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A STUDY TO EVALUATE EFFECT OF AGE AND GENDER ON NERVE CONDUCTION.

Physiology

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ABSTRACT

Introduction: Nerve conduction studies have become a simple and reliable test of peripheral nerve function. Nerve conduction study assesses peripheral motor and sensory functions by recording the evoked response to electrical stimulation of peripheral nerves. There are several factors which may influence nerve conduction study such as temperature, age, height, body mass index (BMI). They have to be taken into consideration while doing nerve conduction study.

Aim and Objective: The aim of present study was to evaluate effect of age and gender on nerve conduction in Median and Ulnar Nerves of Upper Limb in normal healthy adult individuals.

Material and Method: The study was conducted in the Department of Physiology, Maharishi Markandeshwar Institute of Medical sciences and Research, Mullana (Ambala). The study comprised of 200 healthy subjects between the age group of 16-55 years consisting of equal number of males and females. The equipment used was Allengers Scorpio EMG EP NCS system provided by Allengers Medical System Limited, Chandigarh. Compound Muscle Action potential (CMAP) and Sensory Nerve Action Potential (SNAP) of Median and Ulnar nerve were recorded using standardized technique.

Result and conclusion: From our study, we found out that age has a definite and significant effect on various parameters of nerve conduction study. With increasing age latency increases and amplitude and conduction velocity decreases. The influence of aging is attributed to a decreased number of nerve fibres, reduction in fibre diameter and changes in the fibre membrane.

Gender also affects various parameters of nerve conduction study. The latency tends to be greater in males than females whereas, the nerve conduction velocity is greater in females. The amplitude in sensory nerves is higher in females. Gender difference in nerve conduction parameters can be explained on the basis of gender wise differences in anatomical and physiological factors. This difference in parameters can also be due to greater height and limb length in males.

We concluded that age and gender have definite and significant influence on nerve conduction and these factors have to be taken into consideration while doing nerve conduction study.

KEYWORDS

Nerve conduction study, Compound muscle action potential, Sensory nerve action potential, Latency, amplitude, Nerve conduction velocity.

Introduction

Nerve conduction study assesses peripheral motor and sensory functions by recording the evoked response to electrical stimulation of peripheral nerves[1, 2, 3].

Electrical stimulation of the nerve initiates an impulse that travels along the motor or sensory nerve fibres. The assessment of conduction characteristics depends on the analysis of compound evoked potentials. They are recorded from the muscle and the nerve in the study of the motor fibres and the sensory fibres, respectively.

With adequate standardization, nerve conduction studies not only identify the lesion but also localize the site of maximal involvement of the nerve [4]. These enable the clinicians to differentiate the two major groups of peripheral diseases: Demyelination and Axonal degeneration [5].

Peripheral nerves may be stimulated by passing electrical currents through the skin. It results in a synchronized muscle contraction. When recorded by surface electrodes, this is called the compound muscle action potential (CMAP). Motor responses are recorded over the muscle being studied.

A sensory nerve action potential (SNAP) is produced by electrical stimulation of the sensory nerve. This may be recorded over peripheral sensory nerves in a number of areas. Commonly measured parameters of CMAP and SNAP include latency, amplitude and conduction velocity Nerve conduction studies have become the quantitative hallmark of the extent and progression of impairment in diabetic peripheral neuropathy [6,7]. There are anatomical and physiological aspects to nerve conduction velocity. The conduction velocity of the nerve depends on the fibre diameter, degree of myelination and the internodal distance. There are several other factors which may influence nerve conduction study such as temperature, age, height, body mass index (BMI) etc. They have to be taken into consideration while doing nerve conduction study. The aim of present study was to find out effect of age and gender on nerve conduction study.

Material and method

The study was conducted in the Department of Physiology, Maharishi Markandeshwar Institute of Medical sciences and Research, Mullana (Ambala).

The study comprised of 200 healthy subjects between the age group of 16-55 years consisting of both males and females. The subjects were divided into 4 ages groups each consisting of 50 subjects with equal number of males and females.

Age groups were-

1.Group I- 16-25 years
2.Group II- 26-35 years
3.Group III- 36-45 years
4.Group IV- 46-55 years

Subjects were made comfortable with the laboratory set up and conditions and familiarized with procedure. They were advised to relax completely during recording. Informed written consent was taken from volunteers. Anthropometric data i.e. age, height and weight was noted and BMI was calculated by using Quetelet's index i.e. Weight (in kg)/ (Height (in m))^2. The subjects were screened for any history of drug intake or medical illness i.e. Neuropathy, Limb Injury, Neuromuscular transmission disorders and myopathy likely to affect the nerve conduction study parameters based on clinical history and physical examination including detailed Neurological assessment.

