

# Does gender have a significant effect on normal nerve conduction studies values?

## Abstract

**Background:** nerve conduction study (NCS) is a neurophysiologic medical diagnostic test used commonly to evaluate the function of the peripheral nerves. It is an extension to the clinical examination and extremely useful to diagnose and document a peripheral nerve disorder, localize the lesion, and to establish underlying pathophysiology.

**Objective:** The aim of this study is to evaluate the influence of gender on nerve conduction study values and to generate reference nerve conduction studies (NCS) data for the commonly tested nerves among healthy adults in Oman.

**Subjects and methods:** This study was conducted in the Neurology Department at the Royal Hospital, a tertiary care hospital in Muscat-Oman, for a period of four years (from March 2015 until May 2019) which included a total of 143 (80 females and 63 males) healthy Omani subjects. Sensory and motor nerve conduction studies were performed to the Median, Ulnar, Peroneal and Tibial nerves to establish the normative data. Statistical analysis was performed using Minitab comparing the mean values of all NCS parameters for both genders.

**Results:** Gender comparison concluded that Omani males have longer distal motor latencies for all of the tested nerves and slower motor conduction velocities for the lower limbs' nerves ( $p < 0.005$ ) than the females. While sensory latencies were significantly delayed in males as compared to Omani females for the upper limbs' nerves and the sensory nerve potential amplitudes in the upper limbs were greater in females ( $p < 0.0001$ ) than males. A normative data for distal latencies, conduction velocities and responses amplitudes for motor and sensory nerves were set up for the first time for normal adult Omani population.

**Conclusion:** Gender has a significant influence on distal latencies and conduction velocities of some peripheral nerves in healthy Omani adult subjects, suggesting that different cut-off values for the two genders may be needed for interpreting such studies. These differences could be related to anatomical (height and limbs' length gender differences) and/or physiological factors. Our normative data for nerve conduction study values are comparable to other published studies in the literature.

**Keywords:** nerve conduction study, normal ncs values, gender effect, oman, omani adults, ncs parameters

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## Introduction

Nerve conduction study (NCS) is widely utilized to examine the integrity of the peripheral nerve fibres. It is effective in outlining the extent and severity of neural dysfunction and in differentiating between demyelinating versus axonal forms of neuropathy. NCS is considered an extension of the clinical assessment of a patient being evaluated for suspected peripheral neuropathy and it has been used extensively in research as well as in clinical practice.<sup>1-4</sup>

NCS examination involves electrically stimulating the peripheral nerves and recording the motor and sensory responses from the targeted muscles or nerves, respectively. NCS data interpretation is influenced by some technical and physiological factors, such as fixed measurements, skin temperature, height, Body Mass Index (BMI), gender and age; in addition to the nerve diameter and degree of myelination.<sup>2,3,5-8</sup>

It is clearly required, in a clinical setting, to have standardized data acquired from a sample population that represents, as nearly as possible, the demographic and ethnic features of the examined patients.<sup>2,3</sup> In the

context of developing normative data for nerve conduction studies among healthy Omani adults for our Neurophysiology laboratory, we aimed also to examine the influence of gender on our data.

## Subjects and methods

This is an observational descriptive prospective study, which has included a total of 143 healthy Omani subjects (80 females and 63 males) aged between 16 and 67 years old (mean age: 36 years, Standard deviation (SD)  $\pm$  11.2 years). A standardized questionnaire (Appendix A) and a neurological examination were employed to exclude subjects with any of the following: systemic and neuromuscular diseases, limb injury, and history of alcoholism, diabetes mellitus and/or the long term use of certain medications that may influence NCS parameters. An ethical approval was obtained from our Institutional Ethical Committee prior to data collection. Room temperature was maintained at 24-26 °C throughout the procedure. Blood tests (e.g., random blood sugar, glycosylated hemoglobin, liver function tests, lipid profile, electrolytes and renal functions tests) were also obtained for the subjects and confirmed to be normal.

