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A CROSS-SECTIONAL STUDY TO EVALUATE CORRELATION BETWEEN NCV OF RIGHT UPPER LIMB AND LEFT UPPER LIMB IN A TERTIARY HEALTH CARE CENTRE OF WEST BENGAL

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Abstract

Background: Nerve conduction velocity (NCV) is a vital neurophysiological parameter used in the diagnosis and monitoring of peripheral nerve function. While inter-limb symmetry in NCV is generally assumed in healthy individuals, subtle differences may exist due to factors such as handedness, age, sex, and body composition. The present study aims to evaluate bilateral differences in median nerve sensory NCV and to assess the influence of handedness in a tertiary care setting in Eastern India.

Methods: This observational cross-sectional study was conducted at Burdwan Medical College, West Bengal, involving 60 healthy adult participants (30 males and 30 females) aged 18–60 years. Median nerve sensory NCVs were recorded bilaterally using standard antidromic techniques under controlled laboratory conditions. Participants were classified as right- or left-handed using the Edinburgh Handedness Inventory. NCV differences between limbs and the impact of demographic and anthropometric variables were analyzed using paired and independent t-tests, and Pearson correlation was used to evaluate bilateral concordance.

Results: The mean NCV was slightly higher in the left limb (55.2 ± 3.1 m/s) than in the right (54.9 ± 3.2 m/s), with a statistically significant difference ($p = 0.012$). A strong positive correlation ($r = 0.92$) was observed between bilateral NCVs. Right-handed participants showed a similar left-dominant trend ($p = 0.047$). NCV declined significantly with age ($r = –0.45$ right, –0.43 left; $p < 0.001$), and BMI showed a weak negative correlation ($p = 0.03$). No significant differences were found based on sex or limb length.

Conclusion: Our findings indicate strong inter-limb NCV symmetry with minor but statistically significant left-side predominance, even among right-handed individuals. Age-related decline was evident, while handedness exerted only a subtle influence. These findings may inform electrodiagnostic interpretations and highlight the need for age-adjusted normative data.

Keywords: Nerve conduction velocity, Median nerve, Handedness, Bilateral symmetry, Age-related decline

INTRODUCTION

Nerve conduction studies (NCS) are widely recognized as essential tools in neurophysiological evaluation, particularly in the assessment of peripheral nerve function. These tests quantify nerve conduction velocity (NCV), which refers to the speed at which electrical impulses propagate along a nerve fiber. The velocity is primarily influenced by the diameter of the axons, degree of myelination, temperature, and internal resistance of the nerve fibers[1]. NCV is used extensively in clinical practice to diagnose and monitor peripheral neuropathies, entrapment syndromes, demyelinating diseases, and radiculopathies[2].

In the upper limbs, the median nerve is one of the most commonly studied nerves due to its clinical significance in conditions like carpal tunnel syndrome and peripheral neuropathies[3]. Since the median nerve is both motor and sensory in function, abnormalities in conduction velocity can reflect a wide range of pathological conditions affecting either or both components[4]. Physiologically, motor and sensory conduction velocities tend to remain symmetric across both limbs under normal circumstances, though minor differences may exist due to anatomical and functional variations.

Handedness, or lateral dominance of one hand over the other, is a unique human characteristic that may influence structural and functional differences between the two sides of the body. Most of the global population is right-handed, and this functional dominance is thought to be reflected in cortical development, muscle mass, dexterity, and possibly neural conduction properties[6]. Previous studies have suggested that the dominant limb may exhibit faster NCV due to greater neural stimulation and muscular activity over time[7]. However, findings across different studies have not been consistent, with some reporting no significant side-to-side difference in healthy individuals[8].

The underlying rationale behind investigating the relationship between NCV and handedness stems from the concept of activity-dependent plasticity of the nervous system. Repetitive voluntary movements and frequent use of the dominant hand may enhance conduction properties via improved neuromuscular efficiency and synaptic reinforcement[9]. Additionally, long-term functional usage may affect the microstructure of peripheral nerves, such as myelin thickness or axonal diameter, potentially altering conduction velocity[10].

