



ORIGINAL ARTICLE

NERVE CONDUCTION PARAMETERS OF THE MEDIAN AND ULNAR NERVES IN HEALTHY ADULTS FROM NORTHERN PAKISTAN

Aamir Nazir, Najma Ishtiaq*, Maria Shafiq, Abdus Saboor**, Sahar Farhat, Shazia Faqir, Uzma Khan***

Department of Physiology, Ayub Medical College, *Department of Psychiatry, Abbottabad International Medical College, Abbottabad,

**Department of Orthopedics, School of Medicine Dentistry and Allied Health Sciences, Haripur, Pakistan,

***Department of General Surgery, College of Medicine, Al Rayan National Colleges, Al-Madinah Al-Munawwarah, Saudi Arabia

Background: Nerve conduction studies (NCS) evaluate peripheral nerve function through nerve conduction velocity (NCV), distal latency and amplitude, and show nerve health, disease diagnosis, and axonal degeneration/demyelination. NCS parameters are influenced by age, gender, BMI, ethnicity, environmental and pathological factors. Standardized NCS values from western countries are used in Pakistan, and local reference values are unavailable. This study aimed to determine normal median and ulnar NCS parameters in healthy adults from Northern Pakistan, and assessed correlations with demographic and body-composition variables. **Methods:** This study was conducted at Ayub Medical College/CMH Abbottabad on 180 healthy adults from Jun 2024 to Nov 2025. Participants underwent neurological examination, laboratory screening and standardized median and ulnar NCS using Nihon Kohden Neuropack. Pearson correlation with 95% CI assessed associations between NCS parameters and demographic/body-composition variables. **Results:** Age showed moderate positive correlations with median motor wrist latency ($r=0.48$, 95% CI 0.35–0.58, $p<0.001$) and median sensory latency ($r=0.51$, 95% CI 0.39–0.61, $p<0.001$), and negative correlations with amplitudes and sensory NCV. Height showed positive correlations with ulnar motor latency at wrist ($r=0.46$, 95% CI 0.34–0.57, $p<0.001$), and elbow ($r=0.53$, 95% CI 0.42–0.63, $p<0.001$). Weight/BMI showed weak associations. Several body-composition measures, i.e., body fat, body water, visceral fat, and muscle mass, were significantly correlated with selected ulnar parameters. **Conclusion:** Age and height were important determinants of median and ulnar nerve conduction parameters, while associations with weight, BMI, and body-composition measures were generally parameter specific.

Keywords: Age, Body mass index, BMI, Nerve conduction studies, Median nerve, Ulnar nerve

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INTRODUCTION

Nerve conduction studies (NCS) provide objective measures of peripheral nerve function and assist in distinguishing axonal and demyelinating abnormalities.¹ Interpretation of NCS requires appropriate reference data because latency, amplitude and conduction velocity are influenced by age, sex, height and recording conditions. Temperature, measurement distance and technical factors may also affect results.²

Peripheral neuropathy (PN) is a common neurological problem, globally prevalent and frequently encountered by most family physicians. It is characterised by peripheral nerve damage or dysfunctional nerves, consequently causing a wide array of sensory, motor, and autonomic disruptions which may result from a variety of common identifiable causes like diabetes mellitus, nerve compression or physical injury, alcohol abuse, exposure to chemicals/toxin, some hereditary diseases, nutritional deficiencies, medication side effects and metabolic disorders.³ It can be classified in number of ways, e.g., clinically by anatomic pattern of patient's

symptoms and, if designated, by the results of electro-diagnostic studies NCS for axonal and demyelinating disease.⁴ The prevalence of PN ranges from 1% to 7% in the general population, with higher rates observed among patients older than 50 years and is idiopathic in 25–46% of cases. Therefore, diagnosis requires a comprehensive history, comprehensive physical, neurological and musculoskeletal examination, as well as vigilant laboratory testing and electro-diagnostic studies (EDX) where mandatory.⁵