Exclusion criteria

- Age less than 16 years or greater than 55 years.
- Diabetes
- Hypertension
- Alcohol intake
- Smoking
- Obese (BMI ≥ 25kg/m^2 As per revised body type classification for Indian population recommended by Health ministry and Diabetes Foundation of India in 2008) [8]
- Limb injury
- Neuropathy
- Neuromuscular transmission disorders
- Myopathy

Recording procedure

The Equipment used was Allengers Scorpio EMG EP NCS system provided by Allengers Medical Systems Limited, Chandigarh. Nerve conduction study was done at the room temperature of 26ºc. At this temperature, the skin temperature of 31-34ºc is achieved and in this range normal Nerve Conduction Velocity may be obtained [9,10]. Filters were set at 2 Hz to 5 kHz and sweep speed was 5 ms per division for motor study and for sensory study, filters were at 20 Hz to 3 kHz and sweep speed was 2 ms per division. Duration of stimulus for both motor and sensory study was at 100 µs. A current of supramaximal stimulus was delivered in order to get adequate responses.

Compound Muscle Action potential and Sensory Nerve Action Potential of: (i) Median nerve (ii) Ulnar nerve was recorded. Two sites of stimulation were used for motor nerve conduction study. The site of stimulation for motor median and ulnar nerves were wrist and elbow and recording site were motor point of abductor pollicis brevis and abductor digiti minimi respectively. Disc electrodes were used for motor nerve study. The distance between the two points of stimulation was measured.

For Sensory nerve conduction study, antidromic study using ring electrodes was done. Electrodes were placed on index and little finger for median and ulnar nerve respectively and point of stimulation was wrist. The various sites of stimulation and recording are summarized in table 1[11].

Table 1: various sites of stimulation and recording in median and ulnar nerves.

NERVE		STIMULATION SITE	RECORDING SITE
MEDIAN	MOTOR	1.PROXIMAL:- ANTICUBITAL FOSSA (Medial to the biceps tendon) 2.DISTAL:- WRIST (Between the flexor carpi radialis and the Palmaris longus tendon)	THENAR MUSCLE (Abductor Pollicis Brevis)
	SENSORY	WRIST (Medial to the flexor carpi radialis tendon)	INDEX FINGER
ULNAR	MOTOR	1.PROXIMAL:- ELBOW (Distal to the medial epicondyle) 2.DISTAL:- WRIST (Posterior to the flexor carpi ulnaris tendon)	HYPOTHENAR MUSCLE (Abductor Digiti Minimi)
	SENSORY	WRIST (Posterior to the flexor carpi ulnaris tendon)	LITTLE FINGER

For each stimulation site, the following parameters were recorded for both motor and sensory nerves.

1. Latency in milli-seconds (ms)
2. Amplitude in milli-volt (mv) and micro-volt (µV) for Motor and Sensory nerves respectively.
3. Conduction velocity in meters per second (m/s) The conduction velocity in m/s for motor nerve between the two sites of stimulation was calculated by

$$\text{Conduction velocity} = \frac{\text{Distance in mm}}{\text{(Latency proximal – Latency distal) in ms}}$$

The sensory conduction velocity was calculated by dividing the distance between stimulating and recording sites by the latency.

$$\text{Conduction velocity} = \frac{\text{Distance in mm}}{\text{Latency in ms}}$$

Data Management and statistical analysis

The data entry was carried using Microsoft Office Excel Worksheet. Statistical analysis was done using statistical package for social sciences (SPSS) 19.0 version. Results were presented as Mean ± SD. T test was used for comparing means of two groups. Means of more than two groups were compared using ANOVA test. Pearson's correlation analysis was performed to assess the co relationship between different variables. P value of less than 0.05 was considered statistically significant. P value of less than 0.01 was considered highly significant.

Results

The values of various parameters of nerve conduction study in different age groups for median and ulnar motor nerve are shown in table 2.