The NCS study was performed with the subject lying comfortably in the supine position and a standardized technique was used to obtain and record action potentials for the motor and sensory nerves.<sup>1</sup> A four-channel EMG machine (Medtronic v5.13) was used for performing NCS, with the following conventional settings: For motor nerve studies, the low and the high pass filters were set at 20 Hz and 10 KHz respectively. For sensory nerve studies, the low and high pass filters were set at 20 Hz and 2KHz respectively; the sweep speed was set at 5ms/division for the motor studies and 2ms/division for the sensory studies. Amplification between 20,000 and 100,000 times was used and the electrode impedance was kept below 5 kΩ. Stimulus duration 1000 μs and an incremental current of 0-100 mA were used, adjusted as required to get the maximum sensory response. While supramaximal stimulation (10%–30% more than the current required for maximal action potential) was used to insure maximal amplitudes of the compound muscle action potential (CMAP) for the motor conduction study.

Bipolar surface electrodes (1-cm disc) were used to record and a ground was placed between the recording electrodes and the stimulating site. Motor studies were measured orthodromically whereas sensory studies were measured antidromically. Distal latencies (DL) were measured in milliseconds at the onset of the action potential. Amplitudes of the compound muscle action potential (CMAP) and the sensory nerve action potential (SNAP) were measured in millivolts (negative peak-to-positive peak) and microvolts (baseline-to negative peak) respectively. Conduction velocities (CV) were calculated from the distances between the distal and the proximal stimulation sites in motor studies and from the recording position to the stimulation site in sensory studies, which were divided by the time (in ms) required for the electrical signals to traverse along the nerves between those points. Late responses (F-waves) were also measured by supra-maximally stimulating the ulnar and the posterior tibial nerve distally (Figures 1 & 2) (Table 1).<sup>9</sup>

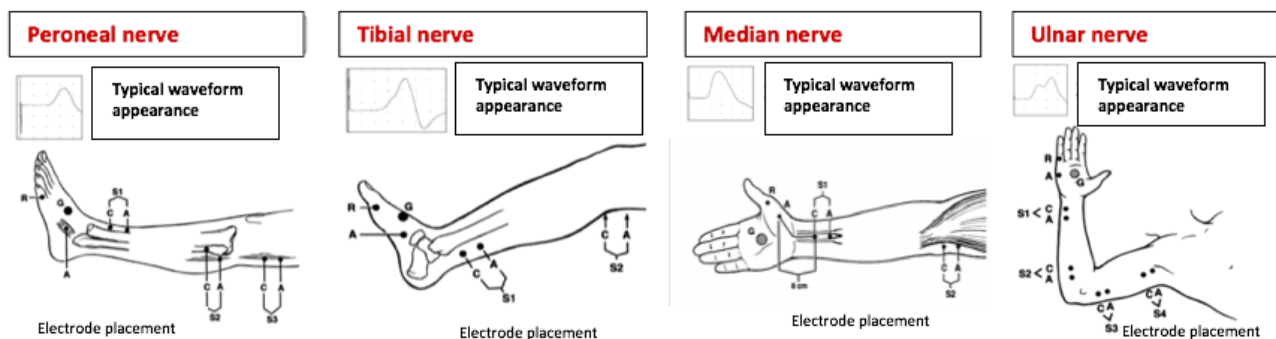


Figure 1 The protocol used to perform motor studies.

