■ *Original Article*

Nerve Conduction Study in Healthy Individuals: a Gender Based Study

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Abstract

Background: Nerve conduction study (NCS) assesses peripheral nerve functions and has clinical implication. **Objective:** To study effect of gender on NCS variables in healthy adults. **Settings and Design:** Department of Physiology, B.P. Koirala Institute of Health Sciences, Dharan, Nepal. **Material and Method:** The study was done in 34 (m=19, 32±11 years; f=15, 32±12 years) consenting healthy adults. The compound muscle action potential (CMAP) and sensory nerve action potential (SNAP) were recorded. **Statistical analysis:** The effect of gender on NCS variables was analyzed using Mann Whitney U test. **Results:** Male vs. female: males had increased CMAP and F-wave latencies (ms) in all tested motor nerves. CMAP duration (ms) was longer in males ($p<0.05$) in all tested motor nerves: right median (5.9±1.3 vs. 4.92±0.65), left median (5.54±0.91 vs. 4.72±0.57), right ulnar (5.55±1.01 vs. 4.56±0.59), left ulnar (5.71±0.97 vs. 4.64±0.51), right tibial (6.58±0.95 vs. 5.95±0.71), and left tibial (6.98±1.31 vs. 6.21±0.78). Females showed higher sural SNAP amplitude (μV) (23.26±9.23 vs. 15.94±8.42). SNAP duration (ms) was longer in males: right ulnar (1.16±0.19 vs. 1.03±0.06). SNAP latencies (ms) were also longer in males: right sural (2.61±0.44 vs. 2.21±0.36). Males had greater height (165.9±4.74 vs. 149.3±7.24) and weight (60.4±7.2 vs. 53±7.2)**. Conclusion:** Gender has definite effects on NCS variables. Males had higher CMAP amplitude, longer latencies and duration. SNAP latencies and duration were longer in males whereas amplitude was higher in females. Without adjustment for these factors, the sensitivity and specificity of NCS will decrease when using the same reference data in patients with different gender.

Keywords: compound muscle action potential, gender, nerve conduction study, sensory nerve action potential

Introduction

The electro-diagnostic assessment of peripheral nerves includes two major components: nerve conduction (NCS) and needle electromyography (EMG) studies. Nerve conduction study assesses peripheral motor and sensory functions by recording the evoked response to electrical stimulation of peripheral nerves. Motor nerve conduction studies require stimulation of a peripheral nerve while recording from a muscle innervated by the nerve. Sensory nerve conduction studies are performed by stimulating a mixed nerve while recording from a mixed or cutaneous nerve. These studies have been used clinically for many years to identify the location of peripheral nerve disease in single nerves and along the length of nerves and to differentiate these disorders from diseases of muscle or neuromuscular junction[3]. Routine nerve conduction study includes assessment of compound muscle action potential (CMAP) and sensory nerve action potentials (SNAP) of accessible peripheral nerves in upper and lower limbs including median, ulnar, radial, common peroneal, tibial and sural nerves. Commonly measured parameters of CMAP include latency, amplitude, duration, conduction velocity and late response, e.g. F-waves. Similarly for SNAP, latency, amplitude, duration and conduction velocity are

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routinely measured. These parameters are known to vary with demographic profile, anthropometric measurements of the population studied and laboratory conditions of the test[1, 2, 3].

Objective

To study the effect of gender on NCS variables in healthy adults

Methods

The study was done in 34 (m=19, f=15) healthy adults of age (male, 32±12 years; female, 32±11 years) in the Neuroelectrophysiology lab of Department of Physiology, BPKIHS, Nepal. Informed written consent was taken from the volunteers and they were screened for any history of drugs/alcohol intake or medical illness likely to affect the nerve conduction study parameters based on clinical history and physical examination including detailed neurological assessment. All the required set up was checked before starting the test. Room temperature of the laboratory was maintained at the thermo neutral zone i.e. 26±2 °C. Further, subjects were made comfortable with the laboratory set up and conditions, and were advised to relax completely during recording.

Recording procedure[1, 2]

In the upper limbs, CMAP and SNAP of median, ulnar and radial nerves were recorded whereas in the lower limbs, the same of common peroneal, tibial, and sural nerves were recorded under standard laboratory condition. For each stimulation site, latency (onset & peak), amplitude (base to peak & peak to peak), duration (baseline to baseline, baseline to deepest point & baseline to down stroke point meeting baseline), conduction velocity and F-waves (maximum, mean and minimum) were measured.

