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Original Article

Physiology Section

Nerve Conduction Studies in the Upper Limb in the Malwa Region-Normative Data

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ABSTRACT

Objective: To establish the normal electrophysiological data for the median and the ulnar nerves in normal healthy adults in the Malwa region of Punjab, India.

Methods: Nerve conduction studies were performed prospectively in the upper limbs of 100 carefully screened, healthy individuals of either sex, who were between the ages of 20 and 60 years, by using a standardized technique.

Results: Motor studies: The median distal latency (DL) in men was 3.4 (0.2) ms, the amplitude (CMAPA) was 10.80 (2.8) mV, the conduction velocity (MNCV) was 55.6 (2.5) m/s and the F-wave (min latency) was 27.57±2.54(21.5-34.2). In the ulnar nerve , the motor DL was 2.34 (0.25) ms, the amplitude (CMAPA) was 9.8(2.6) mV, MNCV was 63.4 (3.0) m/s and the F-Wave(min latency) was 26.29±2.12(21.6-34.7). In the sensory studies, the median nerve DL was 2.0(0.35) ms, SNCV was 53.4±3.0 m/s and the amplitude (SNAPA)was 59.3 (16.4) μV for men and it was 68.7(28.4) μV for women. For the ulnar nerve in men, the DL was 1.85(0.25)ms, SNCV was 55.5 (4.1) m/s and the amplitude(SNAPA) was 55.5 (18.4) μV for men and it was 64.9 (16.8) μV for women. Only the gender showed a statistically significant effect on the sensory nerve action potential for the median ($p < 0.04$) and the ulnar nerves ($p < 0.041$) .

Conclusion: The normative conduction parameters of the commonly tested nerves in the upper limb were established in our EMG lab. The mean motor nerve conduction parameters for the median and the ulnar nerves correlated favourably with the existing literature data. However, for the sensory nerves, a higher value for the nerve action potential amplitude was demonstrated in this study.

Key Words: Nerve Conduction Study (NCS), Compound Muscle Action Potential Amplitude (CMAPA), Sensory Nerve Action Potential (SNAPA) Median Nerve, Ulnar Nerve

INTRODUCTION

Nerve Conduction Studies (NCS) are useful in evaluating the functions and the diseases of the peripheral nerves. NCS help in delineating the extent and the distribution of neural lesions and they distinguish two major categories of peripheral nerve diseases: demyelination and axonal degeneration [1]. With the steady improvement and the standardization of these methods, they have become reliable tests in clinical settings. They are now widely used, not only for the precise localization of lesions, but also for the accurate characterization of the peripheral nerve functions. The technique consists of an electrical stimulation of nerves and the recording of the evoked potentials, either from the muscles or from the nerves themselves. Nerve conduction studies are influenced by number of physiological and technical variables [2, 3] such as standardized measurements, temperature, height, the gender and the age of normal healthy individuals and parameters like the nerve diameter and myelination. Stetson et al., showed that in randomly selected adults without an occupational exposure to high forces or repetitive hand exertions, the age, height, and the index finger circumference were found to be important predictors of the median, ulnar, and the sural nerve conduction measures [4].

Many studies have been published with regards to the normative data for the nerves of the upper and lower limbs. However, no study has been performed in this region of Punjab, India. till far. We were therefore interested to obtain a set of data in healthy adults, in order to establish the reference values for our EMG laboratory and to compare our values with other published data in the literature.

For the upper limb, the median and the ulnar nerves were the most commonly tested nerves. Hence, this paper provides the normative electrophysiological data for the median and the ulnar nerves in healthy adult individuals who were carefully screened by using standard distances and temperature controls.

MATERIALS AND METHODS

This study was carried out in the Adesh Institute of Medical Sciences and Research, Punjab, India. 100 healthy individuals who were aged 20–60 years (x = 31.24±11.57 years) were included in the study. These included 50 women and 50 men. An informed consent was obtained from the study subjects. All the individuals were screened, and the inclusion criteria were the adults with no history of systemic or neuromuscular diseases or any kind of limb injury. The neurological examination and the laboratory findings, which included the blood sugar levels, electrolytes and the renal functions, were found to be normal.

A standardized questionnaire was used to exclude those with a history of systemic or neuromuscular diseases. The individuals who were above the age of 60 years, those with a history of alcohol abuse or medications that could affect the results, and those with a history of diabetes, hypothyroidism and systemic diseases, were excluded.

