EFFECT OF AGE, GENDER AND BODY MASS INDEX ON TIBIAL AND PERONEAL MOTOR NERVE CONDUCTION STUDY VARIABLES"

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Abstracts: **Introduction**: Different variables of Nerve Conduction Study (NCS) show changes to different extent in various pathological states. However, certain physiological factors may affect them too. **Aims and objectives**: This cross sectional study aimed to evaluate the role of age, gender and BMI upon these variables in the tibial and peroneal nerves. **Materials and methods**: 51 healthy subjects were chosen according to exclusion and inclusion criteria. Reference limits were derived from the obtained data as Mean±2SD. p<0.05 was considered statistically significant. The Degree of Coefficient of Correlation was graded into low (0.29 ≥ absolute value r ≥ 0.1), moderate (0.49 ≥ absolute value r ≥ 0.3) and substantial (absolute value of r ≥ 0.5). **Results**: No sex-wise correlation was seen with the NCS Parameters of Tibial and Peroneal Nerves, whereas age showed deteriorating correlation (p value <0.05). Also, no substantial correlation was seen, except between Height and Weight of the subject, with the Distal Motor Latency of the Peroneal Nerve.

Key Words: Nerve conduction study, Body mass index, electromyography.

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Introduction

Nerve conduction studies (NCS) and electromyography (EMG) is useful diagnostic tools for the disorders of lower motor neurons. These electrodiagnostic (EDX) techniques not only diagnose the lesion in general, but also give substantial information regarding type of lesion, its localization and severity. It may further help in evaluating the prognosis of lesion [1]. Some indications for performing the Nerve Conduction Study are complains of paresthesia (Numbness, Tingling, or Burning sensations), for instance, Carpal Tunnel Syndrome, Guillain-Barre Syndrome, Peripheral Neuropathies of various causes (for instance Vitamin deficiency, Diabetic Complication, trauma) etc. Depending upon the patient's symptoms, the type of study to be performed can be decided.

NCS can assess peripheral motor and sensory functions. Motor NCS requires stimulation of a nerve while recording from a muscle innervated by that nerve, whereas sensory NCS is done by stimulating a mixed nerve while recording from a mixed or cutaneous nerve [1, 2]. 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. Commonly measured variables of NCS are latency, amplitude, conduction velocity and duration of compound muscle action potential (CMAP) [3].

Age, gender, height, limb length, weight, skin temperature and Body Mass Index (BMI) are some of the physiological factors that alter different NCS variables [4].

Pawar S et al [5] found effect of gender on amplitude and latencies of upper limb nerves whereas; Soudmond R et al [6] observed no influence of gender on NCS variables. Mohammad SA et al [7] also did not observe any significant gender-wise difference on NCS variables. Age shows deleterious effect on all NCS variables including latencies, conduction velocity (CV), CMAP amplitudes, F min latencies and sensory onset latencies [8,9]. Buschbacher RM et al [10], in 1998, studied the effect of Body Mass Index (BMI) on NCV. He observed that there was no correlation note between BMI and NCV. Other studies revealed slowing of NCVs across different BMI groups, and the trend showed slowing of conduction velocities with increasing BMI for both common peroneal and sural nerves [5, 10, 11].

Although more vulnerable to the effects of these demographic and anthropometric factors, researchers have less explored lower limb nerves. Wide range of lower limb NCS normative data used for reference belongs to western population with different ethnicity, race, climatic conditions and taller height of individuals [12, 13]. Further , effects of age is well established but gender and BMI effect on NCS variables remains an area with ambiguity in various studies. Among variables too, duration of amplitude remains less explored.