Table 2: Effect of age on various parameters of Median and Ulnar motor nerve

MEDIAN MOTOR NERVE			
AGE GROUPS	LATENCY (ms) (MEAN±SD)	AMPLITUDE (mv) (MEAN±SD)	VELOCITY (m/s) (MEAN±SD)
GROUP I (16-25 yrs)	2.93±0.35	14.84±2.52	60.03±1.37
GROUP II (26-35 yrs)	2.89±0.31	13.01±2.95	59.53±1.11
GROUP III (36-45 yrs)	3.23±0.30	13.57±2.12	56.00±1.63
GROUP IV (46-55 yrs)	3.43±0.32	13.69±1.73	51.61±1.66
ULNAR MOTOR NERVE			
GROUP I (16-25 yrs)	2.47±0.37	10.41±1.79	60.02±1.80
GROUP II (26-35 yrs)	2.38±0.23	9.73±1.95	59.69±1.12
GROUP III (36-45 yrs)	2.55±0.28	10.37±1.75	56.12±1.68
GROUP IV (46-55 yrs)	2.97±0.36	10.12±1.51	51.86±1.71

The values of various parameters of nerve conduction study in different age groups for median and ulnar sensory nerve are shown in table 3.

Table 3: Effect of age on various parameters of Median and Ulnar sensory nerve.

MEDIAN SENSORY NERVE			
AGE GROUPS	LATENCY (ms) (MEAN±SD)	AMPLITUDE (µv) (MEAN±SD)	VELOCITY (m/s) (MEAN±SD)
GROUP I (16-25 yrs)	2.38±0.08	38.11±8.84	58.82±2.03
GROUP II (26-35 yrs)	2.39±0.08	35.95±6.82	58.43±2.03
GROUP III (36-45 yrs)	2.58±0.13	33.23±7.34	54.37±2.75
GROUP IV (46-55 yrs)	2.78±0.12	33.31±6.57	50.40±2.26
ULNAR SENSORY NERVE			
GROUP I (16-25 yrs)	2.28±0.15	34.06±7.70	59.88±1.72

GROUP II (26-35 yrs)	2.29±0.15	30.94±6.60	59.07±1.64
GROUP III (36-45 yrs)	2.50±0.15	30.84±6.33	55.40±2.32
GROUP IV (46-55 yrs)	2.68±0.16	29.65±5.44	51.60±2.30

One way ANOVA test was applied to see the effect of age on various Parameters of Nerve Conduction Study in different age groups.

From the above tables, it can be seen that age has a definite and significant effect on various parameters of nerve conduction study. The median motor latency increases with increasing age and is highly significant (p<0.001). The median motor amplitude decreases with increasing age. The median motor conduction velocity decreases with increasing age and is highly significant (p<0.001). The ulnar motor latency increases with increasing age and is highly significant (p<0.001). The ulnar motor amplitude decreases with increasing age. The ulnar motor conduction velocity decreases across with increasing age and is highly significant (p<0.001). The sensory median nerve latency increases with increasing age and is highly significant (p<0.001). The median sensory amplitude also decreases with increasing age and is significant (p<0.05). The median sensory nerve conduction velocity shows a highly significant decrease (p<0.001) with increasing age. The sensory ulnar nerve latency increases with increasing age and is highly significant (p<0.001). The ulnar sensory amplitude also decreases with increasing age and is significant (p<0.05). The ulnar sensory nerve conduction velocity shows a highly significant decrease (p<0.001) with increasing age.

Pearson's Correlation test was applied to find correlation between age and different parameters of nerve conduction study i.e. latency, amplitude and conduction velocity as shown in table 4.

Table 4: Correlation between age and latency, amplitude and velocity of both motor and sensory median and ulnar nerves in all subjects (Pearson's correlation).

NERVE PARAMETERS	N	PEARSON CORRELATION	SIG. (2-TAILED)
MEDIAN MOTOR LATENCY (ms)	200	0.557	<0.001
MEDIAN MOTOR AMPLITUDE (mv)	200	-0.143	<0.05
MEDIAN MOTOR VELOCITY (m/s)	200	-0.893	<0.001
ULNAR MOTOR LATENCY (ms)	200	0.488	<0.001
ULNAR MOTOR AMPLITUDE (mv)	200	-0.008	>0.05
ULNAR MOTOR VELOCITY (m/s)	200	-0.870	<0.001
MEDIAN SENSORY LATENCY (ms)	200	0.822	<0.001
MEDIAN SENSORY AMPLITUDE (µv)	200	-0.243	<0.05
MEDIAN SENSORY VELOCITY (m/s)	200	-0.827	<0.001
ULNAR SENSORY LATENCY (ms)	200	0.720	<0.001
ULNAR SENSORY AMPLITUDE (µv)	200	-0.217	<0.05
ULNAR SENSORY VELOCITY (m/s)	200	-0.849	<0.001

The age was positively correlated with latency of both the motor and sensory median and ulnar nerves and was highly significant. The age was negatively correlated with amplitude of both the motor and sensory median and ulnar nerves and was significant. The age was negatively correlated with conduction velocity of both the motor and sensory median and ulnar nerves and was highly significant.