None of the individuals were taking any medication at the time of the study. A simple neurological examination was performed, which included muscle power testing, muscle stretch reflexes and sensation, which included a superficial and a deep sensory testing.

THE RECORDING PROCEDURE

This study was performed with the clarity vision NCV/EMG machine in the Dept. of Physiology, with the subject sitting comfortably in the upright position. The room temperature was kept at 25-28°C. The filters were set at 2-5 kHz for the motor studies and at 20-2kHz for the sensory studies. The sweep speed was set at 5ms/division for the motor studies and at 2 ms/division for the sensory studies. A stimulus duration of 50 μs to 1000 μs and a current of 0–100 mA are required for an effective nerve stimulation. The supramaximal stimuli were delivered in order to get adequate responses.

1-cm disc recording electrodes were used for the motor studies and ring recording electrodes were used for the sensory studies. The data was collected for the following parameters: for the motor nerve: the onset/Distal Latency(DL), the conduction velocity(MNCV) and the amplitude of the Compound Muscle Action Potential (CMAPA) and for the sensory nerve: the distal latency, the Sensory Nerve Conduction Velocity (SNCV) and the Sensory Nerve Action Potential (SNAPA) were measured from the peak of the negative potential, to the peak of the positive potential. A standardized technique was used to obtain and to record the action potentials for the motor and sensory studies [5-8].

The motor and sensory studies were performed on the ulnar and the median nerves, both proximally and distally along the forearm. The ground electrode was placed on the dorsum of the hand, between the stimulating and the recording electrodes.

For the motor studies, the active electrodes were placed over the motor point of the abductor pollicis brevis for the median nerve, and over the abductor digiti minimi for the ulnar nerve. The reference electrode was placed 4 cm distal over the 1st metacarpophalangeal joint for the median nerve and over the 5th metacarpophalangeal joint for the ulnar nerve.

The sites of stimulation for both were the wrist and the elbow. With surface bar electrodes, distal stimulations were performed at the wrist (3cm proximal to the distal wrist crease) between the flexor carpi radialis and the Palmaris longus tendon for the median nerve, while they were performed posterior to the flexor carpi ulnaris for the ulnar nerve. The proximal stimulation for the median nerve was performed medial to the biceps tendon, on the volar crease of the brachial arterial pulse, whereas for the ulnar nerve, the proximal stimulation was 3-4cm distal to the medial epicondyle, with the wrist and the elbow in 90° of flexion [9]. A 90° or 130° flexion during the stimulation and the measurement of the distance is recommended [10].

For the sensory studies, the median and the ulnar nerves were examined antidromically. The active ring electrode was placed over the 2nd and 5th digits to record the responses along the median and the ulnar nerves, respectively. The reference electrode was placed about 4 cm distal to the active electrode. The median nerve stimulation was performed 14 cm proximal to the active electrode and medial to the flexor carpi radialis tendon. For the ulnar sensory nerve, the stimulation was performed 10cm proximal to the active electrode and posterior to the flexor carpi ulnaris tendon.

The F –wave study was also done with the supra-maximal stimulation of the median and the ulnar nerves. The F wave, a long latency response, is a muscle action potential that occurs, following the regular compound action potential. It is induced by the backfiring of the antidromically activated motor neurons [1]. The F wave latencies are measured from the stimulus artifact to the beginning of the evoked potential. It may vary by a few ms from one stimulus to the other. Hence, a no. of ten stimuli were given to obtain the F-waves and the minimum F wave latency(F- min) was noted.The dominant limbs were chosen for the study, as a majority of the subjects in the study were right handed.

The data from the upper limb of all the individuals were evaluated on a computer by using the Statistical Package for Social Sciences (SPSS) for the data processing. The values were expressed in form of the mean and the standard deviation. The Student's t test was used to assess the significance between the means of the males and females. A p value of <0.05 was used as a cut-off level for the statistical significance.

RESULTS

100 individuals who were aged 20-60 years (x == 31.24±11.57 years), who included 50 women and 50 men, participated in the study. Their arm lengths ranged from 67 to 87 cm, with a mean value of 77.6 cm for males and a men value of 73.6 cm for females. The mean and standard deviation for the parameters of the median and the ulnar motor nerves and the sensory nerves have been summarized in [Table/Fig-1 and 2].