Aims and Objectives

With above background, researchers want to explore effect of age, gender and body mass index on lower limb tibial and peroneal motor nerve conduction study parameters like Distal Motor Latency (DML), Amplitude, Conduction Velocity (CV) and Duration of Compound Muscle Action Potential (CMAP) in central Gujarat population with the following specific objectives:

1. To find out correlation of age, gender and BMI with DML, CV, Amplitude and Duration of CMAP obtained from tibial and peroneal motor nerve conduction studies.
2. To obtain normal reference values of NCS variables for tibial and peroneal motor nerves in study population.

Materials and Methods

Study design: Cross sectional study

Duration of study: May and June 2016

Site of study: Department of Physiology, Clinical Neurophysiology Laboratory at GMERS Medical College and General Hospital, Vadodara in Central Gujarat.

Ethics: Proposal has been approved by the Institutional Human Ethics Committee. Written informed consent was taken in vernacular language structured format from all the participants and the study was carried out in accordance with the World Medical Association Declaration of Helsinki.

Selection of participants

Inclusion Criteria:

Fifty-one healthy participants were recruited in this study following strict inclusion and exclusion criteria. Most of them were from hospital staff and relatives of patients. They underwent a thorough history taking and neurological examination by consultant physician to rule out any evidence of neuromuscular or musculoskeletal disorder. A brief electrophysiological assessment was done to assess peripheral nerve function.

Exclusion criteria: Participants with H/O hypertension, diabetes, hyperthyroidism, hypothyroidism, musculoskeletal disorders, neuromuscular disorders, developmental disorders, and alcohol abuse were excluded from the study.

Age, sex, height, and weight were recorded prior undergoing EDX tests. Body Mass Index (BMI) was calculated as weight in Kg divided by height in meter square (Kg/m^2). All the EDX procedures were done by same electromyographer on same electromyograph at constant room temperature.

EDX procedures

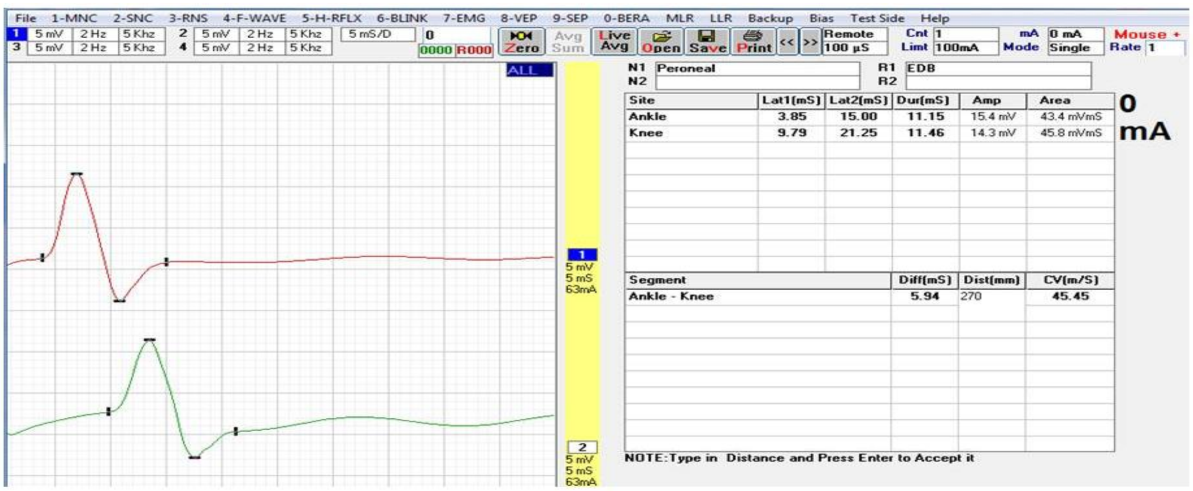
All tests were done on RMS Portable Aleron Electromyograph machine. We adopted standard techniques by Preston DC and Shapiro BE for nerve conduction studies.

(Figure 1: The RMS Portable Aleron Electromyograph employed during the study.)