In order to study the nerve conduction parameters in multiple diseases, it is necessary to know the normal values of those in particular ethnic population as a baseline. Normal and deranged values of these parameters can determine the site of nerve damage, diagnose polyneuropathy and can differentiate between poly neuropathy and myopathy, in addition to separating different muscle disorders.⁶ It has been observed that epidemiological data about NCS parameters and causes of peripheral neuropathies in the geographical regions such as Asia are sparse. Therefore, assessing the normal values of NCS parameters may further help to diagnose, classify and treat the particular types of neuropathies.⁷ Despite the

widespread use of standardized NCS values from the United States, Canada, and Europe in Pakistan, local population-specific reference values are not available. This gap is significant as nerve conduction parameters are influenced by demographic and physical factors, including age, gender, BMI, and ethnicity, as well as environmental and pathological conditions.

This study aimed at determining normal NCS parameters of median and ulnar nerves in persons aged 20–70 years and correlation of various demographic/body-composition factors with these NCS parameters.

METHODOLOGY

Approval of the study was obtained from the Ethical Review Committees of Ayub Medical College and CMH Abbottabad. This was a cross-sectional study performed on 180 healthy subjects aged 20–70 years at Ayub Medical College and CMH Abbottabad from Jun 2024 to Nov 2025.

Sampling was done by convenience sampling. Sample size was calculated by STAT UBA keeping the power of 0.80 and α power of 0.05. Potential participants were selected with no previous history of neuropathy, entrapment, upper-limb injury, systemic disease, medications and other factors affecting NCS and normal neurological examination. People with history of neurological disease, bleeding disorders and pregnant females were excluded from the study. All eligible participants gave written informed consents.

The height, weight, BMI, along with body fat and water content of each participant was recorded using MI[®] Body Mass Analyser. Blood was taken for fasting blood sugar, urea, creatinine, calcium, ESR, and LFT's. The subject was kept in sitting or lying in supine position while conducting the NCS. A standard technique was used to obtain and record action potentials for sensory and motor functions using NCS data acquisition system (Nihon Kohden Neuropak). Filters for motor studies were set at 2 Hz to 5 kHz and Sweep Speed was kept 5 ms per division. Filters for sensory studies were set at 20 Hz to 3 kHz and Sweep Speed was 2 ms per division. For motor studies the nerves were studied orthodromically. For sensory studies the nerves were studied antidromically. All electrodes were placed on specific and measured distances from each other according to the standard technique given by AANEM.⁸

Stimulus duration was kept between 50 μ Sec to 1,000 μ Sec with a current of 0 to 100 mA for effective and maximal stimulation of the nerve. Disc electrodes were used for both the sensory and motor studies. The room temperature was kept between 25 to 35 °C. Gel was applied between skin and electrodes for better conduction and felt pads of stimulator were soaked in water before stimulating the nerve fibre. A

specific software compatible with the NC electrodes was used for recording nerve conduction parameters.

RESULTS

Table-1 shows the demographic and body composition of study population. Table-2 presents the motor and sensory nerve conduction parameters of the median and ulnar nerves.

Table-3 shows significant correlations between several demographic and body composition variables and motor nerve conduction parameters. Age positively correlated with median motor wrist latency ($r=0.48$, $p<0.001$) and negatively correlated with median wrist amplitude ($r= -0.42$, $p<0.001$). Height showed significant positive correlations with ulnar wrist latency ($r=0.46$, $p<0.001$) and ulnar elbow latency ($r=0.53$, $p<0.001$). Body fat showed significant negative correlations with ulnar wrist latency ($r= -0.53$, $p<0.001$) and ulnar elbow latency ($r= -0.54$, $p<0.001$). Muscle mass was positively correlated with ulnar wrist latency ($r=0.51$, $p<0.001$) and ulnar elbow latency ($r=0.55$, $p<0.001$). Overall, BMI demonstrated relatively weak associations with most motor nerve conduction parameters.

