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Normal neurophysiologic parameters of the median nerve among adult healthy Sudanese population

Abstract

Background: Nerve conduction studies (NCSs) help in delineating the extent distribution of neural lesion, and the diagnosis of peripheral nerve disorders. Because normative nerve conduction parameters were not yet established in Sudan EMG laboratories, this study aims towards having our own reference values, as we are using the American and British parameters. This will allow avoiding the discrepancies that might be induced by many factors.

Methods: NCSs were performed in 200 Median nerves of 100 adult healthy Sudanese subjects using standardized techniques.

Results: The median SNAP (sensory nerve action potential) values were as follows: distal latency, 2.6± 0.3 ms with a range of (2.3-2.9); peak latency, 3.5±0.5 ms (3.0-4.0); amplitude, 47.7±18.0μV (29.7-65.7); conduction velocity, 53.0±7.8 m/s (45.2-60.8). The following values were obtained for the Median nerve CMAP (compound muscle action potential) at wrist stimulation: distal latency, 3.5±0.5 ms with a range of (3.0-4.0); peak latency, 9.4± 1.0 ms (8.4-10.4); duration, 5.9±0.9 ms (5.0-6.8); amplitude, 12.3±2.5 mV (9.8-14.8); area, 43.0±10.4 mVms (32.6-53.4); conduction velocity, 63.6±6.2 m/s (57.4-69.8). The F wave was 28.4±1.8 ms (26.6-30.2).

Conclusion: The overall mean sensory and motor nerve conduction parameters for the tested nerve compared favorably with the existing literature with some discrepancies that were justified.

Keywords: EMG, median nerve, adult healthy, Sudanese

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Introduction

Nerve conduction study is a test commonly used to evaluate the electrical conduction of motor and sensory nerves of the human body.[1] With steady improvement of recording procedures, NCSs have become a simple and reliable test of peripheral nerve function. They help in delineating the extent distribution of neural lesions and precisely localize the site of maximal involvement[2–4] and enables differentiating the two major groups of peripheral nerve diseases; demyelination versus axonal degeneration.[5]

The classification of biological conditions into normal and abnormal is the principle basis of medical science.[1,6] A normal range may be defined in different ways in clinical medicine, depending on the nature and purpose of the measurement.[7,8] Consequently, the information obtained from the comparison between reference normal NCS values and the emerging results of tested patient nerves narrow the differential diagnosis and helps plan treatment and determine the prognosis.[1,9]

So far, no available data of normal NCSs parameters among adult Sudanese population were established; our neurophysiologic laboratories in Sudan, depend solely on the standard values generated in the USA and UK. [10] The aim of the present study is to determine the normal neurophysiologic parameters of the Median nerve among normal adult healthy subjects in Sudan. This will allow avoiding the discrepancies that might be induced by many factors such ethnic and environmental influences. Anatomically the Median nerve contains fibers from the lateral and medial cords of brachial plexus.[11] It has no branches in the axilla or arm, but it does supply articular branches to the elbow joint. It supplies some muscles in the forearm and then passes through the carpal tunnel and enters the palm to terminate by dividing into muscular and cutaneous branches.[12–15]

Subject and methods

This study has been approached through a non-interventional, clinic-based study, where 200 median nerves of 100 healthy adult Sudanese (≥18 years old) were recruited. The study was conducted in Elmagzoub Neuroscience Centre; supported by the Faculty of Medicine, National Ribat University, Khartoum, Sudan. Patients with nerve disease, chronic illnesses i.e. diabetes mellitus, hypertension and hypothyroidism, alcoholics and those taking medications that might affect the results were excluded. A verbal consent was obtained from each volunteer before the test. The confidentiality was maintained. Some variables were taken from the subjects by pre coded check list; height measured by digital height scale to the nearest centimeter; weight; measured by digital weight scale to nearest 100 gram; mass index: calculated by the formula (Kg/m²) and temperature recorded immediately before the study, and measured by digital thermometer in the axilla in degree centigrade. Room temperature was around 25 °C.