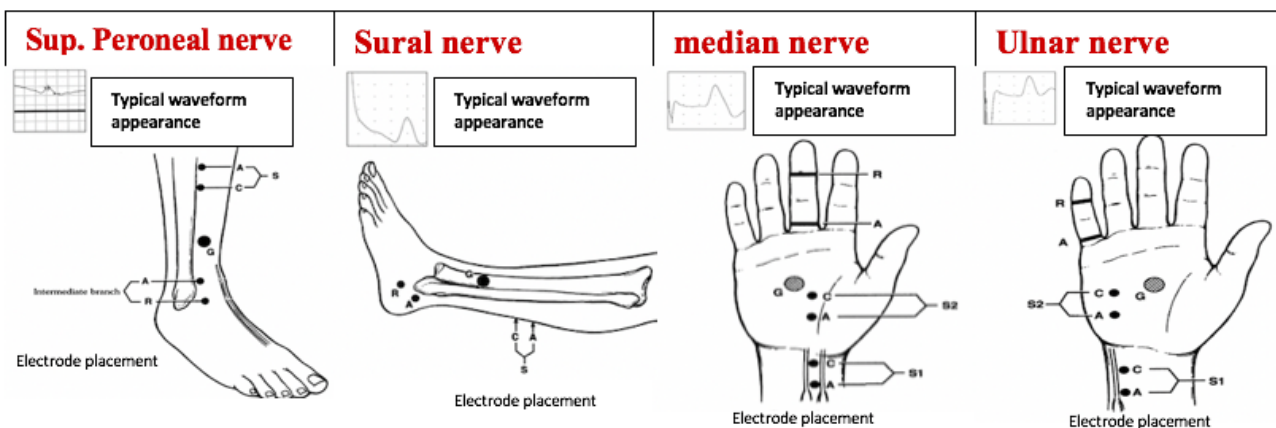
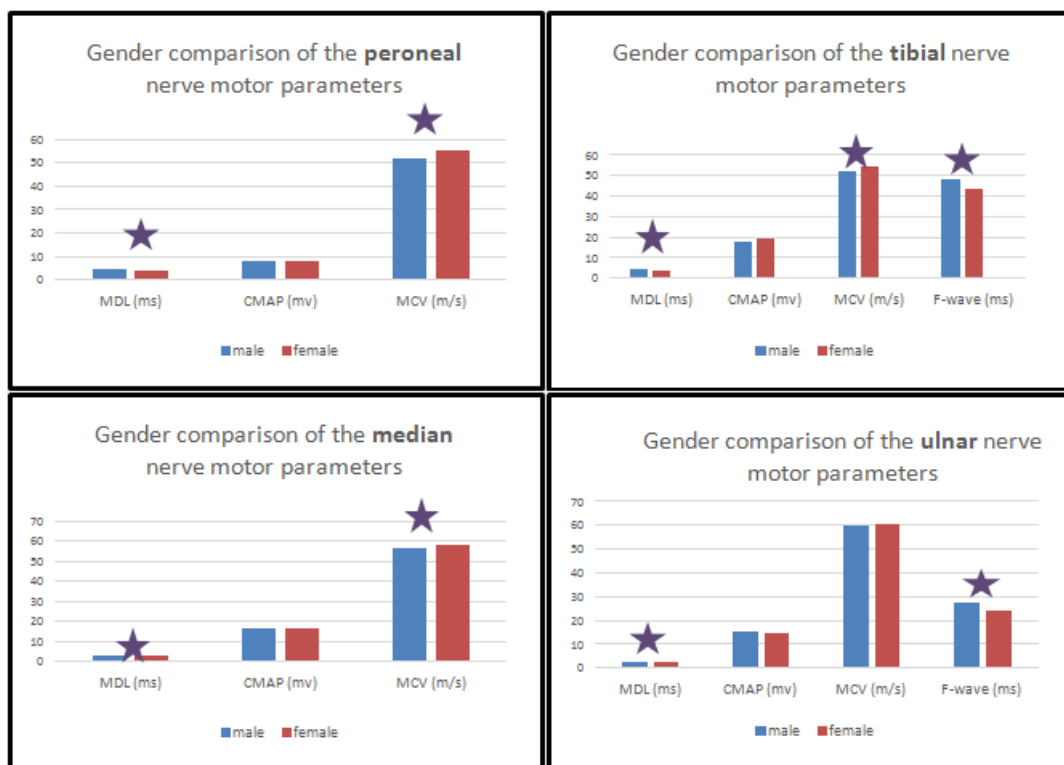


Figure 2 The protocol used to perform sensory studies.