1. Recording of the tibial motor nerve conduction study (MNCS) – Belly tendon montage with the active electrode on the belly of Abductor Hallucis 2 cm below medial malleolus and the reference on tendon of the muscle at ball of great toe. Stimulation was given at the ankle and popliteal fossa in the course of the tibial nerve distally and proximally respectively.

Duration 100ms, sweep speed 2ms/D, sensitivity 2mV/D and stimulus strength max at 100mA.

2. Recording of the peroneal motor nerve conduction study (MNCS) – Belly tendon montage with active electrode on the belly of Extensor Digitorum Brevis and the reference on the tendon of the muscle at little toe on dorsum of foot. Stimulation was given at ankle and head of fibula in the course of peroneal nerve distally and proximally respectively. Duration 200ms, sweep speed 2ms/D, sensitivity 2mV/D and stimulus strength max at 100mA.



(Figure 2: Compound Muscle Action Potential of the Peroneal Nerve.)

DML, Amplitude and Duration of CMAP and Conduction velocity (CV) of the two nerves were recorded and stored for further analysis.

Parameters under study

Demographic and physical parameters of study population like age, sex and BMI. NCS tibial and peroneal motor nerves variables like DML, CV, Amplitude and Duration of CMAP.

Statistical analysis

Data obtained was stored in Microsoft Excel sheet for further analysis. Data obtained from tibial and peroneal motor nerve conduction study was analyzed using Statistical Package for Social Sciences (SPSS) 10.0 version.

Demographic data are presented as obtained from descriptive analysis results of the study group.

Reference limits were derived from Mean ± 2Standard deviation (SD).

p Values lesser than 0.05 were considered as statistically significant.

Degrees of Coefficient of Correlation have been graded into; low ($0.29 \geq$ absolute value $r \geq 0.1$), moderate ($0.49 \geq$ absolute value $r \geq 0.3$) and substantial (absolute value of $r \geq 0.5$) [12]

Observations and Results

Table 1 – Anthropometric Table

	Male (n=28)	Female (n=23)	p Value	Total
Age	25.19±15.52	39.56±11.85	0.00064	31.67±15.62
Height	1.53±0.23	1.54±0.04	0.88	1.54±0.17
Weight	50.70±22.04	57.47±10.13	0.185	53.8±17.85
BMI	20.10±5.59	24.08±4.13	0.0066	21.89±5.33

Table 1 shows the comparison of anthropometric factors between the male and female subjects, participating in the study. It also compares, whether the differences seen in these factors are statistically significant or not. Applying the Student's unpaired t-test; the results showed that there was no statistically significant difference between the male and female participants of the study, with respect to the height and weight criteria. However, age and BMI showed a significant difference. The mean age of the male participants was 25.19 as compared to 39.56 of the females. This was probably because of the 6 male participants who were less than 7 years of age, thus pulling the mean. Excluding these 6 subjects, the male subjects have a mean of 30.91±11.96 among 22 subjects (as compared to 23 females). Then applying the t-test, the result shows p=0.02, which is still statistically significant. Also, the t-test results for BMI shows that the females have a statistically significantly higher mean BMI than the male subjects. Comparison of the right to left difference of the various NCS parameters tested (i.e. DML, Duration of the CMAP, its Amplitude, and the MNCV) in the two nerves tested bilaterally (i.e. Tibial and Peroneal Motor Nerves). Applying the Student's unpaired t-test, no statistically significant difference was observed. Comparison of the sex-wise difference in the right and left tibial and peroneal motor NCS variables showed NO statistically significant difference between the two genders with respect to the NCS Variables, except the Duration of the CMAP of the Right Tibial Nerve and DML of right peroneal nerve where the males had a statistically significant difference with p value <0.05.

