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Exploring the Age and Gender Dynamics: Insights from Median Nerve Conduction Studies

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ABSTRACT:

Objective: To evaluate the impact of age and gender on motor and sensory parameters of nerve conduction studies (NCS), with a focus on the Median nerve and F-wave analysis.**Methods:**A total of 49 patients underwent NCS to assess the influence of age and gender on nerve function. Key parameters measured included compound motor action potential (CMAP) amplitude, F-wave latency, and sensory nerve action potential (SNAP) amplitude.**Results:**i) **Gender Differences:**Males exhibited higher CMAP amplitude and longer F-wave latency. Females demonstrated elevated SNAP amplitude. ii)**Age-Related Changes:**Increased age was associated with prolonged latencies, diminished amplitudes, and reduced conduction velocities across NCS parameters.**Conclusion:**The findings highlight the significant influence of age and gender on NCS results. Understanding these variations is crucial for accurate and nuanced interpretation of nerve function assessments, which can enhance clinical decision-making and improve the effectiveness of nerve function evaluations in diverse patient populations.

Keywords:

Nerve conduction study, age, gender, median nerve, F-wave, CMAP, SNAP

INTRODUCTION:

With the advent of advanced electronic machines, it was made possible to make clinical assessment of peripheral nerve and muscle physiology in the mid-twentieth century, which marked a new division of neurologic specialty.[1] The main technique involved for the study of peripheral nerve function involves the transcutaneous stimulation of motor or sensory nerves and recording the action potentials in the muscle (compound muscle action potential, CMAP) and the sensory nerve action potential or SNAP[2]. The nerve conduction studies measure the speed and strength of an electrical impulse conducted along a peripheral nerve.[1] Hodes and co-workers, in 1948, were the first to describe nerve conduction studies in patients and the techniques to elicit conduction of the nerves stimulated have not changed much.[2]In the process of nerve conduction -a bipolar stimulator is positioned on the skin surface along the nerve's anatomical pathway to generate an impulse. The intensity and duration of this transcutaneous stimulus are gradually increased until all axons within the nerve are depolarized, initiating an action potential that travels down the nerve to the recording site. In sensory nerve conduction studies, the process involves the following:

Electrode Placement

- Recording electrodes are placed on the skin surface over the nerve, typically over a purely sensory branch of the nerve.
- The recording electrodes are placed at a distance from the stimulation site.

Nerve Stimulation

- The nerve is electrically stimulated at a specific location, usually proximal to the recording electrodes.
- This stimulation generates an electrical impulse that travels along the sensory nerve fibers.

Recording

- The recording electrodes detect the electrical activity generated by the propagation of the nerve impulse along the sensory nerve.

- The recorded electrical signals are then analyzed to assess the function and integrity of the sensory nerve.

By placing the recording electrodes over a purely sensory branch of the nerve, the study can focus on the conduction of sensory information without the influence of motor nerve fibers. The distance between the stimulation site and the recording electrodes allows for the measurement of the nerve conduction velocity, which provides valuable information about the health and function of the sensory nerve. In motor nerve conduction studies, recording electrodes are positioned over the motor end-plate region of a muscle innervated by the nerve.[1]

The correlation between age and alterations in nerve conduction study (NCS) parameters is well-established. Numerous studies have demonstrated a link between advancing age and reduced sensory conduction velocity in healthy individuals.[3,4,5,6,7] Similarly, the decline in motor conduction velocity with increasing age has also been documented[3,4,5,7-9] paralleling findings observed in sensory nerves.There is an inversecorrelation with the amplitude of sensory and motor NCS.[5,10]With advancing age minimal latency also increases as regards F-wave in both upper and lower limbs studies[11,12]Impact of Age and Gender on Sensory Nerve conduction studies. In age considerations-many electrophysiology laboratories maintain normative data tables for sensory nerve conduction studies that are organized by age groups. This is because a person's age can influence the results of these tests, necessitating the use of age-appropriate reference values for accurate interpretation. As per gender differences, research has demonstrated that gender can also impact the outcomes of sensory nerve conduction studies.[7,13-15]Specifically, studies have found that females tend to exhibit greater amplitudes compared to males in sensory nerve conduction studies of the median and ulnar nerves.[13-15]This gender-based variation in results must be accounted for when analysing and interpreting sensory nerve conduction data.