Table-4 shows the correlations between demographic/body composition variables and sensory nerve conduction parameters. Age was positively correlated with median sensory latency ($r=0.51$, $p<0.001$) and negatively correlated with median sensory amplitude ($r= -0.47$, $p<0.001$) and median sensory conduction velocity ($r= -0.46$, $p<0.001$). Height was positively correlated with ulnar sensory latency ($r=0.41$, $p<0.001$) and negatively correlated with ulnar sensory conduction velocity ($r= -0.22$, $p=0.004$). Body fat and body water showed significant associations with several ulnar sensory parameters. In contrast, weight showed no significant correlation with any of the sensory nerve conduction parameters.

Table-1: Demographic and body composition parameters of study participants

Parameter	Mean $\pm$ SD
Age (Years)	53.83 $\pm$ 8.33
Height (Cm)	162.67 $\pm$ 7.91
Weight (Kg)	72.59 $\pm$ 11.38
BMI (Kg/m ²)	27.32 $\pm$ 3.68
Systolic BP (mmHg)	117.27 $\pm$ 9.67
Diastolic BP (mmHg)	76.87 $\pm$ 7.25
Pulse rate (beats/min)	84.11 $\pm$ 11.27
Temperature (°C)	37.05 $\pm$ 0.23
Respiratory rate (breaths/min)	14.53 $\pm$ 12.57
Body fat (%)	32.81 $\pm$ 7.85
Body water (%)	46.77 $\pm$ 4.99
Basal metabolic rate (Cal/day)	1333.53 $\pm$ 208.25
Visceral fat (%)	10.40 $\pm$ 3.43
Muscle mass (Kg)	46.02 $\pm$ 8.18
Bone mass (Kg)	2.49 $\pm$ 0.40

Table-2: Motor and sensory nerve conduction parameters of study participants

Nerve	Wrist latency (mSec)	Wrist amplitude (mV/ μ V)	Elbow latency (mSec)	Elbow amplitude (mV)	NCV (m/Sec)
Right median motor	3.50 $\pm$ 0.46	9.32 $\pm$ 2.44	7.75 $\pm$ 0.67	8.76 $\pm$ 2.54	55.10 $\pm$ 3.88
Left median motor	3.34 $\pm$ 0.41	9.34 $\pm$ 2.60	7.49 $\pm$ 0.69	8.90 $\pm$ 2.72	56.40 $\pm$ 4.53
Right ulnar motor	2.44 $\pm$ 0.32	9.23 $\pm$ 1.84	6.55 $\pm$ 0.60	8.58 $\pm$ 1.97	56.10 $\pm$ 5.22
Left ulnar motor	2.46 $\pm$ 0.33	8.89 $\pm$ 1.77	6.43 $\pm$ 0.70	8.18 $\pm$ 1.82	58.40 $\pm$ 5.46
Right median sensory	2.62 $\pm$ 0.44	29.22 $\pm$ 12.66	---	---	54.74 $\pm$ 8.47
Left median sensory	2.48 $\pm$ 0.35	33.94 $\pm$ 13.71	---	---	57.57 $\pm$ 7.81
Right ulnar sensory	2.06 $\pm$ 0.41	33.53 $\pm$ 15.37	---	---	59.20 $\pm$ 9.84
Left ulnar sensory	2.08 $\pm$ 0.33	35.70 $\pm$ 17.31	---	---	58.09 $\pm$ 7.40

Table-3: Correlations of demographic and body composition factors with motor NCS parameters [r (95% CI), p]