1. Motor nerve conduction study variables[1,2]

For motor nerve conduction study, the stimulator with water soaked felt tips were placed on the skin overlying the nerve at two or more sites (see table 1). The recording and reference electrode were placed using belly tendon montage. Stimulation of the nerve being studied was accomplished using a brief burst of direct electric current. The gain was set at 2-5 mV per division. Stimulation duration was in the range of 50-300 micro seconds and the amount of current never exceeded more then 50 mA because i.e. its upper limit available in the machine. The current of the stimulator was initially set to zero, then gradually increased with successive stimuli. A CMAP appeared that grew larger with the increasing stimulus strength. Current was increased to the point that CMAP no longer increased in size, from that point the current was increased by another 20% to ensure the supra-maximal stimulation.

Table 1: Stimulation and recording sites of motor nerves [1]

Motor nerve	Site of stimulation				Recording site
	Proximal 3	Proximal 2	Proximal 1	Distal	
Median	-	-	Antecubital fossa	Wrist	Abductor pollicis brevis
Ulnar	Axilla	Above elbow	Below elbow	Medial wrist	Abductor digiti minimi
Radial	-	Below spiral groove: lateral midarm	Elbow	Forearm: over the ulna	Extensor indicis proprius
Common peroneal	-	Lateral popliteal fossa	Below fibular head: lateral calf	Anterior ankle	Extensor digitorum brevis
Tibial	-	-	Popliteal fossa	Medial ankle	Abductor hallucis brevis

2. Sensory nerve conduction study variables[1,2]

In sensory nerve conduction study, antidromic method of stimulation was used for the sural nerve and orthodromic for the median, ulnar, and radial nerves (see table 2). Gain was set at 10-20 mV per division. Stimulating or recording electrode was placed on a purely sensory portion of the nerve. For orthodromic conduction, ring electrodes were used to stimulate the digital nerve whereas surface stimulating electrodes were used for antidromic stimulation. An electrical pulse of either 100 or 200 micro seconds of duration was used and most nerve required a current in the range of 16 to 30 mA to achieve supra-maximal stimulation. Current was slowly increased from a base line of 0 mA, usually by 3-5 mA at a time until the recorded sensory nerve potential was maximized.

Data collected were first entered in the Microsoft Excel Worksheet and then statistically analyzed using SPSS 10.0 version. Depending on the nature of distribution of data, Mann Whitney test was applied to see the effect of gender on NCS variables. Significant difference was considered at $p< 0.05$ and is indicated in appropriate places, if present in any of the parameters.

Table 2: Stimulation and recording sites of sensory nerves [1]

Sensory nerve	Method of stimulation	Stimulation site	Recording site
Sural	Antidromic	Posterior-lateral calf	Posterior ankle
Median	Orthodromic	Index finger	Middle of the wrist
Ulnar	Orthodromic	Little finger	Medial wrist
Radial	Orthodromic	Thumb	Distal- mid radius

Results

Effect of gender on physical and anthropometric variables (see table 3).

Among the physical and anthropometric parameters, height, weight, body surface area, trunk length, lower limb length and trunk length- lower limb ratio showed statistically significant difference between male and female ($p<0.05$). Males had greater height, weight, body surface area, trunk length, lower limb length and trunk length- lower limb ratio than the females. However, gender wise difference in body mass index, chest circumference and mid arm circumference were not found to be statistically significant.

Table 3: showing gender difference in physical/anthropometric variables (n= 34)

Sex		Age	Ht (cm)	Wt (Kg)	BMI (Kg/m^2)	BSA (m^2)	MAC (cm)	CC (cm)	Trklt (cm)	Lllt (cm)	Trllra
Male	Mean	31.63	165.9	60.4	21.95	591.3	26.16	86.5	58.53	75.3	0.78
= 19	SD	11.49	4.745	7.2	2.491	34.49	2.582	4.265	3.281	4.57	0.07
Female	Mean	32.13	149.3	53	23.85	511.6	27.23	85.59	50.7	70.8	0.7
=15	SD	12.03	7.247	7.2	3.56	36.23	2.757	5.548	5.596	3.65	0.08
P value		.918	.000	.009	.077	.000	.256	.190	.000	.003	.006
Mean (n=34)		31.24	158.5	57.09	22.8	555.6	26.64	86.02	55	73.182	0.7455
SD		11.57	10.21	8.002	3.11	53.1	2.675	4.816	5.892	4.7101	0.083