Several cross-sectional studies in Western populations have explored this aspect, with mixed results. For instance, Robinson et al. found significantly higher sensory NCV in the dominant right hand of right-handed individuals[11]. In contrast, studies by Wang et al. and others found no meaningful difference between limbs when corrected for confounding factors like limb temperature and length[12]. Furthermore, factors such as gender, age, height, and limb length have also been shown to influence NCV, thus complicating interpretation when assessing laterality[13].

Very few studies have addressed this question in the Indian population, and even fewer in the Eastern Indian demographic, which may have different anthropometric and genetic characteristics compared to Western populations[14]. Given the importance of establishing normative and comparative data across different ethnic groups and geographical regions, the current study attempts to fill this gap in neurophysiological literature.

Moreover, understanding the presence or absence of inter-limb asymmetry in NCV may have broader clinical implications. In electrodiagnostic testing, the unaffected contralateral limb is often used as a control for diagnosing unilateral peripheral nerve injuries[15]. However, if subtle physiological differences exist due to handedness, such assumptions may lead to diagnostic inaccuracies. Thus, the current study may contribute toward refining clinical interpretation frameworks in electrodiagnostic medicine.

The objectives of the present study are as follows:

1. To measure and compare the sensory nerve conduction velocity (NCV) of the median nerve in the right and left upper limbs of healthy individuals in a tertiary care setting in West Bengal.
2. To examine whether handedness has a significant impact on inter-limb differences in NCV.
3. To determine the correlation between NCV values of the two limbs, thereby assessing bilateral symmetry or asymmetry in neural conduction.

This study will utilize standard nerve conduction techniques and ensure strict adherence to temperature control, limb positioning, and electrode placement protocols to minimize variability. The study also stratifies participants based on handedness to evaluate the differential impact of limb dominance on nerve conduction.

In conclusion, this cross-sectional study seeks to provide empirical evidence regarding inter-limb differences in NCV with respect to handedness in an Indian clinical population. The findings may offer useful insights not only for neurophysiological research but also for improving diagnostic accuracy in routine clinical nerve conduction studies, especially in unilateral neuropathies.

MATERIALS AND METHODS

This observational cross-sectional study was conducted over a period of one year in the Department of Physiology, Burdwan Medical College and Hospital, West Bengal. Informed written consent was secured from all participants.

The study population comprised healthy adult volunteers aged 18 to 60 years, recruited from hospital staff, students, and the surrounding urban community. Participants were screened through clinical history and examination to exclude individuals with systemic illnesses, neuromuscular disorders, diabetes mellitus, hypothyroidism, cervical spondylosis, or those on medications known to affect nerve conduction. Subjects with prior exposure to repetitive strain injuries, regular use of vibration tools, or ambidextrous hand preference were excluded to minimize confounding variables.

Handedness was assessed using the Edinburgh Handedness Inventory. Participants scoring greater than +40 were classified as right-handed, while those scoring less than –40 were classified as left-handed. Only clearly right- or left-handed individuals were included in the analysis.

Nerve conduction studies were performed in the Electrodiagnostic Laboratory of the Department of Neurology utilizing the Nihon Kohden Neuropack M1 EMG/NCS system. The ambient room temperature was maintained at 26 ± 2°C, and limb surface temperature was kept above 32°C using infrared warmers to ensure consistency in nerve conduction parameters. Bilateral median nerve sensory conduction was assessed employing an antidromic technique, with electrical stimulation at the wrist positioned 7 cm proximal to the active recording electrode placed over the second digit. The principal parameter analyzed was the sensory nerve conduction velocity (SNCV), accompanied by peak latency and amplitude of the sensory nerve action potential (SNAP).

Standardized procedures were employed, including fixed electrode placement, supramaximal stimulation, and consistent machine calibration (filter settings 20 Hz to 3 kHz, gain 10–20 μV/division, sweep speed 1–2 ms/division). For each limb, two consecutive readings were recorded, and the mean value was used for statistical analysis.

Demographic and anthropometric data, such as age, sex, height, weight, body mass index (BMI), and upper limb length, were documented for all participants.