The study was performed with the subject lying comfortably. A standardized technique was used to obtain and record action potentials for motor and sensory studies. An 8-channel machine (Viaysis Select) with stimulator (S403) was used. Motor and sensory studies were performed on both Median nerves, proximally and distally along the forearm.

The Median sensory nerve was stimulated antidromically. the machine was adjusted as follows: low frequency filter-20 Hz; high frequency filter-2 kHz; sensitivity-20 μV/division and Sweep speed-1 msec/division. An active ring electrode was placed over the 2nd digit, the reference electrode was placed 2-3 cm distally and stimulation was performed at 14 cm proximal to the active electrode between the flexor carpi radialis and palmaris longus tendons.

The Median motor nerve fibres were stimulated orthodromically; the machine setting was as follows: low frequency filter- 2-3 Hz, high frequency filter-10 kHz, sensitivity-5 mV/division and sweep speed-2 msec/division. The active electrode was placed over the abductor policis brevis, the reference electrode was placed slightly distal to the first metacarpophalangeal joint. The nerve was stimulated at three sites; at wrist where the cathode was placed 8 cm proximal to the active recording electrode. The second stimulation site was at elbow where the cathode was placed slightly medial to the brachial artery pulse in the antecubital region. At the axilla; the cathode was placed slightly lateral to the mid axillary line. The anode was always proximal to the active electrode at all sites.

For the F wave recording; the cathode was positioned as for wrist stimulation site. The action potential recorded as a result of the stimulation of the sensory component of the median nerve is termed SNAP, and that resulting from the stimulation of the motor component is termed CMAP. The SNAP parameters are the latency (distal 'onset' and peak latency), amplitude and conduction velocity. Distance is measured between the stimulating and active recording electrodes.

The CMAP parameters are latency (distal/onset and peak latency), duration, area, amplitude and conduction velocity. Distances are measured between the stimulating points in term of nerve segments. Data analysis was done through SPSS program. All data was presented as a mean and standard deviation (S.D). Unpaired T test was used to compare between means groups. P value less than 0.01 and 0.05 was accepted as significant value.

Results

Two hundred median nerves of 100 healthy Sudanese subjects were studied. Ninety four percent showed right hand dominance. Sixty-four (64%) were males and 36 (36%) were females. Their ages ranged between 18 and 85 years with an overall average of 36.1 years, and of standard deviation (5), as a measure depression of 10.2 years, an indication of relatively age heterogeneous population. Most of them (67%) were within the age bracket of 18 and 39 years. They have an average weight of 71.7 kg and average height of 172.2 cm.

The normal range of the Median nerve parameters in the whole subjects was set as (mean±standard deviation). It was found that the median SNAP values were as follows; distal latency, 2.6± 0.3 ms with a range of (2.3-2.9); peak latency, 3.5±0.5 ms (3.0-4.0); amplitude, 47.7±18.0μV (29.7-65.7) and conduction velocity, 53.0±7.8 m/s (45.2-60.8).

The Median nerve CMAP showed the following values at wrist stimulation; distal latency, 3.5± 0.5 ms (3.0-4.0); peak latency, 9.4± 1.0 ms (8.4-10.4); duration, 5.9±0.9 ms (5.0-6.8); amplitude, 12.3±2.5 mV (9.8-14.8); area at wrist stimulation, 43.0±10.4 mVms (32.6-53.4); conduction velocity, 63.6±6.2 m/s (57.4-69.8). The F wave was 28.4±1.8 ms (26.6-30.2). The mean and standard deviation for the right and left Median nerves SNAPs and CMAPs are summarized in Table 1-3. Table 4 shows a comparison between the results of the current study and those reported in other EMG laboratories.