By considering both age and gender when evaluating sensory nerve conduction study findings, clinicians can ensure more accurate diagnoses and better management of neurological conditions affecting the peripheral nervous system.As a result, many electro diagnostic laboratories have tables of normative data that are divided by age-groups. Hennessey et al[14] discovered that gender does not impact nerve conduction velocity or distal latency; however, it significantly affects sensory nerve potential amplitude. Given the documented influence of age and gender on NCS outcomes, including late response F-wave studies, utilizing identical reference limit data across gender and age groups can diminish the sensitivity and specificity of NCS. With the above background the objectives of the study were to find out the effect that increasing age have on the median nerve both the motor and the sensory component. Also, in this study, I tried to find out the effect of gender on median motor and sensory nerve conduction study alongwith the effect of age and if any gender differences between on minimal latency of median F –wave study.

MATERIALS AND METHODS:

The period of study was from Marchto April 2022.The research protocol underwent review and received approval from the Institutional Ethics Review Board prior to initiation. The tests were done in the electrophysiology laboratory for nerve conduction. Participants who were having comorbidities like diabetes mellitus, hypothyroidism, systemic neurological disorder were excluded. Persons with prior neuropathy were excludedForty-nine patients were ultimately enrolled in the study, with the gender breakdown being 23 males and 26 females.

.The key electrophysiological parameters that were the focus of the investigation were those related to median motor nerve conduction studies. Specifically, the researchers examined the distal latency, amplitude, and conduction velocity of the median motor nerves. In addition, the sensory component of the nerve with the onset latency, amplitude and conduction velocity were studied. The median F-wave study was also done with minimal conduction.

NCS was conducted using the neurostim machine and software. The recordings were performed with surface recordings and stimulations. For median motor NCS, the active electrode was placed over the motor point of abductor pollicis brevis and the reference electrode 3cm distally. The nerve was stimulated at the wrist and elbow, and distal latency, CMAP amplitude, and conduction velocity were analyzed. Distal latency was the time from stimulus to CMAP onset, amplitude was baseline-to-negative peak, and velocity was calculated by dividing the distance between stimulation sites by latency difference.

A median sensory nerve conduction study (NCS) was conducted using antidromic stimulation. The median sensory nerve was electrically stimulated at the wrist, 3 cm proximal to the distal wrist crease, and the response was recorded at the second digit (Index finger). For each subject, the following values were included for statistical analysis: onset latency, sensory nerve action potential (SNAP) amplitude, and conduction velocity. The onset latency was measured as the time from the stimulus to the initial negative deflection of the baseline for a biphasic SNAP or to the initial positive peak for a triphasic SNAP. The amplitude of the sensory nerve action potential (SNAP) was quantified from the isoelectric baseline to the first negative deflection. Conduction velocity was calculated by dividing the distance (in millimetres) between the stimulating and recording sites by the onset latency (in milliseconds) and expressed in meters per second.In conducting the median F-wave assessment, the locations for stimulation and recording were analogous to those employed in median motor NCS, the sole difference being the distal placement of the cathode electrode.

The median nerve motor conduction study was performed using supramaximal stimulation. Ten artefact-free responses were recorded and included in the analysis. Additionally, the minimal latency of the F-wave study was included for statistical analysis

STATISTICAL ANALYSIS: For analytical purposes, the study population was divided into four age-defined categories: 36-45 years, 46-55 years, 56-65 years, and a group encompassing those aged 65 years and above. In each age group the mean±SD of the NCS parameters was calculated using MS Excel. The correlation coefficient(r) was calculated between age and the NCS parameters. The degrees of correlation were graded into low ($r<0.29$); Moderate ($0.29\leq r\leq 0.5$) and substantial ($r\geq 0.5$)

RESULTS:

The study included 49 subjects with a mean age of 55.73 ± 11.80 years. The mean age of the 23 male subjects was 58.87 ± 12.20 years, in comparison to the 26 female subjects, whose mean age was 52.96 ± 10.80 years.

Table 1: Electrophysiological parameters (Mean±SD) of Median nerve conduction study of study subjects

Study parameter		Males	Females	Total
Motor	Latency (milliseconds)	3.46±0.47	3.29±0.51	3.37±0.49
	Amplitude (microvolts)	8.25±2.39	6.98±2.08	7.58±2.31
	Conduction velocity (meters/second)	54.80±5.57	55.27±5.35	55.05±5.43
Sensory	Latency (milliseconds)	2.75±0.30	2.67±0.34	2.70±0.32
	Amplitude (µv)	23.70±11.37	27.71±14.77	25.83±13.37

	Conduction velocity (m/s)	49.98±5.84	46.75±5.58	48.27±5.90
Fwave	Latency (milliseconds)	27.52±1.85	25.52±1.86	26.46±2.10