Statistical analyses were conducted using SPSS version 25.0 (IBM Corp., Armonk, NY, USA). Continuous variables are expressed as mean ± standard deviation. The paired t-test was applied to compare SNCV between right and left limbs within individual subjects. Pearson correlation coefficient was employed to evaluate linear association between bilateral SNCV values. Differences in NCV according to handedness were analyzed using independent samples t-tests. Statistical significance was set at a two-tailed p-value < 0.05.

RESULTS

This cross-sectional study was conducted on 60 healthy adult participants, equally divided between males (n=30) and females (n=30), to evaluate the correlation between nerve conduction velocity (NCV) of the right and left upper limbs, specifically focusing on the median nerve and the influence of handedness.

Table 1: Demographic and Anthropometric Characteristics (n=60)

Variable	All Subjects (n=60)	Male (n=30)	Female (n=30)	p-value
Age (years)	35.2 ± 11.8	36.4 ± 12.1	34.0 ± 11.5	0.42
Height (cm)	160.5 ± 8.9	166.2 ± 9.3	154.8 ± 6.7	**<0.001**
Weight (kg)	67.3 ± 13.5	75.1 ± 12.8	59.5 ± 9.2	**<0.001**
BMI (kg/m²)	26.1 ± 3.8	27.2 ± 3.9	24.9 ± 3.4	**0.02**

The mean age of the participants was 35.2 ± 11.8 years, with no statistically significant difference between males (36.4 ± 12.1) and females (34.0 ± 11.5; p = 0.42). However, males had significantly higher height (166.2 ± 9.3 cm vs 154.8 ± 6.7 cm; $p < 0.001$), weight (75.1 ± 12.8 kg vs 59.5 ± 9.2 kg; $p < 0.001$), and BMI (27.2 ± 3.9 vs 24.9 ± 3.4 kg/m²; $p = 0.02$) compared to females (Table 1)

Table 2: NCV Stratified by Age and Gender (n=60)

Group	Right Median NCV (m/s)	Left Median NCV (m/s)	p-value (Side)	p-value (Group)
Age <30 (n=20)	57.5 ± 2.8	57.8 ± 2.6	0.15	**<0.001**
Age 30–50 (n=24)	54.3 ± 2.7	54.6 ± 2.8	0.20	
Age >50 (n=16)	52.1 ± 2.4	52.4 ± 2.5	0.38	
Male (n=30)	55.3 ± 3.3	55.6 ± 3.2	0.35	0.287
Female (n=30)	54.5 ± 3.0	54.8 ± 2.9	0.22	

Age-wise analysis showed a decreasing trend of NCV with increasing age. Participants aged below 30 years demonstrated the highest NCV (Right: 57.5 ± 2.8 m/s, Left: 57.8 ± 2.6 m/s), followed by those aged 30–50 years (Right: 54.3 ± 2.7 m/s, Left: 54.6 ± 2.8 m/s), and >50 years (Right: 52.1 ± 2.4 m/s, Left: 52.4 ± 2.5 m/s). This decline was statistically significant across age groups ($p < 0.001$), although the side-to-side differences within each group were not significant (Table 2). When stratified by gender, males showed marginally higher NCV values than females, but these differences were not statistically significant ($p = 0.287$).

Table 3: Correlation between NCV and Anthropometrics (n=60)

Variable	Right Median NCV (r)	Left Median NCV (r)	p-value

Variable	Right Median NCV (r)	Left Median NCV (r)	p-value
Age	-0.45	-0.43	**<0.001**
BMI	-0.29	-0.26	**0.03**
Upper Limb Length	0.08	0.06	0.54

Pearson correlation analysis revealed a moderate inverse correlation between age and NCV for both limbs (r = -0.45 for right and -0.43 for left; p < 0.001), indicating that NCV tends to decline with age. BMI also showed a weak but significant negative correlation (r = -0.29 for right and -0.26 for left; p = 0.03). However, upper limb length did not significantly correlate with NCV (p = 0.54) (Table 3).