Table 1 The left and right Median nerve sensory parameters in the whole study group

Side	Components	N	Minimum	Maximum	Mean	Std. deviation
Right	Distal (onset) Latency(ms)	100	1.9	3.7	2.6	0.3
	Peak latency (ms)	100	2.6	5.6	3.5	0.5
	Amplitude(μV)	100	18	105	47.7	18.0
	Distance(mm)	100	110	210	137.1	14.7
	Conduction Velocity (m/s)	100	35	75	53.0	7.8
Left	Distal (onset) Latency(ms)	100	1.9	3.6	2.6	0.4
	Peak Latency(ms)	100	2.5	4.6	3.4	0.5
	Amplitude(μV)	100	20	100	50.6	18.4
	Distance(mm)	100	110	180	144.5	11.7
	Conduction Velocity (m/s)	100	37	70	56.0	7.4

Table 2 The right Median Motor parameters in the whole study group

Stimulation site	Components	N	Minimum	Maximum	Mean	Std. deviation
Wrist	Distal (onset) Latency(ms)	100	2.1	4.5	3.5	0.5
	Duration(ms)	100	2.4	8.5	5.9	0.9
	Amplitude(mV)	100	6.2	18.3	12.3	2.5
	Area(mVmS)	100	15.4	74.6	43.0	10.4

Table Continued...

Stimulation site	Components	N	Minimum	Maximum	Mean	Std. deviation
Elbow	Latency(ms)	100	5.1	9.3	7.7	0.8
	Duration(ms)	100	2.8	9.2	6.4	1.0
	Amplitude(mV)	100	4.5	16.2	10.8	2.4
	Area(mVmS)	100	14.2	63	36.6	10.1
	Distance(mm)	100	110	330	265.9	30.1
	Conduction Velocity (m/s)	100	51	83	63.6	6.2
Axilla	Latency(ms)	100	6.6	12.5	10.1	1.0
	Duration(ms)	100	2.6	9.3	6.0	1.1
	Amplitude(mV)	100	3	18.2	10.5	2.8
	Area(mVmS)	100	5.7	61.7	35.9	11.4
	Distance (mm)	100	100	250	158.1	30.3
	Conduction Velocity (m/s)	100	52	86	64.1	5.9
	F Wave (ms)	100	24.1	32.2	28.4	1.8

Table 3 The left Median motor parameters in the whole study group

Left median motor						
Stimulation site	**Components**	**N**	**Minimum**	**Maximum**	**Mean**	**Std. deviation**
wrist	Distal (onset) Latency(ms)	100	2.7	5.1	3.5	0.5
	Duration(ms)	100	3.7	8.9	6.0	0.9
	Amplitude(mV)	100	4.9	20.7	11.2	2.9
	Area(mVmS)	100	16.4	90.3	38.5	11.7
Elbow	Latency (ms)	100	5.1	10.1	7.8	0.9
	Duration(ms)	100	2.8	9.4	6.3	1.1
	Amplitude(mV)	100	3.3	18.3	9.8	2.9
	Area(mVmS)	100	10.5	62.5	33.4	11.6
	Distance(mm)	100	170	340	269.5	28.6
	Conduction Velocity (m/s)	100	50	87	64.1	6.3
Axilla	Latency (ms)	100	6.4	13.3	10.2	1.1
	Duration(ms)	100	4.1	10.1	6.2	1.1
	Amplitude(mV)	100	2.9	17.5	9.7	3.1
	Area(mVmS)	100	11.3	62.9	33.0	11.2
	Distance(mm)	100	100	240	151.9	24.6
	Conduction Velocity (m/s)	100	50	85	64.2	6.1
	F wave(ms)	100	21.4	33.3	28.4	2.3

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Table 4 A comparison of SNAP and CMAP values of the median nerve between the current study and some reported in other EMG laboratories**.** The values are presented as mean ±SD, SL; The values between brackets represent the range. CV (conduction velocity); SNAP (sensory nerve action potential); CMAP (compound muscle action potential amplitude)