Factor	Median wrist latency	Median wrist amplitude	Median elbow latency	Median elbow amplitude	Median NCV	Ulnar wrist latency	Ulnar wrist amplitude	Ulnar elbow latency	Ulnar elbow amplitude	Ulnar NCV
Age	0.48 (0.35-0.58), <0.001	-0.42 (-0.53--0.29), <0.001	0.36 (0.23-0.48), <0.001	-0.40 (-0.52--0.27), <0.001	-0.13 (-0.27-0.02), 0.08	0.16 (0.02-0.30), 0.03	-0.14 (-0.28-0.01), 0.07	0.21 (0.07-0.35), 0.01	-0.16 (-0.30--0.01), 0.04	-0.15 (-0.29--0.00), 0.05
Height	0.10 (-0.05-0.24), 0.19	0.21 (0.06-0.34), 0.01	0.39 (0.26-0.51), <0.001	0.21 (0.06-0.34), 0.01	-0.08 (-0.22-0.07), 0.29	0.46 (0.34-0.57), <0.001	0.24 (0.09-0.37), 0.001	0.53 (0.42-0.63), <0.001	0.16 (0.02-0.30), 0.03	-0.08 (-0.22-0.07), 0.30
Weight	0.10 (-0.05-0.24), 0.18	0.06 (-0.09-0.20), 0.46	0.26 (0.12-0.39), <0.001	0.01 (-0.13-0.16), 0.85	-0.08 (-0.22-0.07), 0.31	0.14 (-0.01-0.28), 0.07	0.23 (0.09-0.36), 0.002	0.18 (0.04-0.32), 0.02	0.12 (-0.03-0.26), 0.11	0.01 (-0.14-0.15), 0.92
BMI	0.07 (-0.08-0.21), 0.36	-0.08 (-0.22-0.07), 0.29	0.03 (-0.12-0.17), 0.73	-0.13 (-0.27-0.02), 0.09	-0.02 (-0.17-0.13), 0.77	-0.20 (-0.33--0.05), 0.008	0.11 (-0.04-0.25), 0.15	-0.18 (-0.32--0.04), 0.01	0.03 (-0.11-0.18), 0.65	0.05 (-0.10-0.20), 0.49
Body fat	-0.15 (-0.29--0.00), 0.05	-0.12 (-0.26-0.03), 0.12	-0.30 (-0.43--0.17), <0.001	-0.20 (-0.34--0.05), 0.007	0.09 (-0.06-0.23), 0.25	-0.53 (-0.63--0.42), <0.001	-0.05 (-0.20-0.09), 0.48	-0.54 (-0.63--0.42), <0.001	-0.06 (-0.21-0.09), 0.41	0.17 (0.02-0.31), 0.02
Body water	0.08 (-0.07-0.23), 0.27	0.10 (-0.05-0.24), 0.18	0.37 (0.23-0.49), <0.001	0.15 (0.00-0.29), 0.04	-0.19 (-0.32--0.04), 0.01	0.47 (0.35-0.58), <0.001	0.07 (-0.08-0.21), 0.36	0.51 (0.39-0.61), <0.001	0.04 (-0.11-0.19), 0.58	-0.13 (-0.27-0.02), 0.09
BMR	-0.01 (-0.15-0.14), 0.92	0.13 (-0.02-0.27), 0.08	0.19 (0.05-0.33), 0.01	0.13 (-0.02-0.27), 0.10	0.03 (-0.12-0.18), 0.68	0.31 (0.17-0.44), <0.001	0.14 (-0.01-0.28), 0.06	0.32 (0.18-0.45), <0.001	0.05 (-0.09-0.20), 0.48	-0.03 (-0.18-0.12), 0.68
Visceral fat	0.25 (0.11-0.39), <0.001	0.01 (-0.14-0.15), 0.93	0.48 (0.36-0.59), <0.001	0.04 (0.11-0.18), 0.64	-0.28 (-0.41--0.14), <0.001	0.34 (0.20-0.46), <0.001	0.29 (0.15-0.42), <0.001	0.39 (0.26-0.51), <0.001	0.21 (0.07-0.35), 0.005	-0.11 (-0.25-0.04), 0.15
Muscle mass	0.18 (0.04-0.32), 0.02	0.09 (-0.06-0.24), 0.22	0.50 (0.38-0.60), <0.001	0.11 (-0.04-0.25), 0.14	-0.19 (-0.33--0.05), 0.01	0.51 (0.39-0.61), <0.001	0.16 (0.01-0.30), 0.04	0.55 (0.44-0.65), <0.001	0.04 (-0.10-0.19), 0.56	-0.08 (-0.23-0.06), 0.26
Bone mass	0.09 (-0.06-0.23), 0.24	0.19 (0.04-0.33), 0.01	0.38 (0.25-0.50), <0.001	0.20 (0.06-0.34), 0.007	-0.24 (-0.37--0.09), 0.001	0.44 (0.31-0.55), <0.001	0.22 (0.08-0.36), 0.003	0.41 (0.29-0.53), <0.001	0.10 (-0.05-0.24), 0.19	-0.12 (-0.26-0.03), 0.11