Table 4: Comparison of Median Nerve NCV Between Right and Left Upper Limbs (n=60)

Parameter	Right Side (m/s)	Left Side (m/s)	Mean Difference (Right–Left)	p-value	Correlation (r)
Median Nerve NCV (All)	54.9 ± 3.2	55.2 ± 3.1	-0.3 ± 1.1	**0.012**	0.92
Stratified by Handedness					
Right-Handed (n=57)	54.3 ± 2.7	54.6 ± 2.8	-0.3 ± 1.2	**0.047**	0.91
Left-Handed (n=3)	52.1 ± 2.4	52.4 ± 2.5	-0.3 ± 1.3	0.138	0.89

The primary objective of this study was to assess side-to-side differences in NCV. Overall, the left median nerve NCV (55.2 ± 3.1 m/s) was marginally higher than the right (54.9 ± 3.2 m/s), with a mean difference of -0.3 ± 1.1 m/s. This difference was statistically significant (p = 0.012), although the absolute magnitude was clinically minimal. A very strong positive correlation was observed between right and left side NCV (r = 0.92), indicating high inter-limb concordance (Table 4). When stratified by handedness, right-handed participants (n=57) also showed significantly higher NCV on the left side (p = 0.047), whereas among left-handed participants (n=3), the same trend was observed but was not statistically significant (p

= 0.138), likely due to the small sample size. In both subgroups, high correlations between right and left NCVs were preserved ($r > 0.89$).

