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Original Research Article

Effect of Aging on Nerve Conduction Study of Median Nerve and Ulnar Nerves in Healthy Individuals: A Cross-Sectional Study

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Abstract:

Background: Numerous physiological and environmental factors are known to have an impact on nerve conduction studies (NCS). The purpose of the current investigation was to ascertain how aging affected the nerve conduction velocity (NCV) of the two often studied upper limb nerves, the ulnar and median, in subjects of varying ages. Moreover, the goal was to gather reference information for use in clinically relevant nerve diagnostic tests. The objectives of this study were to examine how aging affects the median and ulnar nerve's nerve conduction velocities and to track changes in the NCS of these two nerves in relation to age.

Methods: In this cross-sectional and observational study, 110 healthy participants (60 males and 50 females) were involved. Medical students and staff members, both teaching and non-teaching, at the ANMMCH in Gaya, Bihar, volunteered to be the study's subjects between April 2023 and December 2023. Group I (18–30 years old) (n = 38), Group II (31–45 years old) (n = 38), and Group III (46–60 years old) (n = 34) were the age groups into which the subjects were divided. The amplitudes, NCVs, and motor and sensory distal latencies of the ulnar and median nerves were measured, and the results were assessed.

Results: For both the sensory and motor components, the latencies, amplitudes, and velocities of the median and ulnar nerves were examined, together with their mean and standard deviation. In comparison to the younger age group, patients who were older had longer latencies (median: Motor and sensory $P < 0.001$, ulnar: Motor = 0.013 and sensory = 0.006), smaller amplitudes (median: Motor $P = 0.013$ and sensory <0.001, ulnar: Motor $P = 0.014$, and sensory = 0.008), and slower conduction velocities (median: Motor $P < 0.001$ and sensory = 0.006, ulnar: Motor $P = 0.003$ and sensory = 0.069). This change was clearly noticeable in the age group of ≥46 years. The ulnar and median nerves' sensory nerve conduction changed more with aging.

Conclusion: The findings of our study show a substantial correlation between age and each of the three nerve conduction characteristics that were measured from both nerves. The findings of routine testing should be compared age-wise in order to improve NCS's diagnostic sensitivity.

Keywords: Age; Ageing; Median; Ulnar; Motor; Sensory; Nerve Conduction Studies; Nerve Conduction Velocity.

Introduction

The definition of aging is the progressive, widespread degradation of function that leads to the loss of the ability to adjust to stresses in the environment and body.[1] It is also described as the gradual, deteriorating changes that occur throughout the adult stage of life and cause an organism's susceptibility to challenges to rise, ultimately lowering its chances of survival. Gerontologists distinguish between basic and secondary concepts of aging. Primary aging refers to age-related changes that arise naturally and are not brought on by illness or other factors. Secondary aging is the result of changes brought about by the interaction of environmental factors, disease processes, and the aging process itself. Aging individuals have been shown to lose height and lean body mass, and women gain fat and experience its redistribution.[2] Aging and various other changes in biochemical, morphologic, and functional aspects affect the peripheral nerve system (PNS).[3] Declining muscle contraction, decreased muscle metabolism, reduced nerve conduction velocity (NCV), and neuromuscular junctions are frequently associated with these alterations. NCV and aging are substantially inversely correlated.[4] Age-related morphologic studies have shown a reduction in both myelinated and unmyelinated nerve fibers. Autonomic reactions, endoneurial blood flow, muscle strength, and sensory discrimination are all declining. Age-related alterations do not follow a linear trajectory. While the processes of axonal regeneration and reinnervation are often less efficient and occur gradually, they persist throughout an individual's lifespan.[3]

Action potentials, which start in the cell body of the neuron and travel via the nerve fibers to the axon terminal, are the means by which information is transmitted in the nervous system under physiological conditions. Electrophysiologic studies can be used to examine artificial neural impulses that are activated at certain places along a nerve when an electrical stimulation is applied.[5] In many clinical situations, electrodiagnostic investigations are therefore performed for patients suspected of having a PNS illness involving nerve roots, peripheral nerves, or the neuromuscular junction in order to provide comparative and supporting evidence for the diagnosis.[6] Numerous physiological and environmental factors are known to have an impact on nerve conduction studies (NCSs). Numerous research investigations have published the region- and population-specific normative reference values needed for comparison and outcome evaluation. Researchers in their NCS have concurred that anthropometric and chronological age variations might also affect outcomes; however, information regarding reference values that are unique to age groups is not easily accessible. The objective of the present study was to ascertain how aging affected the nerve conduction velocity (NCV) of the upper limb's two frequently evaluated median and ulnar nerves in people of various ages. In addition, the goal was to gather reference data for clinically meaningful nerve diagnostic tests and ascertain whether there was a significant link between changes in NCS values at a particular age group.