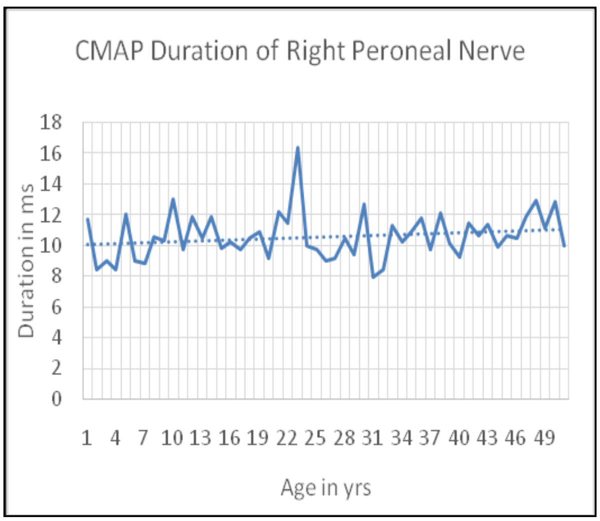
Table no 2: Age-wise distribution of Reference values of tibial and peroneal motor NCS variables.

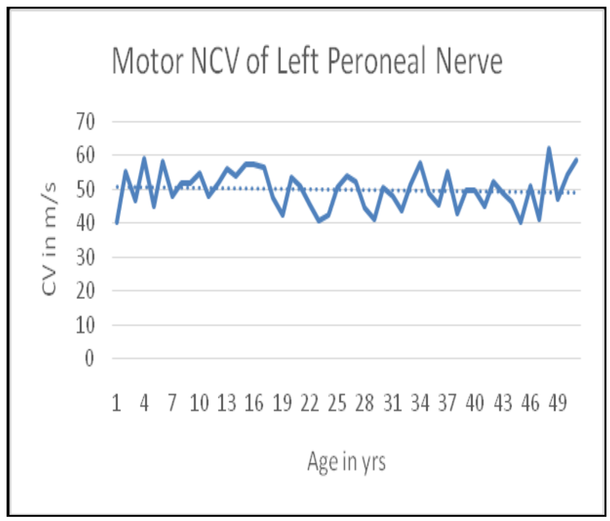
Nerve		Tibial motor nerve (n=51)						Peroneal motor nerve (n=51)					
Age groups		0-10 (n=6)	11-20 (n=10)	21-30 (n=5)	31-40 (n=16)	41-50 (n=10)	>50 (n=04)	0-10 (n=6)	11-20 (n=10)	21-30 (n=5)	31-40 (n=16)	41-50 (n=10)	>50 (n=04)
DML (ms)	RT	2.90 (0.5)	3.57 (0.7)	3.63 (0.57)	3.6 (0.6)	3.6 (0.6)	3.67 (0.7)	2.6 (0.7)	3.9 (0.6)	3.6 (0.3)	3.4 (0.8)	3.7 (0.9)	3.4 (0.1)
	LT	2.95 (0.6)	3.61 (0.52)	3.42 (0.6)	3.61 (0.6)	3.84 (1.1)	3.54 (0.8)	2.4 (0.5)	4.2 (0.7)	3.5 (0.4)	3.3 (0.9)	3.8 (0.9)	3.6 (0.1)
Amplitude (mV)	RT	16.73 (6.6)	14.04 (6.68)	15.08 (5.22)	15.9 (5.2)	15.4 (5.5)	10.8 (4.7)	7.4 (3.3)	10.4 (3.5)	10.3 (4.9)	9.2 (2.3)	6.7 (3.0)	8.1 (1.5)
	LT	17.97 (6.57)	13.63 (5.4)	14.7 (4.5)	15.1 (6.4)	18 (6.9)	9.3 (1.7)	6.8 (3.7)	9.7 (3.4)	9.5 (4.2)	10.2 (2.8)	7.4 (3.2)	7.2 (3.5)

