.17±2.62	10.32±2.45	10.52±2.04	0.088	0.019
H Reflex	Min H latency	30.75±5.88	30.79±5.07	31.46±5.46	28.64±5.14	28.56±5.07	38.87±5.07	0.060	<0.001
	Min M latency	12.33±2.64	12.39±2.47	12.41±2.15	12.25±2.66	12.28±1.74	12.28±1.62	0.987	0.715
	Max H amplitude	1.32±0.34	1.31±0.21	1.33±0.23	1.20±0.39	1.21±0.25	1.23±0.26	0.633	0.009

* The data are presented as mean ± standard deviation

** A significance level of less than 0.05 has been considered

The findings indicate that for all the variables examined, except for Min M latency, the inter-group differences were statistically significant with p-values less than 0.05 (Table 1). Therefore, significant differences were found between the groups for these variables ($p<0.05$). Additionally, the results in the table show that there were no significant differences in reflex and F response times across the

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different time points (initial disease phase, 3 months, and 6 months).

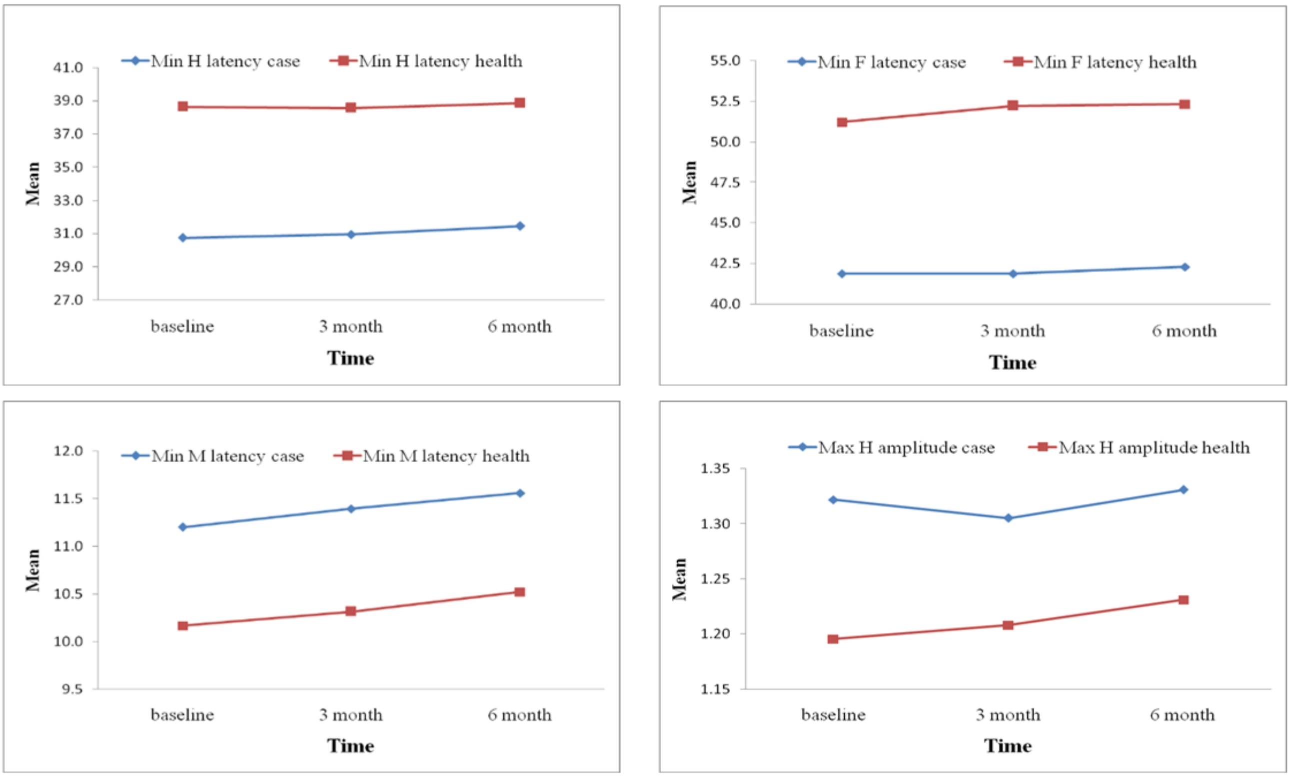
Table 2

Comparison of the H reflex and F response variables between two groups

Variables		Evaluation time	Paralyzed limb*	Healthy limb*	Significance level **
F response	Min F latency	Early stage	41.88±4.90	51.23±5.66	<0.001
		Third month	41.87±4.95	52.23±3.64	<0.001
		Sixth month	42.29±5.37	52.33±3.01	<0.001
	Min M latency	Early stage	11.20±2.91	10.17±2.62	0.043
		Third month	11.39±2.75	10.32±2.44	0.025
		Sixth month	11.56±2.52	10.52±2.04	0.015
H Reflex	Min H latency	Early stage	30.75±5.88	28.63±5.14	<0.001
		Third month	30.95±5.06	38.56±5.07	<0.001
		Sixth month	31.46±5.46	38.87±5.07	<0.001
	Min M latency	Early stage	12.33±2.64	12.25±2.66	0.876
		Third month	12.39±2.47	12.28±1.74	0.783
		Sixth month	12.41±2.15	12.28±1.62	0.723
	Max H amplitude	Early stage	1.32±0.34	1.20±0.39	0.061
		Third month	1.31±0.21	1.21±0.25	0.026
		Sixth month	1.33±0.23	1.23±0.26	0.028

Figure 1

Changes in the H reflex and F response variables in two groups.



The results of the T-test in the following table indicate that Min F latency, Min M latency, and Min H latency differed significantly between the two groups at all time points ($p<0.0001$) (Table 2 and Figure 1). No significant

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difference in Min M latency was observed at any time point between the two groups ($p>0.05$). Furthermore, Max H amplitude showed significant differences between the two groups at the 3-month and 6-month time points ($p< 0.05$).

4. Discussion and Conclusion

Stroke patients with paralyzed limbs are limited in their daily activities due to reduced physical capabilities, muscle weakness, and muscle spasticity (12). Therefore, the restoration of motor function becomes a primary goal in the rehabilitation of stroke patients (13). These patients cannot produce voluntary muscle contractions at normal levels and are unable to generate appropriate timing and intensity for muscular activities. Rehabilitation in stroke patients improves by enhancing balance ability and facilitating functional movements. Consequently, objective and quantitative assessment of functional impairments, treatment