	SNAP distal latency (ms)	SNAP peak latency (ms)	SNAP CV (m/s)	SNAP Amplitude (µV)	CMAP Distal Latency(ms)	CAMP CV (m/S)	CMAP (mv) amplitude	F wave (ms)
Present study (Sudanese)	2.5± 0.3 (2.2-2.8)	3.5 ±0.5 ms (3.0-4.0)	54.8±7.7 (47.1-62.5)	55.7±18.8 (36.9-74.5)	3.3±0.4 (3.1-3.7)	63.0±5.3 (57.7-68.3)	12.2±2.4 (9.8-14.6)	28.3±1.8 (26.5-30.1)
Farqad (Iraqi)[20]	1.87±0.18 (1.5-2.5)		52.98±3.83 (43.5-66.6)	61.1±29.57 (14-140)	3.34±0.45 (2.3-4.8)	59.72±4.39 (47.7-68.5)	15.83±5.57 (7.7-30)	26.67±2.31 (21.3-35.4)
Deborah (USA)[17]	2.5±0.3 (2.2-2.8)			35.6±14.8 (20.8-50.4)				/
Shehab (Kuwaiti)[16]	2.3±0.3 (2.0-2.6)		56.6±7.6 (49.0-64.2)	63.3±18.9 (44.4-82.2)	3.1 ±0.3 (2.8-3.4)	56.5 ±3.5 (53-60)	11.07± 2.8 (8.27-13.87)	/
Diagan (Malwa)[19]	2.0 ±0.35 (1.65-2.35)		53.4±3.0 (50.4-56.4)	59.3±16.4 (42.9-75.7)	3.4 ±0.2 (3.2-3.6)	55.6 ±2.5 (53.1-58.1)	10.80 ±2.8 (8.0-13.6)	27.57±2.54 (25.3-30.1)
Amatya and Khanal (Nepal)[41]	2.5±0.37		59.86±9.19	24.92±9.64	3.26±0.45	61.26±6.77	19.27±4.28	
Owolabi (Nigeria)[39]	1.98–4.52 As range		44.8–70.5 As range	16.6–58.4 As range	(1.95–4.52) As range	(49.48–66.92) As range	(4.3–11.3) As range	
Shan Chen (USA)[21]	3.3	4		11	4.1	49	4.5	

Discussion

The current study is mainly concerned with determining normative neurophysiologic parameters of the median nerves among healthy adult Sudanese population; aiming to establish our own normative reference values of the common upper and lower limbs nerves for our EMG laboratories in Sudan.

Our results were generally found to be in accordance with those laboratories that used standardized techniques and included the different variables we used e.g. gender, age, height, weight, BMI, temperature and hand domination.

The mean median nerve SNAPs and CMAPs parameters in this study correlated favorably with those of Shehab, Deborah, Diagan and Hennessey.[16–19] as shown in table 4. However, some notable differences were observed between the distal latency of SNAP and CMAP. This is obvious in the findings of Farqad[20] in Iraqis, where SNAP distal latency reported in his work was less than that shown in our results. These differences could be attributed to the fact that Farqad has examined a considerable number of subjects below the age of 18 years, which might had induced the decrease in mean latency for the median sensory values. On the other hand, they reported high amplitude CMAPs; similarly Deborah[17] showed high amplitude median SNAP than those obtained in this study. These high amplitude CMAP of Farqad and SNAP of Deborah could be explained by the fact that, they measured the amplitude from peak to peak, while in this study amplitude was measured from the baseline to the negative peak. Other causes that might explain these differences include the technique of measuring the distance between stimulating and recording electrodes; and the type of electrodes used as some used needle electrodes, while in this study surface electrodes were used. Most studies did not show peak latency values, although it is of considerable importance in determining demyelination versus axonal degeneration or both in extremely low amplitude SNAPs or signals affected by base line noise or artifacts. The only reference we came across showing this the value of SNAP peak latency[21] is in agreement with our results. This study also included CMAP duration and area at wrist stimulation, which is lacking in other studies to compare with. The importance of using these additional values might give clues as an early ongoing demyelinating or axonal process when all other parameters seem to be normal.