Duration (ms)	RT	10.02 (1.16)	9.98 (1.61)	10.16 (1.4)	9.55 (1.3)	10.6 (1.4)	9.55 (1.1)	9.7 (1.4)	10.6 (1.1)	10.4 (1.0)	10.5 (1.9)	10.7 (0.8)	11.7 (1.2)
	LT	9.69 (1.32)	9.95 (1.68)	10.3 (1.6)	9.76 (1.4)	9.8 (1.1)	9.7 (1.1)	9 (2.2)	10.1 (1.3)	10.5 (1.0)	10.4 (1.7)	10.8 (1.1)	10.9 (0.8)
CV (m/s)	RT	47.87 (6.16)	50.54 (3.41)	47.8 (4.13)	46.3 (3.5)	44.1 (4.5)	48.9 (6.6)	50 (6.1)	54.6 (3.9)	49.4 (4.0)	49.3 (4.0)	47.54 (6.4)	50.3 (3.6)
	LT	48.98 (6.5)	48.27 (3.38)	48.63 (5.43)	47.1 (4.1)	46.4 (5.1)	43.9 (2.1)	50.7 (7.1)	53 (3.2)	50 (4.9)	49.1 (5.0)	46.6 (3.96)	55.5 (5.5)

(Note: n= sample size, NCV variables values expressed as Mean and standard deviation (SD), SD values in parenthesis, RT= Right, LT= Left, DML=Distal Motor Latency, ms= milliseconds, mV= millivolts, m/s= meters/seconds, CV= conduction velocity.)

Figure No 3 and 4: effect of age on CMAP duration and velocity of Lower limb nerves.





The collected raw data was segregated into age groups with a class interval of 10 years, ranging from 2.5 years to 68 years. However, the number of subjects in each was NOT the same. Though not very significant, but an overall positive trend was seen in the DML of the Right Tibial Nerve. Similarly, an overall negative trend was observed in the Motor Nerve Conduction Velocities of the Left and Right Tibial Nerves (more negative in left than right). Not very significant, but an overall positive trend was seen in CMAP Durations of the Right as well as Left Peroneal Nerves (more in left than right), and an overall negative trend was seen in the Motor NCV of the Left Peroneal Nerve. (Figure 3 and 4) Other parameters of the NCS did NOT show any significant trend with increasing age, as tested by the Coefficient of Correlation.

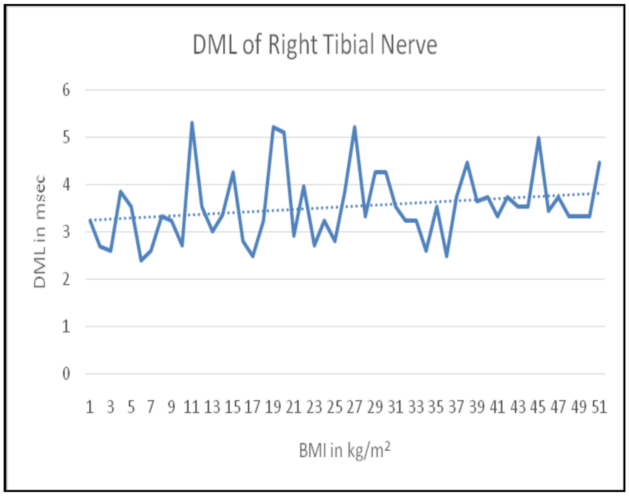
Table no 3: BMI-wise distribution of tibial and peroneal motor NCS variables.