outcomes, and prognosis is essential for stroke patients with paralyzed limbs (14). Among the quantitative assessments used in clinical settings, H reflex and F response play critical roles in controlling body posture and muscle function. Identifying the precise causes and investigating abnormal areas in the bodies of stroke patients, as well as comparing and evaluating findings through objective and quantitative processes, is essential. Paralyzed limbs of stroke patients have been the subject of ongoing research, with assessments conducted through EMG. However, studies based on EMG regarding H reflex and F response in stroke patients with paralyzed limbs over time are limited.

This study aimed to investigate changes in H reflex and F response in stroke patients on both the healthy and paralyzed sides over 6 months. A total of 60 patients with a mean age of 65.47 ± 8.57 years (58.3% male) were evaluated. H reflex and F response were assessed at the onset of the disease, at the 3-month mark, and the 6-month mark in both the healthy and paralyzed limbs.

The results indicated that all parameters of F response, including Min F latency, Min M latency, Min H latency, and Max H amplitude in H reflex, showed significant differences between the healthy and paralyzed limbs at all assessment time points. Specifically, in F response, Min F latency was higher in the healthy limb compared to the paralyzed limb, and Min M latency was higher in the paralyzed limb compared to the healthy limb. Additionally, in the H reflex, Min H latency was higher in the healthy limb than in the paralyzed limb, while Min M latency and Max H amplitude were higher in the paralyzed limb than in the healthy limb. These findings suggest that the neural mechanisms responsible for regulating body posture may differ between the healthy and affected limbs in stroke patients.

After moderate to severe hemiplegic stroke, motor unit activity may decrease on the affected side, which could be attributed to secondary trans-synaptic degeneration of upper motor neurons (15). The increased excitability of the stretch reflex in stroke patients with spasticity is thought to be caused by abnormal reorganization of the descending pathways above the spinal cord and processing errors at the spinal cord level (16). All of these changes can impact the excitability of alpha motor neurons (17). H reflex is a monosynaptic reflex that provides information important for both sensory and motor peripheral nerves. The amplitude of the H reflex shows significant variations with changes in stimulation and is highly influenced by the central nervous system. Furthermore, it is greatly affected by factors such as gait, muscle tone, the intensity and duration of electrical stimulation, electrode placement, age, and body temperature. Therefore, the H reflex varies widely not only between individuals but also within the same individual. This phenomenon is due to the presence of various factors that can influence alpha motor neurons and cause changes in synaptic excitability within the central nervous system, between the Ia afferent nerve and motor neurons in muscle spindles (18).