The ethnic groups studied in most laboratories were Caucasians, some were Asian, pure Africans and others were pure Arabs. This study was performed in a different ethnicity, as an Afro-Arab group. Hence this might have resulted in the discrepancies mentioned above.

Interestingly, this study showed obvious influence of gender in the median nerve parameters values between males and females. The onset and peak latencies of both SNAPs and CMAPs, as well the F wave were decreased in females. The prolonged distal latency and F wave in males might be attributed to height. This agrees with the study of Thakur et al.,[22] where they showed that height has a positive correlation with CMAP duration and latency of the median nerve.[23] Rivner MH et al.[24] found that height was positively associated with the latencies of the median and other nerves electrophysiologic parameters and this is almost in accordance with our results. In agreement of this study, Hennessey et al.[19] and showed positive correlation of height with sensory latencies. On the other hand, unlike the parameters we obtained, height was found to have a negative correlation with SNAPs amplitude as reported by Setson et al.[25] Some authors found no correlation between height and the median nerve. Soudmand et al.[26] investigated the correlation of upper and lower extremities nerves conduction velocity (NCV) to height, they found that the median motor and sensory NCV showed no significant relationship to hight;

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whereas the peroneal and sural NCV correlated inversely with height. They concluded that these findings are consistent with the hypothesis of abrupt distal axonal tapering in the lower extremities. Similar findings were observed by Awang et. al[27] and S. Kumari et.al who admitted their failure to demonstrate any obvious trend of slowing of NCVs in median and ulnar nerves across different height groups. Although they noticed this slowing of NCVs in the common peroneal nerve with increasing height. Wagman et al.[28] on examining the Ulnar nerve showed also no relation of NCV to height after maturation of nerves in adults and this was confirmed by Kato et al.[29] in athletes.

With regard to F wave latency, these results showed a strong positive correlation to height. This is in accordance with the findings of Peioglon[30] and Salerno DF et al.[31] who found strong correlations between minimal and maximal F latencies and height, and much weaker relationships between these parameters and age. Likewise, Lin[32] and Pukasa et al.[33] in different studies showed that the minimal latency of the F wave increases with height in upper and lower limb nerves.[34,35]

Strikingly, females showed as well higher amplitude of both SNAPs and CMAPS and faster conduction velocity than in males. This is supported by Shehab[16] and agrees with the findings of Bolton and Carter[36] who attributed the higher SNAP amplitude to variation in finger circumference between males and females. However, Stetson et al[25] attributed the lower amplitude in males to the thicker subcutaneous tissue in a finger and eventually the greater diameter may diminish the amplitude by providing more distance between the electrodes and digital nerves. The faster conduction velocity in females could be attributed to their height as they are shorter than males at least in the present study. This could be elicited from the work of Takano et al.[37] who found that shorter persons have statically significant fast conduction velocity than taller persons.[38]

The current study showed that age was also found to influence nerve conduction velocity of the median sensory fibers; as a negative correlation; so that with increasing age; the nerve conduction velocity declines, a finding that collaborates with literature and with Farqad et al.,[20] Thakuer et al.[22] who further added that age has definite inverse effects on amplitude and duration of motor and sensory nerves signals, a finding that was reestablished by Owolabi LF et al.[39] and Letz R et al.[40] Our results disagree with Amatya and Khanal[41] who revealed that no significant correlations of NCVs with age, height, weight, and body mass index.

Conclusion

Normative median nerve conduction parameters were determined. The overall mean sensory and motor values for the tested nerve compared favorably with the existing literature data. These values could be useful as reference normative data for evaluating median nerve conduction disorders in Sudanese patients.

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Conflicts of interest

The authors declare no conflicts of interest.

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