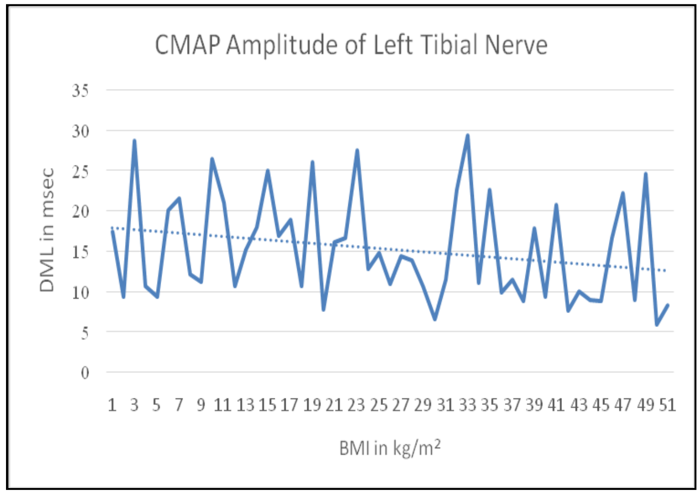
Nerve	**Tibial motor nerve (n=51)**	**Peroneal motor nerve (n=51)**

BMI groups (Kg/m²)		9-13 n=3	13-17 n=7	17-21 (n=12)	21-25 (n=16)	25-29 (n=12)	>29 n=04)	9-13 (n=3)	13-17 (n=7)	17-21 (n=12)	21-25 (n=16)	25-29 (n=12)	>29 (n=04)
DML (ms)	RT	2.8 (0.3)	3.09 (0.5)	3.77 (0.95)	3.53 (0.72)	3.75 (0.46)	3.61 (0.5)	2.51 (0.1)	3.52 (0.6)	3.68 (0.93)	3.6 (0.71)	3.82 (0.54)	3.46 (1.2)
	LT	2.84 (0.3)	3.33 (0.3)	3.78 (0.82)	3.51 (0.78)	3.9 (0.69)	3.18 (0.33)	2.08 (0.2)	3.47 (0.7)	3.45 (1.0)	3.73 (0.79)	3.85 (0.8)	3.62 (0.96)
Duration (ms)	RT	10.4 (0.9)	10.3 (1.1)	9.95 (1.5)	9.5 (1.2)	10.3 (1.57)	9.57 (1.68)	9.69 (1.4)	9.75 (1.0)	11.6 (2.0)	10.67 (1.18)	11.18 (1.2)	9.56 (10.2)
	LT	10.2 (0.7)	9.54 (1.4)	9.95 (1.6)	9.76 (1.43)	9.57 (1.22)	10.9 (0.34)	8.54 (2.5)	9.88 (1.8)	10.5 (1.46)	10.4 (1.3)	11.14 (0.7)	10.21 (1.71)
Amplitude (mV)	RT	16.2 (8.8)	16.9 (5.5)	16.28 (5.37)	13.56 (5.59)	13.35 (4.27)	17.38 (4.27)	6.77 (3.9)	10.0 (4.2)	8.17 (2.5)	8.92 (3.5)	8.84 (2.32)	9.32 (4.23)
	LT	18.5 (7.9)	15.9 (5.7)	16.87 (5.29)	14.87 (6.58)	13.85 (5.4)	11.9 (7.36)	6.13 (4.4)	8.83 (3.8)	8.69 (2.66)	9.0 (3.46)	9.54 (4.16)	9.6 (2.99)
CV (m/s)	RT	44.8 (3.2)	51.2 (4.9)	46.66 (3.81)	47.4 (5.58)	47.06 (3.88)	43.71 (2.56)	50.1 (7.7)	52.2 (4.0)	48.8 (4.59)	49.76 (5.21)	50.2 (5.29)	52.4 (6.17)
	LT	46.6 (5.7)	49.8 (4.1)	47.49 (4.38)	46.24 (4.46)	47.99 (4.47)	45.9 (5.4)	48.6 (7.8)	53.2 (4.3)	47.62 (5.37)	50.66 (4.86)	50.83 (5.61)	46.8 (3.74)

(Note: n= sample size, NCV variables values expressed as Mean and standard deviation (SD), SD values in parenthesis, RT= Right, LT= Left, DML=Distal Motor Latency, ms= milliseconds, mV= millivolts, m/s= meters/seconds, CV= conduction velocity.)

Figure No 5 and 6: effect of BMI on NCV variables of lower limb nerves.