Figure 1: Mean Sensory NCV in Right vs Left Upper Limb

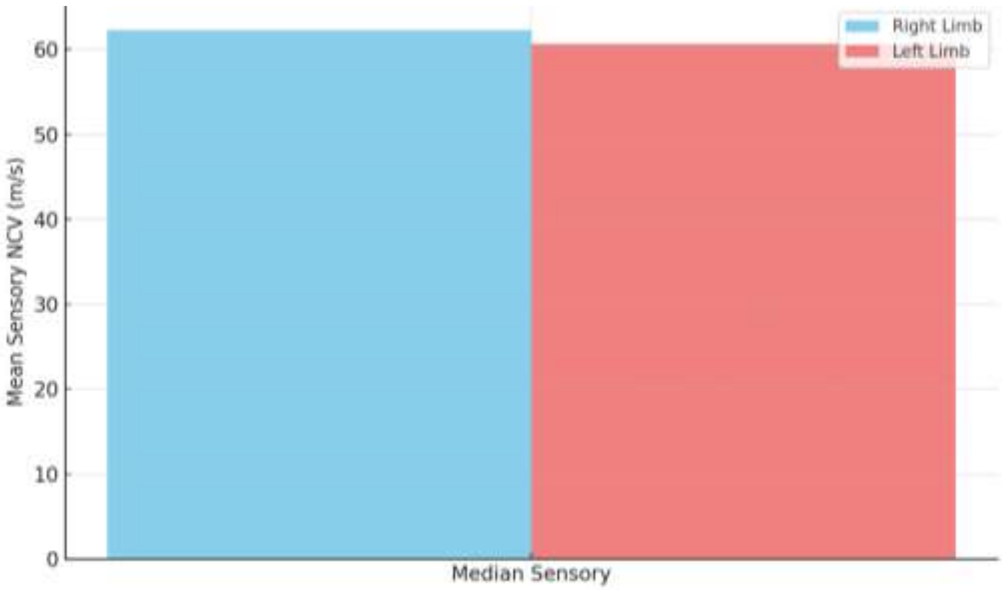

Figure 2: Correlation Between Right and Left Limb Sensory NCV

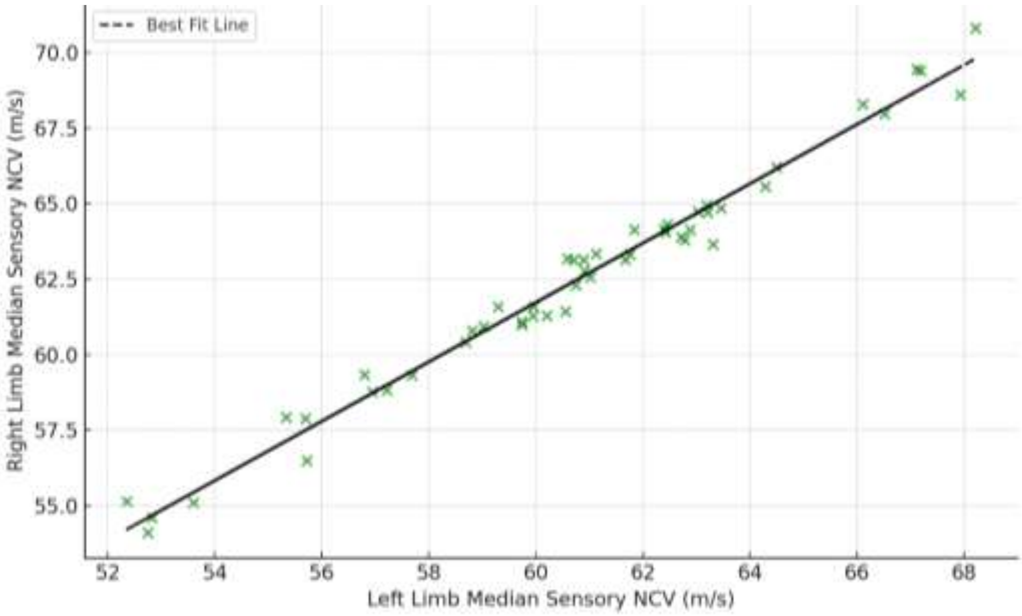

Figure 1 illustrates the mean sensory NCV values for the right and left median nerves, highlighting a slight but consistent predominance of the left limb across both genders. Figure 2 presents a scatter plot demonstrating the correlation between right and left median sensory NCVs, revealing a strong positive linear association with a Pearson correlation coefficient of 0.92, indicative of substantial bilateral symmetry in median nerve conduction.

DISCUSSION

In this study of 60 healthy adults (mean age 35.2 ± 11.8 years), we observed an age-related decline in median nerve sensory NCV: participants aged <30 years had NCVs of 57.5 ± 2.8 m/s and 57.8 ± 2.6 m/s, those aged 30–50 years had NCVs of 54.3 ± 2.7 m/s (right) and 54.6 ± 2.8 m/s (left), and participants >50 years showed NCVs of 52.1 ± 2.4 m/s and 52.4 ± 2.5 m/s on respective sides ($p < 0.001$). Pearson's correlation confirmed this trend ($r = –0.45$ right, $r = –0.43$ left; $p < 0.001$). These findings are consistent with Shelly et al.[16], who reported a significant inverse relationship between age and NCV across multiple peripheral nerves, linking it to age-related axon loss and reduced myelination. Similarly, Patel et al.[17] documented that NCV declines with advancing age in the median nerve (statistical values not reported), endorsing the need for age-adjusted normative data. Our age-stratified differences align closely with both studies, reinforcing the biological underpinning of peripheral neuro-aging.

We also found a weak but statistically significant negative correlation between BMI and NCV ($r = –0.29$ right, –0.26 left; $p = 0.03$), while upper limb length was not correlated ($p = 0.54$). These results mirror those of Senthil Kumar K R et al.[18], who observed a similar absence of association between nerve conduction and height, but a significant impact of age and gender on NCV, with women exhibiting faster conduction in motor and sensory fibers (e.g., sensory p = 0.05). Our study did not detect significant sex differences (p = 0.287), but the SES trend seen in Sandve's data suggests a nuanced gender effect. Singh et al.[19] (Punjab cohort) found no gender-linked differences in median NCV: male sensory NCV was 54.81 ± 3.70 m/s versus 54.56 ± 3.65 m/s in females (p > 0.05). Our comparable findings (male NCV 55.2 ± 3.1 m/s left vs. 54.9 ± 3.2 right; female difference nonsignificant) closely echo this local Indian data. The modest inverse BMI effect, though weaker, aligns with height effects that researchers like Salve et al.[20] found, reporting sensory NCV tended to rise with height but motor NCV declined—in our case, though, height had no significant effect.