Materials and Methods

From April 2023 to December 2023, 110 healthy participants participated in this cross-sectional observational study. The study's subjects were chosen from among the volunteers—medical students, faculty members, and non-teaching staff at the Anugrah Narayan Magadh Medical College and Hospital in Gaya, Bihar, as well as willing participants from other spheres of society. The aim of the study and methodology were presented to the participants in straightforward language, and each one gave their informed consent as required. In this study, healthy volunteer men and women between the ages of 18 and 60 were recruited.

Exclusion criteria included a history of diseases affecting the nervous system or muscles, as well as any injuries, fractures, or pain in the wrist or forearm, tremors, ataxia, muscle weakness, or muscle wasting, damage to the upper limbs, spinal cord, or brain, abnormal sensations over the limbs, such as tingling, numbness, pain in limbs, or burning sensations, neurological deficit, diabetes mellitus, hypertension, thyroid disorders, alcoholism, smoking, and leprosy.

A personal history and diet were determined. Individuals with obesity (body mass index [BMI]> 24.99 kg/m^2) were excluded from the study. In the physiology department of the ANMMCH in Gaya, NCS was conducted using a 16-channel Medicaid physiograph machine. The study room's temperature was kept steady at 25 to 27 degrees Celsius. As seen in Table 1, the ulnar and median nerves underwent the motor and sensory NCSs.

Table 1: Sites for stimulation and recording of median and ulnar nerves

Nerve	Stimulation site	Recording site
Median • Motor • Sensory	 Wrist, Elbow Wrist	 Thenar muscle Index finger
Ulnar • Motor • Sensory	 Wrist, elbow Wrist	 Hypothenar muscle Little finger

Data from distal stimulation, such as compound muscle action potentials (CMAPs), motor NCV (MNCV), and distal motor latency (DML), were collected for each subject. The time interval between the stimulus and the CMAP's first baseline departure is represented by the DML.

From the baseline to the negative peak, the CMAP (CMAPA) amplitude was computed. For every patient, the sensory nerve action potential (SNAP) and sensory NCV (SNCV) recording data were examined. The time interval between the stimulus and the baseline's initial negative deflection is known as the onset latency for a biphasic SNAP. For the study, surface electrodes were employed. A ground electrode was positioned between the stimulating and recording electrodes as a safety measure, and the recording electrodes were adhered to the patient's well cleaned and scrubbed skin using adhesive tape.

Using a stimulator, a stimulus current was delivered to the targeted nerve in order to excite it supramaximally. A recording electrode picked up the subsequent action potential. A flexible measuring tape was used to measure each nerve's length.

Results

Table 2 shows the data from the current study on the height of males (167.40 ± 4.04 cm), weight (66.27 ± 5.17 kg), BMI (23.63 ± 1.32), BSA (1.75 ± 0.08), and height of females (159.44 ± 3.16 cm, 58.38 ± 5.07 kg, BMI (22.95 ± 1.70), BSA (1.60 ± 0.07).

Table 2: The age, height, weight, BMI, and BSA of all subjects included in the study

Variables	Male Mean±SD	Female Mean±SD	Total Mean±SD
Age (years)	37.87±11.94	37.08±12.49	37.51±12.14
Height (cm)	167.40±4.04	159.44±3.16	163.78±5.40
Weight (kg)	66.27±5.17	58.38±5.07	62.68±6.45
BMI (Body mass indec)	23.63±1.32	22.95±1.70	23.32±1.54
BSA (Body surface area)	1.75±0.08	1.60±0.07	1.68±0.11

Table 3 shows longer latencies, smaller amplitudes, and slower NCV of both median and ulnar nerve (motor, sensory).

Table 3: Comparison of median and ulnar nerve NCS mean values between three age groups

Variables	18–30 years (group1)		31–45years (group2)		46–60years (group3)		P-value	Significance
	Mean	SD	Mean	SD	Mean	SD		
Median nerve								
Motor latency	3.07	0.15	3.20	0.22	3.57	0.23	<0.001	Highly significant
CMAPA	9.63	0.87	9.28	1.05	8.91	1.12	0.013	Significant
MNCV	62.44	2.83	58.77	3.33	53.52	3.74	<0.001	Highly significant
Sensory latency	2.23	0.11	2.31	0.15	2.42	0.17	<0.001	Highly significant
SNAPA	11.77	0.81	10.84	1.33	9.97	1.25	<0.001	Highly significant
SNCV	60.87	3.33	60.14	3.81	57.55	3.93	0.001	Highly significant
Ulnar nerve								
Motor latency	2.18	0.19	2.20	0.21	2.33	0.28	0.013	Significant
CMAPA	10.09	0.83	9.81	1.01	9.40	1.10	0.014	Significant
MNCV	62.01	2.72	61.14	3.33	59.39	3.53	0.003	Highly significant
Sensory latency	2.16	0.09	2.18	0.10	2.24	0.12	0.006	Highly significant
SNAPA	10.78	1.07	11.01	1.31	10.19	0.90	0.008	Highly significant
SNCV	63.07	2.56	62.73	2.91	61.54	3.22	0.069	Highly significant