Table-4: Correlations of demographic and body composition factors with sensory NCS parameters [r (95% CI), p]

Factor	Median sensory latency	Median sensory amplitude	Median sensory NCV	Ulnar sensory latency	Ulnar sensory amplitude	Ulnar sensory NCV
Age	0.51 (0.39-0.61), <0.001	-0.47 (-0.57--0.34), <0.001	-0.46 (-0.57--0.33), <0.001	0.30 (0.16-0.43), <0.001	-0.33 (-0.45--0.19), <0.001	-0.11 (-0.25-0.04), 0.14
Height	0.11 (-0.03-0.26), 0.13	-0.10 (-0.24-0.05), 0.20	0.10 (-0.05-0.24), 0.20	0.41 (0.28-0.53), <0.001	-0.15 (-0.29--0.01), 0.04	-0.22 (-0.35--0.07), 0.004
Weight	0.04 (-0.11-0.18), 0.62	-0.03 (-0.17-0.12), 0.71	0.10 (-0.05-0.24), 0.18	0.05 (-0.10-0.20), 0.51	0.00 (-0.14-0.15), 0.97	0.00 (-0.14-0.15), 0.98
BMI	-0.02 (-0.17-0.13), 0.79	0.03 (-0.12-0.17), 0.72	0.02 (-0.12-0.17), 0.75	-0.26 (-0.39--0.12), <0.001	0.11 (-0.04-0.25), 0.14	0.18 (0.04-0.32), 0.01
Body fat	0.17 (-0.31--0.02), 0.02	0.12 (-0.02-0.27), 0.10	0.07 (-0.08-0.21), 0.39	-0.51 (-0.61--0.39), <0.001	0.32 (0.18-0.44), <0.001	0.34 (0.21-0.47), <0.001
Body water	0.08 (-0.07-0.22), 0.32	-0.16 (-0.30--0.01), 0.04	0.04 (-0.11-0.19), 0.59	0.50 (0.38-0.60), <0.001	-0.30 (-0.43--0.16), <0.001	-0.35 (-0.47--0.22), <0.001
BMR	-0.09 (-0.23-0.06), 0.24	0.13 (-0.01-0.27), 0.08	0.19 (0.05-0.33), 0.01	0.11 (-0.04-0.25), 0.16	0.06 (-0.09-0.20), 0.46	-0.11 (-0.25-0.04), 0.15
Visceral fat	0.27 (0.13-0.40), <0.001	-0.27 (-0.40--0.13), <0.001	-0.09 (-0.23-0.06), 0.24	0.31 (0.17-0.44), <0.001	-0.32 (-0.45--0.18), <0.001	-0.11 (-0.26-0.03), 0.13
Muscle mass	0.15 (0.01-0.29), 0.04	-0.20 (-0.34--0.06), 0.007	0.04 (-0.11-0.18), 0.60	0.48 (0.36-0.58), <0.001	-0.27 (-0.40--0.12), <0.001	-0.30 (-0.42--0.16), <0.001
Bone mass	0.08 (-0.07-0.23), 0.28	-0.14 (-0.28-0.01), 0.06	0.08 (-0.07-0.22), 0.30	0.36 (0.22-0.48), <0.001	-0.21 (-0.35--0.07), 0.004	-0.19 (-0.33--0.04), 0.01