The data were separately analyzed for males and females. There was no statistically significant difference in the median and the ulnar motor parameters, (DL and F-minimum latencies) as well as in the distal sensory latency and conduction velocity of the median and the ulnar sensory nerves. The amplitude of the sensory action potential for both the nerves was found to be more in females than in males. It seemed to be significantly influenced by the gender.

1)Median	Males (n=50)	Females (n=50)	2) Ulnar	Males (n=50)	Females (n=50)
DL ms	3.45± 0.21***	3.48±0.26	**DL ms**	2.34± 0.25 ***	2.35±0.19
NCV m/s	55.62± 2.52 ***	55.94± 2.94	**NCV m/s**	63.41± 3.08 ***	62.97±3.90
CMAPA mV	10.80 ± 2.81 ***	9.86± 1.92	**CMAPA mV**	9.85 ± 2.56***	9.76± 2.90
F-Wave (min) latency	27.57± 2.54***	26.86±2.12	**F-Wave (min) latency**	26.29± 2.13***	25.98±2.41

[Table/Fig-1]: Motor nerve parameters (mean ±SD)in right upper limbs of both sexes

DL = Distal motor latency measured from the onset of action potential; MNCV = Motor nerve conduction velocity; CMAPA = compound muscle action potential amplitude measured from peak to peak.
* p>0.05, ** p<0.01, *** p<0.001when motor parameters of both sexes are compared with each other.

1)Median	Males (n=50)	Females (n=50)	2) Ulnar	Males (n=50)	Females (n=50)
DL ms	2.05± 0.35	1.89± 0.25†††	**DL ms**	1.85± 0.25	1.89± 0.36†††
SNCV m/s	53.43± 3.56	53.14± 3.80†††	**SNCV m/s**	55.78± 4.13	56.86± 6.23†††
SNAPA μV	59.32± 16.39	68.69± 20.48†	**SNAPA μV**	55.51±18.43	64.92 ± 16.84†

[Table/Fig-2]: Sensory nerve parameters (mean SD) in right upper limbs of both sexes

DL = Distal onset latency; SNCV =Sensory nerve conduction velocity; SNAPA = sensory nerve action potential amplitude (peak to peak).
†p>0.05, †† p<0.01, ††† p<0.001, when sensory parameters of both sexes are compared with each other.

DISCUSSION

This study examined the nerve conduction parameters of the two commonly tested nerves: the median and the ulnar nerves, in the upper limbs of a healthy adult population in Malwa region to provide the normative and the reference values in our EMG lab.

A comparison was made between this study and other published studies. The results of this study for the motor nerve conduction parameters of the ulnar and the median nerves were in accordance with those of other studies, as has been seen in [Table/Fig-3] [6, 7, 11-13].

The SNAPA for the nerves which were tested in this study was in agreement with that of other studies [11-13], but it was higher than the data which was published in the literature [6, 7,12], as they had measured the amplitude from the baseline to the peak of the negative potential [Table/Fig-3].The amplitude of the sensory action potential for both the nerves was found to be more in females than in males and it seemed to be significantly influenced by the gender [8,14,15]. Thakur et al. showed that gender had definite effects on the amplitude, duration and the latency of the motor and the sensory nerves. These effects were not identical in different motor and sensory nerves. Males had a higher CMAP amplitude and longer latencies and durations than the females. The SNAP latencies and durations were longer in males, whereas the amplitude was higher in females [15]. However, Stetson found no association between sex and the median or the ulnar nerve conduction measures, that could not be attributed to the correlation between the sex and height or sex and the dominant finger circumference [4]. There was no influence of gender on the nerve conduction velocities and the distal latencies, but the effect of gender was only significant and it affected the sensory nerve potential amplitude [8].The distal and the F-minimum latencies of the motor nerves, the sensory amplitudes and the conduction velocity of the ulnar nerve were found to be significantly influenced by the gender [16]. This difference in the sensory potential amplitude in males and females was because of the varying finger circumferences between men and women [14]. A thicker subcutaneous tissue in a finger of a greater diameter may diminish the amplitude by providing a greater distance between the digital nerves and the surface ring electrode [4]. The values of the F-wave parameters which were recorded from the median and the ulnar nerves were in accordance with those which were reported [5,13,17,18] [Table/Fig-4].