NCS: Nerve conduction studies, NCV: Nerve conduction velocity, MNCV: Motor nerve conduction velocity, SNCV: Sensory nerve conduction velocity

Table 4 displays the relationship between age and the motor and sensory NCS parameters of both nerves. Age and NCV were correlated using Karl Pearson's correlation analysis. Age and median motor and sensory conduction velocity (R = -0.772, R = -0.358), and ulnar motor and sensory conduction velocity (R = -0.579, R = -0.425) showed a statistically significant negative connection.

Table 4: The correlation of median and ulnar nerve conduction study parameters with the influencing factors; age, height, BMI, and BSA

Variables	Age	Height	BMI	BSA
Median motor latency				
R-value	0.700	0.182	0.389	0.314
P-value	<0.001	0.057	<0.001	0.001
Median motor amplitude				
R-value	−0.291	0.196	0.005	0.159
P-value	0.002	0.040	0.957	0.097
Median Motor conduction velocity				
R-value	−0.772	−0.070	−0.321	−0.193
P-value	<0.001	0.465	0.001	0.043
Median sensory latency				
R-value	0.495	0.066	0.226	0.145

P-value	<0.001	0.493	0.018	0.130
Median amplitude sensory				
R-value	−0.599	−0.117	−0.372	−0.255
P-value	<0.001	0.225	<0.001	0.007
Median sensory conduction velocity				
R-value'	−0.358	−0.101	−0.190	−0.157
P-value	<0.001	0.296	0.047	0.101
Ulnar motor latency				
R-value	0.549	0.175	0.240	0.244
P-value	<0.001	0.068	0.012	0.010
Ulnar motor amplitude				
R-value	−0.425	−0.114	−0.211	−0.183
P-value	<0.001	0.234	0.027	0.055
Ulnar motor conduction velocity				
R-value	−0.579	−0.168	−0.214	−0.227
P-value	<0.001	0.080	0.025	0.017
Ulnar sensory latency				
R-value	0.449	0.135	0.176	0.186
P-value	<0.001	0.161	0.066	0.052
Ulnar amplitude sensory				
R-value	−0.601	−0.016	−0.180	−0.083
P-value	<0.001	0.872	0.059	0.390
Ulnar sensory conduction velocity				
R-value	−0.425	−0.087	−0.173	−0.147
P-value	<0.001	0.365	0.070	0.125

Discussion

When assessing the functional integrity of the neuromuscular junction and peripheral nerves, NCS is a crucial diagnostic tool. NCS is often influenced by a number of variables, including height, age, gender, and BMI.[9,10] The normal values of NCS parameters corresponding to the various age groups are obtained from research carried out on persons with normal neurological function or they are compared to published values. Consequently, the current investigation sought to determine the impact of aging on peripheral nerve conduction as well as the relationship between alterations in NCSs and age.
The findings of our study show that the motor and sensory properties of median and ulnar nerves of the upper limb in both genders exhibit increasing latency, decreasing amplitude, and declining nerve conduction velocities with aging. All three nerve conduction parameters obtained from both nerves showed a strong correlation with age.

The DML of the median and ulnar nerves increases significantly ($P < 0.001$) as age increases, according to the results, which are consistent with those of Kumari et al.,[11] and Palve and Palve.[12] Aging-related prolongation of latency may be brought on by the degeneration of peripheral nerve fibers, both myelinated and unmyelinated. When the three age groups are compared, it is evident that both the motor and sensory amplitudes decrease as age increases. The change in the ulnar motor nerve is significant, but it is not significant in the median motor nerve. In both genders, the change in the sensory nerve amplitude of the median and ulnar nerves is highly significant.

Our findings are in line with those of Verdu et al.,[3] Palve and Palve[12], and Thakur et al.,[13], who indicated that as people age, their bilateral median and right ulnar nerve CMAP amplitudes decline. Our findings corroborate the findings of Buchthal et al. [14] and Tackmann et al. [15], who found that aging is associated with a decline in sensory nerve amplitude. The same was also reported by Stetson et al. [16]. Over a period of five years, Tong et al. [17] noted that the median and ulnar SNAP amplitudes dropped by 1.75–2.3 μV. The results of our study are likewise similar to those of Thakur et al. [13], who found that the right median (19.01 ± 7.83 vs. 26.97 ± 10.63) and right ulnar (10.9 ± 3.44 vs. 16.09 ± 5.85) had lower SNAPA in older people than in younger people.