Abbreviations

Ht: Height
Wt: Weight
BMI: Body mass index
BSA: Body surface area
MAC: Mid arm circumference
CC: Chest circumference
Trklt: Trunk length
Lllt: Lower limb length

Effect of gender on motor nerve conduction study variables (see table 4)

1. CMAP duration, latency ($p < 0.05$) and F- wave latencies ($p < 0.01$) were longer in males as compared to females. Also, the amplitude ($p < 0.05$) of right median motor nerve was higher in males
2. CMAP duration ($p < 0.01$), latency ($p < 0.05$), and F- wave latencies ($p < 0.001$) of left median motor nerve were longer in males than the females.
3. CMAP duration ($p < 0.01$), latencies and F-wave latencies ($p < 0.001$) of right and left ulnar motor nerve were longer in males than the females.
4. CMAP duration ($p <0.01$) and latency ($p < 0.05$) of right radial motor nerve were longer in males as compared to females.

5. CMAP duration and latency ($p < 0.001$) of left radial motor nerve were longer in males as compared to females.
6. CMAP duration ($p < 0.05$), latency and F- wave latencies ($p < 0.01$) were longer in males as compared to females. Also, the amplitude ($p < 0.05$) of right tibial motor nerve was higher in males.
7. CMAP duration ($p < 0.05$), latency and F- wave latencies ($p < 0.01$) of left tibial motor nerve were longer in males as compared to females.
8. CMAP duration, latency ($p < 0.001$) and F- wave latencies ($p < 0.05$) of right common peroneal motor nerve were longer in males than the females.
9. CMAP duration ($p < 0.05$), latency ($p < 0.001$) and F- wave latencies ($p < 0.05$) of left common peroneal motor nerve were longer in males than the females.

Table 4: Effect of gender on motor nerve conduction study variables

Motor nerves	Gender	CMAP			F-wave
		Duration (ms)	Amplitude (mV)	Latency (ms)	Latency (ms)
Right median	Male	8.46±1.30	10.47±3.14	9.28±0.96	25±2
	Female	7.5±1.03	7.75±2.39	8.54±0.59	22.96±1.38
	P Value	0.021	0.021	0.017	0.001
Left median	Male	11.64±1.04	9.11±2.57	6.28±0.62	25.06±1.34
	Female	10.51±1.77	8.14±2.22	5.75±0.37	22.82±1.34
	P Value	0.001	0.319	0.015	3E-05
Right ulnar	Male	12.9±2.45	6.85±1.85	8.42±0.79	26.33±1.97
	Female	10.74±1.16	6.15±1.38	7.09±0.5	23.32±1.23
	P Value	0.002	0.271	3E-06	3E-06
Left ulnar	Male	12.35±2.1	6.48±1.59	8.1±0.47	25.87±1.69
	Female	10.74±1.65	6.07±1.15	6.76±0.54	23.15±1.06
	P Value	0.007	0.784	3E-06	3E-06
Right radial	Male	14.41±2.38	4.73±0.99	5.84±0.63	NA
	Female	11.98±2.10	4.17±0.83	5.57±0.59	NA
	P Value	0.003	0.096	0.047	NA
Left radial	Male	13.94±1.99	4.14±1.29	6.02±0.59	NA
	Female	11.79±1.3	4.2±1.04	5.4±0.4	NA
	P Value	3E-05	0.656	3E-05	NA
Right tibial	Male	7.12±1.26	16.57±5.82	11.34±1	43.38±4.51
	Female	6.41±0.72	12.3±2.83	10.22±1	38.72±5.32
	P Value	0.040	0.023	0.003	0.001
Left tibial	Male	6.98±1.31	10.25±3.99	11.32±1.05	44.02±2.9
	Female	6.21±0.78	8.57±2.78	10.1±0.8	40.03±3.68
	P Value	0.018	0.154	0.001	0.001
Right common peroneal	Male	7.77±2.23	4.65±2.04	10.88±0.68	42.83±3.76
	Female	6.06±0.99	3.89±1.58	9.48±0.78	40.44±2.31
	P Value	3E-05	0.302	4.15943E-06	0.0401
Left common peroneal	Male	7.76±2.35	4.15±1.32	10.88±0.61	42.25±3.3
	Female	6.24±1.08	3.92±1.3	9.28±0.67	39.4±3.51
	P Value	0.019	0.607	3.34492E-08	0.0211

NA= Not applicable

Effect of gender on sensory nerve conduction study variables (see table 5)

1. None of the parameters of bilateral median & radial and left ulnar & sural nerves were found to be statistically significant ($p < 0.05$).
2. The SNAP duration ($p < 0.05$) of right ulnar sensory nerve was found to be longer in males as compared to females.
3. The SNAP latencies ($p < 0.01$) were found to be longer in males as compared to females whereas amplitude ($p < 0.05$) of right sural sensory nerve was found to be higher in females.