The raw data collected, was distributed, dividing the BMI's of the subjects into various groups ranging from 9.03 kg/m^2 to 36.31 kg/m^2. The aim of the above two tables is to judge the trends in the various NCS parameters with increasing BMI in the Tibial Nerve. An overall positive trend was observed in the Distal Motor Latency (DML) of the Right Tibial Nerve, but was not found to be very significant, just like an overall negative trend observed in amplitude of the CMAP of the Left Tibial Nerve. Other parameters were NOT found to have any significant trends as seen by the statistical test of Coefficient of Correlation.

Discussion

51 Normal, healthy subjects were included in the study, after thoroughly evaluating them according to the inclusion and exclusion criteria. 28 were males (Age 25.19±15.52 years, and BMI 20.10±5.59 kg/m^2) and 23 were females (Age 39.56±11.85years and BMI 24.08±4.13 kg/m^2). Age has definitely been associated in the past researches with deleterious effects on all parameters of nerve conduction study i.e. DML, Duration, Amplitude, and Conduction Velocity. A decrement in the NCV has been documented by a large number of researches [15-20], and has been attributed to a many reason decrease in the number of fibres, or reduction in the fiber diameter, and changes in the fiber membrane. Our results matched with those done in the past. A negative relationship of an increase in age has been observed with Tibial Motor NCV (r values = -0.19 and -0.25 in right and left lower limb respectively) and also in Peroneal Motor NCV (r values = -0.21 and -0.08 in right and left lower limbs respectively). Negative trends, but not very strongly so, have also been observed in the amplitudes of the CMAP of bilateral Tibial as well as Peroneal Nerves. Some occasional positive trends have also been recorded in the present study, but they may be because of a relatively smaller sample size than the study done by Stetson D et al [4], or because of difference in the NCS techniques.

There were NO statistically significant differences in values observed for males and females, for the 4 parameters of the 2 nerves tested bilaterally, except the CMAP duration of the Right Tibial Nerve, and the Distal Motor Latency of the Right Peroneal Nerves. These could be occasional findings, possibly because of the relatively smaller sample size. These results were in agreement with past studies [4, 14, 15, 16]. Thakur D et al [17] observed CMAPs duration is longer in males as compared to females in motor nerves and it was attributed to larger muscle fibre length, and/or larger size of the motor units in males.

BMI does not seem to affect the NCS parameters particularly (Table No 4). Mild positive correlation is seen between BMI and DML's. Mild positive correlation is also seen between BMI and CMAP Duration (r value =

0.26) of the Left Peroneal Nerve. Similarly, negative correlation (r value = -0.23) has been observed between BMI and the Amplitude of the Left Tibial Nerve. These observations were not statistically significant (p value <0.05) thereby rejecting any association between BMI and NCS variables. These findings are not in agreement with past study [18].

Table no 4: Correlation coefficient of different parameters of tibial motor NCS with age height weight and BMI

PARAMETER	Right Tibial			
	DML	Duration	Amplitude	CV
AGE	0.24	-0.03	-0.09	-0.19
HEIGHT	0.4	0.07	-0.14	-0.02
WEIGHT	0.38	-0.02	-0.11	-0.1
BMI	0.25	-0.13	-0.06	-0.17

PARAMETER	Left Tibial			
	DML	Duration	Amplitude	CV
AGE	0.16	0.18	-0.08	-0.25
HEIGHT	0.36	0.09	-0.08	-0.09
WEIGHT	0.27	0.13	-0.18	-0.11
BMI	0.11	0.1	-0.23	-0.13

Degrees of Coefficient of Correlation were graded into, low (0.29 ≥ absolute value r ≥ 0.1), moderate (0.49 ≥ absolute value r ≥ 0.3), substantial (absolute value of r ≥ 0.5)[12].