The study cohort was stratified into four distinct age-defined categories for analysis: 36-45 years, 46-55 years, 56-65 years, and a group comprising individuals aged 65 years and older.The data revealed that as the participants advanced in age, several key nerve conduction parameters were affected:

- Latencies showed a trend of increasing values with advancing age
- Amplitudes exhibited a decrease as age progressed
- Conduction velocities demonstrated a slowing pattern with increasing age

These findings align with the established understanding that aging has a significant impact on the function of the peripheral nervous system. The physiological changes associated with advancing age, such as loss of myelinated nerve fibers, axonal degeneration, and impaired nerve regeneration, contribute to the observed alterations in nerve conduction parameters.The stratification of the study population into distinct age groups allowed for a more detailed analysis of the age-related changes in nerve conduction studies. This approach is crucial for establishing appropriate reference values and identifying the specific age ranges at which significant changes occur.In summary, this study highlights the importance of considering age as a key factor when interpreting nerve conduction studies and emphasizes the need for age-specific normative data to ensure precise diagnosis and effective management of nerve disorders which affects the peripheral nerves.

Table 2: Age-wise distribution of the electrophysiological parameters (Mean±SD values) among the study subjects

Study parameter		36-45 yrs	46-55 yrs	56-65 yrs	>65 yrs
Motor	Latency (ms)	3.13±.52	3.40±0.60	3.45±0.41	3.41±0.53
	Amplitude (µv)	7.80±1.28	7.30±2.63	7.69±2.74	7.64±1.86
	Conduction velocity	57.78±5.76	56.0±5.74	54.57±4.69	51.90±4.23

	(m/s)				
Sensory	Latency (ms)	2.41±0.23	2.72±0.31	2.76±0.31	2.85±0.29
	Amplitude (µv)	35.22±17.98	28.57±10.50	21.50±11.55	19.75±9.36
	Conduction velocity (m/s)	51.67±5.35	48.90±6.31	47.83±5.61	44.90±4.41
F wave	Latency (ms)	25.05±1.99	26.04±1.83	26.67±1.43	28.04±2.43

The Pearson correlation coefficient (r) was calculated to study the degree of correlation between age and the various parameters of median nerve conduction study. Table3 shows the values of the correlation coefficients of the electrophysiological parameters with age. A strong positive correlation(r=0.509) was found between age and F-wave latency.

Table 3: Correlation coefficients of various electrophysiological parameters with age

Study parameters		Correlation coefficient (r)
Motor	Latency	0.183
	Amplitude	-0.053
	Conduction velocity	-0.362
Sensory	Latency	0.081
	Amplitude	-0.424
	Conduction velocity	-0.381
F wave	Latency	0.509

DISCUSSION:

Effect of gender: In my study, found that the compound muscle action potential (CMAP) amplitude was higher in males compared to females, Sensory nerve action potential (SNAP) amplitude was higher in females compared to males and F- wave latency was longer in males compared to females. Motor and sensory latencies were comparable in males and females. Motor nerve conduction velocity was higher in females but sensory nerve conduction velocity was higher in males. Studies have reported similar findings. Higher CMAP amplitude in males has been reported by Dilip Thakur[16]et al. Again, Dilip Thakur[16] et al and Chi Ren Huang et al[17] have reported that males have longer F-wave latency. Fuji[18] et al, Chi Ren Huang [17] et al commented after doing their research that there is no influence of gender on nerve conduction velocity and distal latency but SNAP amplitude seems to be the only variable which seems to be affected by gender. This observation has been corroborated by Bolton and Carter[15] which is because of varying finger circumferences between men and women. Females have higher SNAP amplitude than males due to the subcutaneous tissues in fingers closeness to the recording of sensory response. The latencies of all motor nerves were longer in males than in females was found out by Dilip Thakur [16] et al & by Shehab DK[19] , the reason behind this finding may be the greater height & limb length of the male volunteers. The study did not find any difference in the distal motor latency between males and females.