Effect of gender on various Parameters of Nerve Conduction Study
Our study comprised of 100 males and 100 females. The data was separately analyzed for both males and females. The mean and standard deviation (SD) of latency, amplitude and conduction velocity of both the motor and sensory median and ulnar nerves is in males and females are shown in Table 5.

Table 5: Effect of gender on various parameters of nerve conduction study.

NERVE	PARAMETERS	MALES (MEAN±SD)	FEMALES (MEAN±SD)
MEDIAN MOTOR	LATENCY (ms)	3.18±0.37	3.05±0.40
	AMPLITUDE (mv)	13.73±2.27	13.82±2.63
	VELOCITY (m/s)	56.77±3.50	56.81±3.86
ULNAR MOTOR	LATENCY (ms)	2.63±0.37	2.55±0.40
	AMPLITUDE (mv)	10.20±1.75	10.12±1.78
	VELOCITY (m/s)	56.81±3.33	57.04±3.99
MEDIAN SENSORY	LATENCY (ms)	2.53±0.18	2.53±0.21
	AMPLITUDE (µv)	30.60±5.49	39.70±6.78
	VELOCITY (m/s)	55.48±3.74	55.54±4.48
ULNAR SENSORY	LATENCY (ms)	2.42±0.20	2.45±0.24
	AMPLITUDE (µv)	28.07±5.06	34.68±6.56
	VELOCITY (m/s)	56.34±3.41	56.63±4.27

The statistical comparison between two groups was done by t test. From the above tables, it can be seen that gender has effect on various parameters of nerve conduction study. The latency of motor median nerves is greater in males than females. Whereas, the amplitude and nerve conduction velocity is greater in females than males. The latency and amplitude of motor ulnar nerve is greater in males whereas, the nerve conduction velocity is greater in females. Gender has highly significant effect on sensory nerve amplitudes. The amplitude of both median and ulnar sensory nerves is greater in females and is highly significant (p<0.001). The nerve conduction velocity of both the sensory median and ulnar nerves is greater in females.

Discussion

Our study was aimed to investigate the effect of age and gender on nerve conduction study variables.

To study the effect of age we made 4 groups of 50 subjects each. we observed that age has a definite and significant effect on various parameters of nerve conduction study. The median motor latency increases with increasing age and is highly significant (p<0.001) while as, the median motor conduction velocity decreases with increasing age and is highly significant (p<0.001). The ulnar motor latency increases with increasing age and is highly significant (p<0.001) while as, the ulnar motor conduction velocity decreases with increasing age and is highly significant (p<0.001). The difference between the groups for median motor nerve amplitude as age increases is statistically significant (p<0.05). However, the ulnar motor nerve amplitude though decreases with increasing age but the difference is not statistically significant (p>0.05). This may be due to minimal effect of aging.

Huang *et al* in their study found that subjects with older age had smaller amplitude compared to younger age groups [12]. With normal aging, probably there may be decrease in amplitude due to decrease in muscle mass and decrease in motor unit size. The decrease in amplitude of older age individuals may be due to decrease or loss in number of nerve fibres. Hennessey *et al* also found decrease in amplitude of median nerve in older age groups. The sensory median nerve latency increases with increasing age and is highly significant (p<0.001). The median sensory amplitude also decreases with increasing age and is significant (p<0.05). The median sensory nerve conduction velocity shows a highly significant decrease (p<0.001) with increasing age. The sensory ulnar nerve latency increases with increasing age and is highly significant (p<0.001). The ulnar sensory amplitude also decreases with increasing age and is significant ($p<0.05$). The ulnar sensory nerve conduction velocity shows a highly significant decrease ($p<0.001$) with increasing age.

Age has been widely accepted to have an influence on nerve conduction study [13]. The increase in latency and decrease in nerve conduction velocity and sensory amplitude associated with increasing age has been well documented and coincides favourably with our study. The influence of aging is attributed to a decreased number of nerve fibres, reduction in fibre diameter and changes in the fibre membrane [14-22].