Thus, the values for the nerves which were tested, agreed with those of most of the other researches, while a few nerve parameters showed considerable differences. This difference between the results of the present study and the data which has been published in the literature could be attributed to a variety of causes.

Firstly, the difference in the distance between the stimulating and

Nerveconduction Parameters	Present study (n = 100) mean± SD	Shebab DK [7]	Robinson et al., [9] (n = 44)	Hamdan FB [10] (n = 5766)	Hennessey et al., [11] (n = 44)	Falco et al., [7] (n = 51)
1) Motor						
ULNAR NERVE						
DL	2.34± 0.25	2.4 ± 0.3	2.9 ±0.4	2.35±0.39	2.6 ±0.3	2.7± 0.3
CMAPA	9.85 ± 2.56	9.2 ±2.2	8.4± 2.1	13.8±4.86	12.6 ±2.3	9.9 ±1.8
MNCV	63.41 ± 3.08	60.4 ± 5.0	56.3± 6.2	63.2±5.61	63 ±4.8	61.6 ± 4.1
Median Nerve						
DI	3.45± 0.21	3.1 ± 0.3	3.6 ±0.4	3.39±0.47	3.2 ±0.4	3.5± 0.5
CMAPA	10.80 ± 2.81	11.1 ± 2.8	9.5 ± 2.9	14.8±4.92	12.1 ±3.8	9.2 ±3.1
MNCV	55.62± 2.52	56.5 ± 3.5	54.4 ± 3.8	58.97±4.8	59.5 ±4.4	54.4± 5.4
Nerve Conduction Parameters	**Present study (n = 100) Mean± SD**					**Falco et al., [7] (n = 51) Mean (SD)**
2) Sensory						
Ulnar Nerve						
DI	1.85±0.25	2.0 ±0.2	3.6 ±0.3	1.94±0.19	2.4± 0.2	
SNAPA:						
In Males	55.51 ±18.43	54.5 ±18.4	32.3 ±13.1	50.1±19.8	52.4 ±14.3	
In Females	64.92 ±16.8 4	63.9 ±16.8	36.5± 16.2		52.9 ±13.9	27.1 ±11.5
SNCV	55.78 ±4.13	52.1 ±7.5	57.7 ±5.6	54.2±3.97	64.0 ±6.9	60.0 ±7.5
Median Nerve						
DI	2.05±0.35	2.3± 0.3	3.7 ±0.3	1.93±0.22	2.5± 0.2	2.8 ±0.4
Snapa:						
In Males	59.32± 16.39	63.3± 18.9	35.6± 11.8	49.5±23.1	31.4± 8.2	
In Females	68.69± 20.48	79.3± 28.8	41.8± 15.4		27.0 ±7.8	27.1± 11.2
SNCV	53.43±3.56	56.6± 7.6	54.6± 3.7	51.9±4.04	61.2 ±4.3	56.0 ±4.5

[Table/Fig-3]: Comparison of motor and sensory parameters of median and ulnar nerves between the present study and those reported by others

	Present Study (n = 100) mean (SD)	Hamdan FB [13] (n = 5766)	Kimura [5] (n=61)	Budak [18] (n = 30)	Buschbacher [17]
	27.57±2.54a	27.23±2.46	26.6±2.2		26.8±2.4 (n = 195)
	26.86±2.12b				
	26.29±2.13a	26.86±2.41	27.6±2.2	25.7±2.6	
	25.98±2.41b				

[Table/Fig-4]: Comparison of F-wave (min) latency of median and ulnar nerves between the present study and those reported by others

the recording electrodes and the muscles which were tested, inflicted well on the lower values. Secondly; the age of the subjects who were studied. Thirdly, the diversity of the methods and techniques (the studies differed in the maneouvering, setting and the recording of the electrical responses, and the equipment which was used). Finally, the type of electrode which was used could also be a source of this variation. Besides, different studies were done on different ethnic groups. Some studies were done on Caucasian subjects and others were done on Asians.

CONCLUSIONS

The normative conduction parameters of the commonly tested peripheral nerves in the upper limb were established for our EMG lab. The overall mean motor and sensory nerve conduction parameters for the median and the ulnar nerves correlated favourably with the literature data .The gender has been shown to have a significant effect on the sensory potential amplitudes for the median and the ulnar nerves.

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