### Results

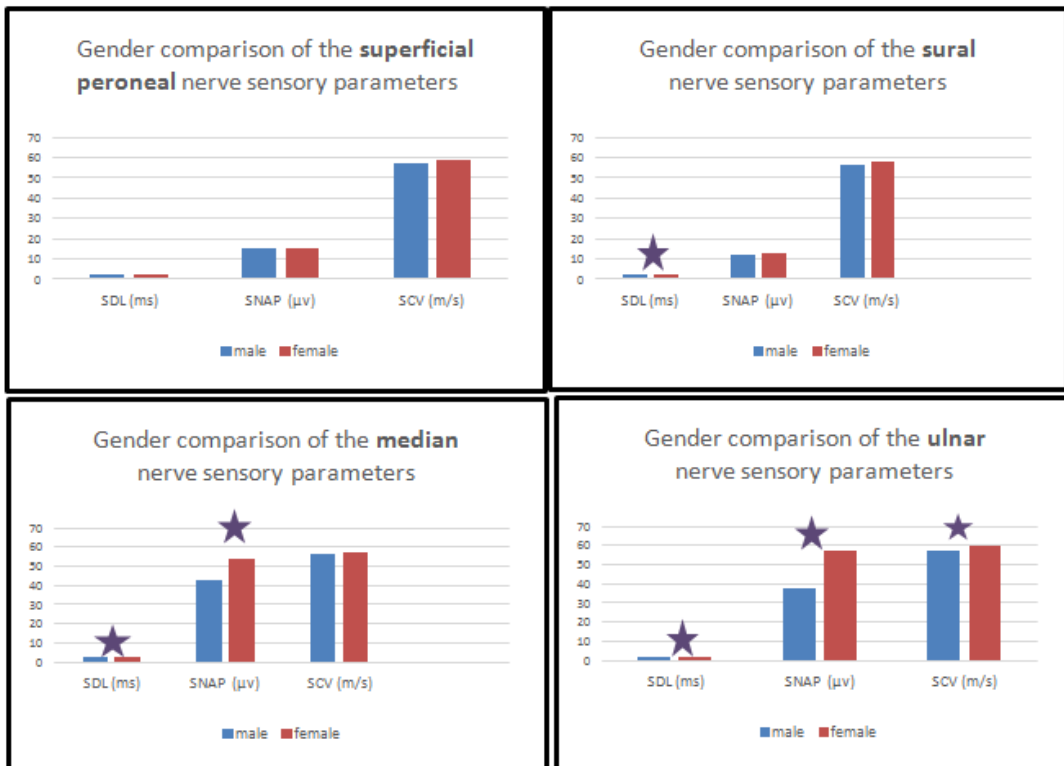
Statistical analysis was performed using Minitab Express™ (Version 1.5.1). P-values in this study are two-tailed and considered significant at <0.05. Quantitative variables were stated as mean and standard deviation (SD) or median and range depending on whether data were parametric or nonparametric, respectively. 143 healthy subjects (80 females and 63 males) completed the study. The mean age for the male subjects was 36.3±10.36 years and for the female subjects, 35.77±11.87 years. The average heights for the participants

were 168.3±7.6 cm for males and 156.1±6.25 cm for females. Based on the statistical analysis performed, all NCS variables showed no significant differences between the right and left sides. A comparison of nerve conduction parameters between males and females was performed using t-test, as shown in Tables 2 & 3. The comparison revealed significant differences between DLs and CVs when comparing males and females of the median, ulnar, peroneal and tibial motor studies and sensory nerve parameters of mainly the upper limbs (Figures 3 & 4).



**Figure 3** Gender comparisons of motor nerve parameters.

★ indicates a significant difference ( $p < 0.005$ ).



**Figure 4** Gender comparisons of sensory nerve parameters.

★ indicates a significant difference ( $p < 0.005$ ).