Aging deeply influences several morphologic and functional features of the peripheral nervous system (PNS). Morphologic studies have reported a loss of myelinated and unmyelinated nerve fibres in elderly subjects, and several abnormalities involving myelinated fibres, such as demyelination, remyelination and myelin balloon figures. The deterioration of myelin sheaths during aging may be due to a decrease in the expression of the major myelin proteins [23]. Axonal atrophy, frequently seen in aged nerves, may be explained by a reduction in the expression and axonal transport of cytoskeletal proteins in the peripheral nerve. Aging also affects functional properties of the PNS, including a decline in muscle strength, sensory discrimination, autonomic responses, and endoneurial blood flow. The age-related decline in nerve regeneration after injury may be attributed to changes in neuronal, axonal, Schwann cell and macrophage responses.

Norris & Wagman found a decrease in nerve conduction in all segments of peripheral nerves with increases in age [24]. It has been reported that loss of axons occurring especially later in life [25] is likely to attenuate sensory action potential more than motor as the later are maintained to some extent by collateral sprouting in the muscle. This might be the reason for declining trend of the sensory amplitude observed in our study too.

Our study comprised of 100 males and 100 females. The data was separately analysed for both males and females. We observed that gender has effect on various parameters of nerve conduction study. The latency in both median and ulnar nerves is more in males than in females whereas, nerve conduction velocity in both motor nerves is more in females. The latency of motor median nerves is greater in males (3.18±0.37) than females (3.05±0.40) whereas, the nerve conduction velocity is greater in females (56.81±3.86) than males (56.77±3.50). The latency of motor ulnar nerve is greater in males (2.63±0.37) than females (2.55±0.40) whereas, the nerve conduction velocity is greater in females (57.04±3.99) than males (56.81±3.33). The amplitude of median motor nerve is greater in females (13.82±2.63) than males (13.73±2.27). whereas, the amplitude of ulnar motor nerve is greater in males (10.20±1.75) than females (10.12±1.78). Hennessey *et al* have also reported that the amplitude of median motor nerve is greater in females whereas, the amplitude of ulnar motor nerve is greater in males [26]. Gakhar *et al* have also reported greater median motor nerve amplitude in females which is in agreement with our study [27]. Gender has highly significant effect on sensory nerve amplitudes. The amplitude of median sensory nerve is greater in females (39.70±6.78) than males (30.60±5.49) and is and highly significant ($p<0.001$). Similarly, ulnar sensory nerves amplitude is greater in females (34.68±6.56) than males (28.07±5.06) and is highly significant ($p<0.001$).

Our findings that latencies of Median and Ulnar are greater in males than females are in agreement with previous studies [28-30]. Pawar *et al* in their study found that latencies of Median and Ulnar Nerves are greater in males than females which is in agreement with our study [30]. Haung *et al* in their study had also found that females had shorter latency in the upper limbs [31].

Robinson *et al* in their study found that women had greater conduction velocities than men [28]. Our study is in agreement with this study. Effect of gender on nerve conduction study can be explained on the basis of gender wise difference in anatomical and physiological factors [29]. Gender difference in nerve conduction parameters could also be due to greater height and limb length in males [28].

In our study, we observed that sensory nerve action potential (SNAP) amplitude of Median and Ulnar nerves was significantly greater in females than males. This observation is in agreement with previous studies [28,30-33]. Garg *et al* in their study of upper limb in Malwa region had found that sensory nerve action potential (SNAP) amplitude of Median and Ulnar nerves was significantly greater in females than males [32]. Huang *et al* had also found that female subjects had higher median and ulnar sensory amplitude [31]. Hennessey *et al* and Fujimaki *et al* in their study found that women had greater sensory nerve action potential (SNAP) amplitude than men in the upper limb nerves [33-35]. Bolton *et al* had found that the amplitude of human, antidromic, Sensory nerve action potentials recorded from median and ulnar digital nerves is greater in females than males. The possible cause of gender differences in median and ulnar sensory amplitude study may be related to smaller finger circumference in females. The less subcutaneous tissue in fingers closer to the recording of sensory response in females can explain the higher sensory nerve action potential amplitude than males. Thicker subcutaneous tissue provides greater distance between digital nerve and surface ring electrode in males and this may diminish SNAP amplitude [29,34].

Conclusion

From our study, we concluded that:

- Age has a definite and significant effect on various parameters of nerve conduction study. With increasing age latency increases and amplitude and conduction velocity decreases. The influence of aging is attributed to a decreased number of nerve fibres, reduction in fibre diameter and changes in the fibre membrane.
- Gender also affects various parameters of nerve conduction study. The latency tends to be greater in males than females whereas, the nerve conduction velocity is greater in females. The amplitude in sensory nerves is higher in females. Gender difference in nerve conduction parameters can be explained on the basis of gender wise differences in anatomical and physiological factors. This difference in parameters can also be due to greater height and limb length in males.

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