As age increases, there is a highly substantial decrease in the motor and sensory CV of the ulnar and median nerves, with alterations being somewhat similar in both genders. According to Tong et al. [17], there was a decline in CV with age at a rate of 0.41 m/s per year and a decrease in the sensory velocity of the median nerve at a rate of 0.14 m/s per year. These findings are similar to those of a study conducted by Awang et al. [4], which also noted a significant reduction in median MNCV. Awang et al.,[4] Palve and Palve[12] found that as people aged, the median SNCV significantly decreased. Our findings similarly concur with those of Kumar et al. [18], who found that male patients aged 51–60 had lower mean SNCV of the ulnar nerve than subjects aged 21–30.

Reduced nerve excitability could be the cause of this reduction. The theory that aging causes an increase in oxygen-free radicals, which damage the mitochondrial enzyme system and reduce ATP production, which causes the slowing of muscle contraction, altered muscle metabolism, and altered neuromuscular junction, explains the decreased conduction velocity of the nerves.[19,20] Our findings were at odds with those of Kumar et al. [18], who reported a 10.62% ($P < 0.001$) rise in the mean MNCV of the median nerve in male patients aged 51–60. Table 3 results indicate that the 46–60 year old age group experiences higher age-related changes in NCS.

Age and motor and sensory latency of both nerves are correlated in HS (+ve) fashion in Table 4, while CMAPA, SNAPA, MNCV, and SNCV of both nerves are correlated in HS (-ve) fashion. These findings are in line with research by Palve and Palve[12] and Kumari et al.[11], who similarly noted a declining tendency in the ≥46-year-old age group and a clear relationship between age and the NCS in the upper limb's motor and sensory nerves. Our findings somewhat concur with those of Huang et al.'s study [21], which found a weak association with ulnar NCS and a moderate correlation with age in the median NCS. The results of studies by Cottrell,[22], Rexed,[23], and Norris et al.,[24] provide an explanation for this drop by showing that as age grows, both connective tissue and blood vascular patency decrease. As early as age forty, this process starts in life.

There is an increase in endo-perineurium invasion, endothelial proliferation, and the appearance of connective tissue elements replacing nerve bundle sites in vascular hyalinization. A slow alteration and reduction of nerve fibers, especially the bigger ones, results from a gradual decrease in blood flow, modifications in the permeability of the capillaries, an increase in connective tissue, and an accompanying metabolic depression.[25, 26] The findings of our investigation contradicted the findings of Falco et al. [25], who reported that age has no bearing on median motor and sensory conduction parameters and that NCS changes between the ages of 60 and 80. Additionally, the influence on ulnar nerve characteristics was statistically significant although of modest strength. This discrepancy was most likely caused by the fact that only one upper limb of healthy senior citizens, aged 60 to 95, was studied prospectively in the aforementioned investigation. With the exception of a substantial but weak correlation ($r = 0.196$) with median nerve CMAPA, Table 4 displays NS weak ($r < 0.182$) height association with ulnar nerve CMAPA, motor and sensory latency, and NS weak ($r < -0.168$) with ulnar nerve CMAPA, SNAPA, MNCV, and SNCV of both nerves. While Awang et al.,[4] and Rivner et al.,[27] reported no link between height and median MNCV, Huang et al.,[21] discovered a moderate correlation with median SNCV. The results were somewhat in line with these findings.

It suggests that age had a greater influence within the constrained height range of the chosen volunteer group. The results presented in Table 4 indicate that the correlation between BMI and median motor latency was weak ($r = 0.389$). However, there was a weak correlation between HS (+ve) and median motor latency, S ($r < 0.314$) and ulnar motor latency, NS (+ve) and median nerve CMAPA, ulnar sensory latency, HS (−ve) and median nerve SNAPA, S (−ve) and MNCV of both nerves, and NS(−) with median nerve SNCV, ulnar nerve CMAPA, SNAPA, and SNCV. Prolonged latency, delayed conduction, and amplitude decrease can be explained by the longer distance traveled by stimulating impulses with the increase in surface area, more distantly placed recording electrodes placed across thicker subcutaneous tissue, and thicker nerve sheath with the increase in body mass index. Predicting the outcome may be hampered by the individuals' notable differences in BMI and BSA. The age variable in this study had a more considerable and highly significant connection with the obtained results, but the limited normal range of BMI (23.2 ± 1.54) and BSA (1.68 ± 0.11) had a lesser association and varying relevance. The patients' forearms and hands were kept warm, and the laboratory temperature was kept between 25 and 27°C to reduce the impact of temperature on the results.

Conclusion

Based on the results of our investigation, we determined that nerve conduction parameters were significantly influenced by age. The findings of routine testing should be compared age-wise in order to improve NCS's diagnostic sensitivity.

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