Qin et al. investigated the Maximal Hoffmann reflex and motor potential (Mmax) in patients with spastic hemiplegia post-stroke and age-matched healthy controls in both standing and prone positions. The results revealed that in healthy individuals, the ratio of Maximal Hoffmann reflex to Hmax/Mmax was significantly lower in the standing position compared to the prone position. However, in stroke patients with spasticity, the Hmax/Mmax ratio increased in the standing position on both affected and unaffected sides, and furthermore, the ratios of Maximal Hoffmann reflex and Hmax/Mmax were significantly higher on the affected side compared to the healthy side (19). In another study conducted by Cho et al., H reflex was compared between hemiplegic stroke patients and healthy volunteers. The results showed a significant difference in the Hmax/Mmax

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(%) ratio during all phases of the gait cycle between the stroke group and the healthy adults (20). Similarly, in a study by Çakır et al., H reflexes and F waves in EMG were examined in stroke patients and healthy individuals. The study demonstrated a significant increase in the Hmax/Mmax ratio on the affected side in stroke patients, while the mean latency of F waves on the affected side was significantly shorter than in healthy controls (11). In another study, H reflex amplitudes were investigated in elderly hemiplegic patients and healthy individuals. The results showed that stroke patients exhibited significantly shorter latencies during mid-swing, mid-stance, and toe-off phases of the gait cycle compared to healthy individuals, while no significant difference was observed in the heel-strike latency (6). Drory et al. reported that serial changes in F wave parameters (such as persistence, maximal duration, average duration, amplitude, and area) were significantly reduced in acute hemiplegic stroke patients (21).

Another key finding of our study was the absence of significant changes in the H reflex and F response over the 6-month evaluation period in the patients. In a study by Grindstaff et al., the short-term effects (0, 10, 20, and 30 minutes) of changes in fibularis longus and soleus activation following tibiofibular joint manipulation were examined in individuals with ankle instability. The study assessed the maximum H-reflex and the ratio of H-reflex to maximum M-wave, revealing a significant increase in the H/M ratio of the foot during the evaluation period following distal tibiofibular joint manipulation. These interventions in the distal tibiofibular joint led to increased activation of the foot muscle (22). McComas et al. reported that in hemiplegic patients, the functional motor units of the intrinsic foot muscles decreased by 50% within two months following a cerebrovascular accident. In the chronic stage, the mean amplitude and area of F waves on the affected side increased, becoming similar to or even greater than those on the unaffected side (23).

Conclusion

Objective and quantitative assessment of stroke patients with limb paralysis is essential for estimating functional loss and predicting treatment outcomes. The results of our study revealed significant differences in the H reflex and F response between the healthy and paralyzed limbs, suggesting that these parameters provide valuable information regarding the excitability of motor neurons. However, the evaluation of these parameters over 6 months did not demonstrate any significant changes. The findings of this study can serve as diagnostic data, assisting in the explanation of patient characteristics and in measuring the degree of recovery for treatment planning in stroke patients with limb paralysis.

Authors' Contributions

A. H. conceptualized the study, designed the methodology, and supervised data collection. M. O. contributed to data acquisition, statistical analysis, and manuscript preparation. S. H. M. assisted in conducting EMG-NCV measurements and interpreting electrophysiological data. A. H. participated in patient recruitment, clinical assessments, and ensuring ethical compliance. R. Y. contributed to data interpretation, manuscript revision, and final approval of the study. All authors reviewed and approved the final version of the manuscript.

Declaration

In order to correct and improve the academic writing of our paper, we have used the language model ChatGPT.

Transparency Statement

Data are available for research purposes upon reasonable request to the corresponding author.

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Declaration of Interest

The authors report no conflict of interest.

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Ethics Considerations

The study placed a high emphasis on ethical considerations. Informed consent obtained from all participants, ensuring they are fully aware of the nature of the study and their role in it. Confidentiality strictly maintained, with data anonymized to protect individual privacy. The study adhered to the ethical guidelines for research with human subjects as outlined in the Declaration of Helsinki. Ethical considerations included obtaining informed consent, ensuring confidentiality and anonymity, and avoiding any harm to participants.

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