Effect of age: As age increases, latencies became longer, amplitudes became smaller and conduction became slower. Negative correlation was found between age and motor NCV, SNAP amplitude and SNCV. The data analysis revealed a positive correlation between the participants' age and their F-wave latencies. This finding indicates that as the age of the study cohort increased, their F-wave latencies also exhibited a corresponding increase.The positive correlation observed between age and F-wave latency is consistent with the established understanding of the impact of aging on peripheral nerve function. As individuals advance in age, various physiological changes occur within the nervous system, such as axonal degeneration, loss of myelinated nerve fibers, and impaired nerve regeneration. These age-related alterations contribute to the slowing of nerve conduction, which is reflected in the prolongation of F-wave latencies.The identification of a positive correlation between age and F-wave latency underscores the importance of considering age as a crucial factor when interpreting nerve conduction studies, particularly F-wave assessments. This finding emphasizes the need for age-specific normative data to ensure accurate diagnosis and management of peripheral nerve disorders.By establishing the relationship between age and F-wave latency, this study provides valuable insights into the age-related changes in nerve conduction parameters. These insights can inform the development of more accurate diagnostic criteria and guide clinicians in the interpretation of nerve conduction studies in older individuals.The reason for the decrease in amplitude of NCV and SNAP with increasing age has been documented well and attributed to a decreased number of nerve fibres,[20] a reduction in fibre diameter [20,21] and changes in the fibre membrane. [22,23]Previous research by Stetson et al.[7] has documented the impact of aging on various nerve conduction parameters. Their findings indicate that with each decade of increasing age, there is a measurable decline in both sensory nerve conduction velocity (SNCV) and motor nerve conduction velocity (MNCV).Specifically, Stetson et al. reported a decrease of 1.3 m/s in SNCV and 0.8 m/s in MNCV per decade of aging. Furthermore, the same authors demonstrated an average reduction of 5 μV in the amplitude of the sensory nerve action potential (SNAP) of the median nerve (wrist-digit II) per decade.While the magnitude of these age-related changes may appear relatively small within a narrow age range, they can nonetheless have a significant impact on the predicted normal values used in the interpretation of nerve conduction studies. This underscores the importance of considering age as a critical factor when establishing reference data and evaluating nerve conduction parameters.The age-dependent declines in nerve conduction velocity and SNAP amplitude observed in the literature reflect the physiological changes that occur in the peripheral nervous system with advancing age. These changes, which include axonal degeneration, loss of myelinated nerve fibers, and impaired nerve regeneration, contribute to the gradual deterioration of nerve function over time.Recognizing and accounting for these age-related alterations in nerve conduction parameters is crucial for precise diagnosis and effective management of disorders which affect the peripheral nerves. Clinicians must be cognizant of the normative data that are stratified by age to ensure the proper interpretation of nerve conduction study findings and to differentiate pathological changes from the expected age-related declines.A prolonged latency in a young age-group will be missed if normal values based on an older age –group are used.[24]Henry C Tong [10] et al found that sensory NCS parameters do change with time. The study by Dorfman and Bosley [3] of 30 normal subjects (15young&15 older adults) estimated a decrease of 0.16m/s per year of age and that of Stetson [7] et al of 105 normal workers (excluding workers on jobs thought to involve repetitive or forceful hand exercises)estimated a decrease of 0.13 m/s per year & that by Letz and Gerr[25]of over 4000 veterans estimated a decrease of 0.13m/s per year. Tong [10]et al noted a slightly larger decrease in SNCV OF 0.21m/s per year of follow up.

F wave: A delayed electrophysiological response produced by the antidromic stimulation of motor neurons is designated as F-wave. F-wave involves neural conduction occurring at the junction between the peripheral and central nervous systems. The name F-wave is attributed to their recognition for the first time in the small muscles of the foot by Magladency and McDongal in 1950. The parameter which is most frequently used to evaluate F-wave is minimal latency The minimal F latencies in the elderly after 65 years is reported to be slightly longer which is more marked in men." [26]According to Chi Ren Huang [17] et al, gender is a significant factor in F wave studies. The female gender has a negative correlation with the latency of F wave after adjustment of other factors. Huang [17] et al reported a significant effect of age on F-wave latency in the median F-wave, increasing 0.02ms/yr. Dilip Thakur [16] et al reported that F-wave latencies of motor nerves were longer in males compared to females.Probably the reason behind this finding may be the greater height and limb length of the male volunteers Huang [17]et al reported that compared to males, females had shorter latencies in the upper limbs and longer latencies in the lower limbs by F-wave studies.

CONCLUSION:

To conclude, the present study shows that age and gender both affect the values of the various parameters of median nerve conduction study, including F-wave The median nerve CMAP amplitude is found to be higher in males, whereas females exhibited higher SNAP amplitudes. It has been found out that increasing age is associated with prolonged latencies, reduced amplitudes, and slower conduction velocities.F-wave latency has a strong negative correlation with age and is longer in males compared to females. It is therefore important to take a person's age and gender into consideration while reporting and evaluating nerve conduction studies.

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