Table 5: Effect of gender on sensory nerve conduction study variables

Sensory nerves	Gender	Duration (ms)	Amplitude (μV)	Latency (ms)
Right ulnar	Male	1.16± 0.19	12.03 ± 5.33	1.94±0.16
	Female	1.03± 0.06	12.63± 4.6	1.82± 0.2
	P Value	0.027	0.891	0.137
Right sural	Male	1.18± 0.25	15.94 ± 8.42	2.61±0.44
	Female	1.07± 0.1	23.26± 9.23	2.21± 0.36
	P Value	0.83	0.017	0.003

Discussions

This study aimed to investigate the effect of age on NCS variables in healthy adults. We found that CMAP duration of all the motor nerves was longer in males as compared to the females. This may be due to the poor volume conduction, large muscle fiber length and/or the large motor units in males.

In our study, latencies of all the motor nerves of upper and lower limbs were longer in males than the females which are similar to earlier reports[13-19]. Probably, the reason behind this finding may be the greater height and limb length of the male volunteers. Similarly, F-wave latencies of all the motor nerves of upper and lower limbs were longer in males as compared to females. Probably, the reason behind this finding may be the greater height and limb length of the male volunteers. This finding is supported by earlier report as well[20]. Huang in his study fond that female subjects had shorter latency in the upper limbs and longer latency in the lower limbs by F-wave studies than males did[21].

Also, in our study, CMAP amplitudes were higher in males in all the nerves but statistically significant only in the right median and tibial nerve. This may be due to the larger muscle mass and motor unit size. Robinson et al in their study found that three of four sensory amplitudes were larger in women; two of four motor amplitudes were larger in men and women had significantly faster conduction velocities than men for all nerves except median motor[6]. Our study has some similarity and some dissimilarity with this study. Sural amplitude was larger in women whereas median and tibial motor amplitudes were larger in men in our study. Conduction velocities did not show any statistical significance in our study. Contrary to our study, Huang found that female subjects had higher median and ulnar sensory amplitude[21].

In our study, SNAP duration of right ulnar was longer in male as compared to females. Also, the latency of right sural nerve was longer in the males. Probably, the reason behind these findings may be the greater height and limb length of the male volunteers. In contrary to our study, Falco et al in their study found that gender had a greater effect on all ulnar nerve conduction velocities as well as the distal sensory amplitudes of median, ulnar and radial nerves and the median sensory distal latency[4].

In our study, the right sural nerve SNAP amplitude was found to be higher in females as compared to males which are known from earlier studies[14, 18]. The probable reason in amplitude differences may be partly related to volume conductor characteristic of body mass. According to Kimura, gender related amplitude differences persist despite of the adjustment of height[15]. In contrast to our study, Stetson et al in their study in sural nerves demonstrated smaller amplitude in women as compared to male[9-12]. Also, contrary to our study, Hennessey et al and Fujimaki et al in their study found that women had greater SNAP amplitude than men in the upper limb nerves (median, ulnar, and radial), but not in the lower limb nerves (peroneal and sural)[5, 7]. In support of our study, Shehab et al and Stetson et al in their study in the upper limb nerves (median, ulnar) confirmed that gender did not have any statistically significant effect on SNAP amplitude[8, 9].

This study is first of its kind in Nepal and bears strength. The study has created a preliminary normative data of our population albeit in a limited sample. A study with larger sample size will certainly add more strength. It has many similarities and some dissimilarity with the reported NCS variables. The probable reasons could be the true difference among populations, and small sample size. Nevertheless, the normative data may be used as preliminary working reference while reporting clinical NCS findings. In this way, this study holds a big strength.

Conclusion

Gender has definite effects on amplitude, duration and latency of motor and sensory nerves. These effects are not identical in different motor and sensory nerves. Males had higher CMAP amplitude, longer latencies and duration than the females. SNAP latencies and duration were longer in males whereas amplitude was higher in females. Using the same reference data in patients with different gender may result in erroneous reporting; thus both the sexes should have their own reference data for clinical purpose. Our results have many similarities and some dissimilarity with the reported NCS variables, and are useful as preliminary working reference for future.

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