**Table 1** The NCS protocol used for both motor and sensory nerves<sup>9</sup>

Sensory Nerve	Stimulation	Recording	Distal distance	Motor nerve	Stimulation	Recording	Distal distance
Median	Wrist: Middle of the wrist between the tendons and the flexor carpi radialis and palmaris longus.	Active electrode: over the metacarpal-phalangeal joint of the Index finger Reference electrode: placed 3-4 cm distally over interphalangeal joint.	13 cm	Median	S1: Middle of the Wrist (between the tendons to the flexor carpi radialis and palmaris longus. S2: Elbow: Antecubital fossa.	Active electrode: over the belly of Abductor pollicis brevis (APB) muscle. Reference electrode: over the 1st metacarpal-phalangeal joint.	7 cm
Ulnar	Wrist: adjacent to the flexor carpi ulnaris tendon.	Little finger Active electrode: over the metacarpal-phalangeal joint. Reference electrode: placed 3-4 cm distally over interphalangeal joint.	13 cm	Ulnar	S1: Wrist: adjacent to the flexor carpi ulnaris tendon. S2: Below elbow: 3-4cm distal medial epicondyle. S3: Above elbow: over the medial humerus. 10 cm from the below-elbow site.	Active electrode: over the abductor digiti minimi (ADM) muscle belly. Reference electrode: placed over the 5th metacarpal-phalangeal joint.	7 cm
Sural	Posterior Lateral calf	Active electrode: Posterior to the lateral malleolus Reference electrode: 3-4cm distally.	14 cm	Common Peroneal	S1: Anterior ankle. S2: Below fibular head. S3: Above fibular head. 10 cm to the below fibular head site.	Active electrode: over the Extensor digiti brevis-(EDB) belly muscle Reference electrode: placed over the metatarsal-phalangeal joint of the little toe.	9 cm
Superficial Peroneal	Lateral calf	Active electrode: Between the tibialis anterior tendon and lateral malleolus Reference electrode: 3-4 cm distally.	14 cm	Posterior Tibial	S1: Ankle S2: Middle of popliteal fossa.	Active electrode: over the Abductor muscle belly Reference electrode: placed over the metatarsal-phalangeal joint of the great toe.	9 cm

**Table 2** Gender comparison of motor nerve parameters

Motor nerve parameters	Male	Female
<b>Peroneal nerve</b>		
MDL (ms)	4.28±0.73	3.61±0.52
CMAP amp (mv)	8.2±3.05	8.05±2.63
MCV (m/s)	51.91±4.51	55.32±4.31
<b>Tibial nerve</b>		
MDL (ms)	4.33±0.87	3.78 ±0.72
CMAP amp (mv)	17.99±5.18	19.05±5.89
MCV (m/s)	52.26±5.07	54.51±6.01
F-wave (ms)	48.34±3.86	43.2±3.2

Motor nerve parameters	Male	Female
<b>Median nerve</b>		
MDL (ms)	3.18±0.36	2.95±0.35
CMAP amp (mv)	16.76±4.19	16.27±3.86
MCV (m/s)	56.68±3.39	58.23±3.83
<b>Ulnar nerve</b>		
MDL (ms)	2.6±0.43	2.29±0.34
CMAP amp (mv)	15.12±3.88	14.5±23.56
MCV (m/s)	59.55±4.66	60.76±3.61
F-wave (ms)	27.18±2.01	24.28±1.68

**Table 3** Gender comparison of sensory nerve parameters

Sensory nerve parameters	Male	Female
<b>Sural nerve</b>		
SDL (ms)	2.44±0.36	2.23±0.33
SNAP amp (µv)	12.34±5.1	13.04±5.10
SCV (m/s)	56.4±5.81	57.84±4.89
<b>Sup. Peroneal nerve</b>		
SDL (ms)	2.23±0.31	2.19±0.33
SNAP amp (µv)	15.38±7.77	15.3±5.8
SCV (m/s)	57.47±4.03	58.86±4.23
<b>Median nerve</b>		
SDL (ms)	2.46±0.32	2.25±0.25
SNAP amp (µv)	42.77±15	53.78±17.46
SCV (m/s)	56.43±5.03	57.52±5.47
<b>Ulnar nerve</b>		
SDL (ms)	2.15±0.24	1.88±0.24
SNAP amp (µv)	37.74±14.52	56.98±18.02
SCV (m/s)	57.03±4.87	59.57±5.28