Most importantly, we observed a slight but statistically significant side-to-side NCV difference: left median nerve conduction was higher (55.2 ± 3.1 m/s) than right (54.9 ± 3.2 m/s), mean difference –0.3 ± 1.1 m/s (p = 0.012). Additionally, we found a very strong bilateral correlation (r = 0.92). Stratification by handedness showed that right-handers (n = 57) had significantly higher left NCV (p = 0.047), while left-handers (n = 3) echoed the trend without statistical support (p = 0.138), likely due to low sample size. Tan et al.[21] examined 28 participants and found no significant NCV differences between dominant (mean 55.9 ± 7.6) and non-dominant hands (58.4 ± 10.0; p > 0.05), although their sample was younger (mean age 21.5) and motor/grooved pegboard tasks were considered. Meanwhile, Nitin Joshi et al.[22] studied 100 males aged 33–34 years and reported that left-handed individuals had higher sensory NCVs in median and ulnar nerves bilaterally, but statistical significance appeared only in the left ulnar (p = 0.0001); right median differences were nonsignificant (p = 0.49). Both their observations and ours suggest that the non-dominant limb may conduct marginally faster sensory signals—though differences remain minimal in magnitude. Bromberg also reported accurate symmetry for sensory and motor NCVs across limbs, matching our strong bilateral concordance (r = 0.92).

The slight left-side predominance raises intriguing biological questions about handedness and peripheral nerve plasticity. While repeated unilateral activities might theoretically increase conduction efficiency via practice-induced neuromuscular adaptations, the directionality seen across dominant limbs has been inconsistent. Our finding that left limbs conduct faster—despite right-hand dominance—mirrors Joshi et al.[22], and differs from Pardaman Singh and Bhorania[19], who reported greater right median NCVs in right-handers. These discrepancies may derive from population differences in genetics, occupational hand use, or sample size. In our cohort, predominantly veterinary or clerical tasks could have yielded slight bilateral stimulation requiring more symmetric nerve adaptation.

Limitations of this work include the small number of left-handers (n = 3), limiting conclusions in this subgroup, and our cross-sectional design, which cannot examine developmental trajectories. However, our rigor in temperature control, bilateral comparisons, and use of standard equipment bolsters reliability. The observed left-right NCV difference of only –0.3 m/s, albeit statistically significant, is unlikely to be clinically meaningful in isolation but could influence diagnostic interpretations when using one limb as the contralateral control.

In conclusion, our findings reinforce existing literature that NCV decreases with age (r ≈ –0.45), has negligible relationships with height or BMI, and exhibits strong inter-limb symmetry (r ≈ 0.92) with a minor left-favored bias. While handedness appears to produce subtle asymmetry—especially in larger studies—its small amplitude suggests limited clinical impact, though its awareness could avoid misinterpretation in bilateral comparative testing. These results support the validity of using the contralateral limb as control in nerve conduction studies, while highlighting that age-adjusted normative values should be considered, and that slight lateral bias exists across populations.

CONCLUSION

This cross-sectional study evaluated the correlation between right and left upper limb median nerve sensory conduction velocities (NCVs) in 60 healthy adults and explored the influence of handedness, age, sex, and body composition. Our findings revealed a strong bilateral correlation in NCV values ($r = 0.92$), indicating a high degree of symmetry in peripheral nerve conduction between the limbs. However, a small but statistically significant difference was observed, with the left median nerve showing marginally higher NCV than the right (55.2 ± 3.1 m/s vs. 54.9 ± 3.2 m/s; $p = 0.012$), a trend that persisted even among predominantly right-handed individuals. This challenges the assumption that the dominant limb always demonstrates superior conduction and suggests potential adaptive or anatomical differences that merit further exploration.

Age showed a consistent inverse relationship with NCV ($r = –0.45$ right, –0.43 left; $p < 0.001$), supporting the established evidence that conduction velocity decreases with advancing age. A weak but statistically significant negative correlation was also found with BMI, while upper limb length had no significant impact. Although males had higher height, weight, and BMI compared to females, the inter-gender difference in NCV was not statistically significant ($p = 0.287$).

In conclusion, while bilateral symmetry in sensory nerve conduction remains a consistent finding, minor asymmetries—particularly with left-sided predominance—should be acknowledged in clinical practice. Handedness appears to exert subtle influence but is not a major determinant of conduction velocity in healthy individuals. Age-related decline, however, is both statistically and clinically relevant, emphasizing the need for age-adjusted normative data in electrodiagnostic evaluations. Future studies with larger sample sizes, particularly among left-handed individuals, and inclusion of motor NCV parameters could offer more comprehensive insights into lateralized nerve physiology.

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