Conclusion

To conclude, this research has provided the factors (for eg. Age) which play an important role in motor NCS and need to be taken into consideration while performing these tests, and also has provided some factors (for eg. BMI, Sex, Height, Weight) which do NOT need strict correction before the NCS Inferences are drawn. This will help to formulate the strategies for consideration of these variables while diagnosing peripheral neuropathies. Although it has provided reference values for lower limb motor nerves, it cannot be extrapolated to general population due to smaller sample size. Further studies with larger sample size may be useful for affirmative outcome.

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References

1. Preston DC, Shapiro BE. Basic nerve conduction studies. In: Electromyography and Neuromuscular Disorders. Boston: Butterworth-Heinemann; 1998:26-56.
2. Misulis KE, Head TC. Nerve conduction study and electromyography. Essentials of Clinical Neurophysiology. 3rd Ed. Burlington: Butterworth-Heinemann. 2003:129-44.
3. Aminoff MJ. Clinical electromyography. In: Electrodiagnosis in clinical neurology. 4th ed. New York: Churchill Livingstone; 1999.214-46.
4. 4.Stetson DS, Albers JW, Silverstein BA, Wolfe RA. Effects of age, sex, and anthropometric factors on nerve conduction measures. Muscle & nerve. 1992;15(10):1095-104.

5. Pawar S, Taksande A and Ramji Singh. Normative data of upper limb nerve conduction in central India. Indian J Physiol and Pharmacol. 2011;55(3):241-245.
6. Soudmand R, Ward LC, Swift TR. Effect of height on nerve conduction velocity. Neurology 1982;32:407–410.
7. Awang MS, Abdullah JM, Abdullah MR, Tharakan J, Prasad A, Husin ZA, Hussin AM, Tahir A, Razak SA. Nerve conduction study among healthy malays. The influence of age, height and body mass index on median, ulnar, common peroneal and sural nerves. The Malaysian journal of medical sciences:MJMS. 2006;13(2):19.
8. Kurokawa K, Mimori Y, Tanaka E, Kohriyama T, Nakamura S. Age-related change in peripheral nerve conduction: compound muscle action potential duration and dispersion. Gerontology. 1999;45(3):168-73.
9. Thakur D, Paudel BH, Jha CB. Nerve Conduction study in healthy individuals, a preliminary age based study. Kathmandu University Medical Journal. 2012;8(3):311-6.
10. Buschbacher RM. Body mass index effect on common nerve conduction study measurements. Muscle & nerve 1998;21(11):1398-404.
11. Pawar SM, Taksande AB, Singh R. Effect of BMI on parameters of nerve conduction study in Indian population. Indian J Physiol and Pharmacol. 2012;56(1):88-93.
12. Hennessey WJ, Falco FJ, Braddom RL. Median and Ulnar nerve conduction studies: Normative data for young adults. Archives of Physical Medicine and Rehabilitation. 1994;75(3):259–264.
13. Falco FJ, Hennessey WJ, Braddom RL, Goldberg G. Standardized nerve conduction studies in the upper limb of the healthy elderly. American Journal of Physical Medicine & Rehabilitation. 1992;71(5):263-71.
14. Campbell WW, Ward LC, Swift TR. Nerve conduction velocity varies inversely with height. Muscle & nerve. 1981;4(6):520-3.
15. Soudmand R, Ward LC, Swift TR. Effect of height on nerve conduction velocity. Neurology. 1982;32(4):407.
16. Bolton CF, Carter KM. Human sensory nerve compound action potential amplitude: variation with sex and finger circumference. Journal of Neurology, Neurosurgery & Psychiatry.
17. Thakur D, Paudel BH, Bajaj BK, Jha CB. Nerve conduction study in healthy individuals: A gender based study. Health Renaissance. 2010;8(3):169-75.
18. Falck B, Stalberg E. Motor nerve conduction studies: measurement principles and interpretation of findings. Journal of Clinical Neurophysiology. 1995;12(3):254-79.

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