Note: r=Pearson correlation coefficient, CI=95% confidence interval, NCV=nerve conduction velocity, NCS=nerve conduction study, BMI=body mass index, BMR=basal metabolic rate. Motor amplitudes are expressed in mV and sensory amplitudes in μ V

DISCUSSION

This study provides descriptive motor and sensory nerve conduction data for the median and ulnar nerves in healthy adults from Northern Pakistan, and demonstrates important associations with demographic and body composition variables. Our findings are similar to the findings of studies done earlier for Indian and Pakistani populations.⁹ As described by Hameed *et al*¹⁰ Pakistani populations generally have statistically significantly higher mean amplitudes and relatively faster conduction velocities showing similarities with South Asian studies. Our NCS findings are similar to the study by López *et al*⁸ that examined asymptomatic and healthy controls which were significantly different from those of the American and multi-ethnic Malaysian origin populations. These differences can be attributed to different demographic and biological characteristics of study population as well

as sampling sizes, and techniques used to record NCS responses. In addition to that equipment settings, certain genetic factors, lifestyle differences, variations in body and environmental temperature can be the source of these minor variations observed amongst different multi-ethnic study populations.⁵

Our NCS values were compared to normative nerve conduction values from other population-based studies, using standardized techniques. Sensory distal latencies were slightly increased which we believe could be related to the variations in distal distances. The results of our study showed comparable findings to that of the Saudi and Indian population.¹¹

Demographic factors, particularly age and height, have a greater influence on upper-limb nerve conduction parameters than most body composition indices. Age showed moderate positive correlations with median motor and sensory latencies and negative

correlations with amplitudes and sensory conduction velocity, indicating age-related slowing of peripheral nerve conduction and reduced axonal function. These findings are consistent with recent large population-based evidence from the Maastricht Study, which reported longer distal latencies, lower conduction velocities, and reduced amplitudes with increasing age across multiple peripheral nerves.¹²

Height demonstrated moderate positive correlations with ulnar motor and sensory latencies, supporting previous observations that taller individuals have longer nerve pathways, resulting in prolonged conduction times. Similar findings have recently been reported in normative studies showing that height independently predicts longer distal latencies and lower conduction velocities.¹³ In contrast, weight and BMI showed weak correlations with most motor and sensory parameters, suggesting that overall body size has only a limited effect on nerve conduction after accounting for anthropometric characteristics, consistent with recent population-based analysis by Sand *et al.*¹⁴

Among body composition variables, muscle mass, body water, bone mass, and visceral fat demonstrated moderate positive correlations with several motor latency parameters, whereas body fat percentage showed moderate negative correlations with ulnar latencies as supported by a contemporary study by Raissi *et al.*, primarily emphasize demographic and anthropometric determinants and body composition contributes modestly to variability in electrophysiological recordings. These associations may be attributed to changes in tissue composition, electrode-to-nerve distance, and electrical impedance rather than intrinsic alterations in nerve physiology.¹⁵

CONCLUSION

The findings of this add locally derived descriptive NCS data and support consideration of demographic and body composition characteristics during interpretation of upper-limb nerve conduction studies.

LIMITATIONS OF THE STUDY

This study provides only NCS parameters in a relatively small sample of adult population without much emphasis upon precise causal relationship or comparison among different ethnic groups. Larger multi centre studies using standardized limb temperature, gender-stratified analyses and multivariable regression

are needed to establish robust population-specific reference limits for clinical use.

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Address for Correspondence:

Dr Maria Shafiq, Department of Physiology, Ayub Medical College, Abbottabad, Pakistan. **Cell:** +92-332-9928090
Email: mariasaboorel@gmail.com

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Authors approved the draft and are accountable in ensuring that questions related to accuracy or integrity of the work are duly investigated and resolved.

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NI: Data analysis and interpretation

MS: Data analysis and interpretation

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