## Discussion

This study of nerve conduction parameters among healthy adult Omani subjects demonstrated significant gender related differences in the various parameters. Differences influencing conduction velocities, distal latencies and amplitudes of evoked responses were considered to be of relevance, as these are often the main parameters utilized in characterizing various neuropathic conditions. Based on the statistical analysis performed, there were significant differences between DLs and CVs between Omani males and females. Similar results were reported by Thakur et al.<sup>10</sup> that indicate a definite effect of gender over DLs and CVs.<sup>10</sup> According to Stetson et al.<sup>11</sup> and other authors, these findings are explained by specific anatomical and physiological factors.<sup>3,4,11</sup> Females are on average shorter than males; therefore, the above results could be explained mainly by height differences among the two genders.<sup>11-13</sup> Earlier studies, as well as ours, have demonstrated that increased height tend to increase DLs and slow CVs. This is explained by the fact that nerve fiber diameter is reduced distally in a length dependant manner.<sup>3,12</sup> In addition, gender has a significant effect on the calculated mean F-waves latencies, which, also most probably caused by height difference.<sup>4, 14, 15</sup>

In a study by Cambell et al.<sup>16</sup> there was a strong negative correlation between height and the CVs of the lower limbs nerves; however, height has no effect on MDLs and SCVs of nerves in the upper limbs.<sup>16</sup> In contrast, our study revealed a stronger correlation of height with the median and ulnar sensory nerve parameters rather than with sural and superficial peroneal nerves. As outlined in Tables 2 & 3, the gender comparison of CMAP amplitudes did not reveal a significant difference. Males have significantly lower SNAP amplitudes of median and ulnar nerves, which match Stetson et al's<sup>11</sup> observations in the same nerves,<sup>11,12,16-18</sup> this difference may be explained by thicker subcutaneous tissue (finger circumference) among males, which result in a greater distance between the surface electrode and the digital nerves, hence causing diminished SNAP amplitudes.<sup>11,19</sup>

Sensory peak latencies (SPL) were also measured along with SDLs and as shown in Table 3, SPLs are more sensitive to gender comparisons. SDLs were employed in this paper because they are a good indication of the fastest nerve fibers. However, often due to the close distance between the stimulation site and the recording electrode, SDLs might produce stimulus artefacts which may interfere with accurate determination of the onset latencies. Therefore and according to Kasiu et al.,<sup>20</sup> in the presence of uncontrollable stimulus artefacts, peak latencies are more reliable.<sup>20</sup>

As mentioned earlier, height and gender have an impact on NCS parameters and a failure to adjust references value to these elements may reduce the specificity and sensitivity of the NCS.<sup>3,11,21</sup> Most of our values were similar to four other similar published studies.<sup>2,3,5,8,13,21,22,23</sup> However, there were some differences, which could be attributed to different NCS techniques, machine settings, and demographic characteristics. A notable dissimilarity was in the CMAP and the SNAP amplitudes because some studies used peak-to-peak measurement and others used baseline-to-negative peak measurements. Another factor is the diverse age and ethnic groups that participated in each study.<sup>24-26</sup>

The most prominent limitation in this study was the incomplete information collected from healthy subjects such as heights, age and blood tests. Moreover, some subjects were not able to tolerate the electric stimulation, which limited our sample size.

## Conclusion

Gender has been shown to have a significant effect on the DLs and CVs for the tested nerves as well as a significant effect on the sensory potential amplitudes for the median and the ulnar nerves. These normal neurophysiological data will play a main role in enhancing the diagnosis of neuropathy disorders in Oman and taking in consideration the significant difference between genders.

We established our first normative conduction study parameters of commonly tested peripheral nerves for our electrophysiologic laboratory. The overall mean motor and sensory nerve conduction parameters correlated favourably with the literature data.

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## Conflicts of interest

The author declares no conflicts of interest.

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