

## RESEARCH ARTICLE

# Physiological variations in nerve conduction velocity does not follow diurnal trend

Ranjeet Kumar Vishwakarma, Bhupendra Singh Yadav

Department of Physiology, Institute of Medical Sciences, Banaras Hindu University, Varanasi, Uttar Pradesh, India

Correspondence to: Bhupendra Singh Yadav, E-mail: bhupendra.georgian@gmail.com

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## ABSTRACT

**Background:** Nerve conduction studies (NCSs) are performed for diagnosis and prognosis of disorders of the peripheral nervous system. Most physiological parameters show diurnal fluctuations. The time at which nerve conduction velocity (NCV) is performed may influence the recorded values if there are diurnal variations in NCV. Diurnal variations in NCV have not been studied in detail and there is a paucity of literature for the same. **Aims and Objectives:** This study aims to investigate the diurnal variations in ulnar motor NCV (MNCV). **Materials and Methods:** NCSs were performed on 89 healthy volunteers (76 males and 13 females) of age range from 18 to 22 years. **Results:** The mean age, height, weight, and body mass index of our study group were  $20.68 \pm 1.77$  years,  $168.02 \pm 8.03$  cm,  $59.57 \pm 10.31$  kg, and  $21.11 \pm 3.11$  kg/m<sup>2</sup>, respectively. Motor NCSs for ulnar nerve revealed no statistically significant diurnal variation in either limb. MNCV was also found to be similar for both genders. Increasing height of the subjects was associated with decrease in MNCV for ulnar nerve while raised pulse rates were found associated with increasing MNCVs. **Conclusion:** Our study suggests that there is no significant diurnal variation in ulnar MNCVs.

**KEY WORDS:** Nerve Conduction Velocity; Diurnal Variation; Compound Muscle Action Potential; Ulnar Nerve

## INTRODUCTION

Diseases and disorders affecting nerves are an important cause of morbidity and decrease the quality of human life. Nerve conduction studies (NCSs) are an important tool to evaluate the peripheral nerve abnormalities. Nerve conduction velocity (NCV) test has been used as a simple non-invasive technique for diagnosis, localization, monitoring, and prognostic evaluation of nerve injuries and neuropathies.<sup>[1]</sup> Early diagnosis and treatment of neural diseases and disorders prevent the irreversible damage and

the debilitating morbidity. Advancements in technology helps early detection of such neural damage, enabling timely intervention to halt disease progression or to treat the underlying cause. Thus, NCV has emerged as an important non-invasive technique for clinicians and researchers to investigate the pathogenesis and to monitor the outcomes of treatment. Several factors may influence NCSs such as temperature, age, sex, height, weight, body mass index (BMI), and laboratory conditions which should be taken into consideration; otherwise, sensitivity and specificity of NCV study would decrease.<sup>[2,3]</sup> As the body composition of different population varies with demographic profile, every population should also have its own normative data to identify abnormal subjects.<sup>[4]</sup> One universal reference value cannot be applied to all population due to geographical and ethnic variation; thus, different regions and laboratories have their own standard reference value. Most physiological parameters show variations over time, in a day. Diurnal variations in NCV have not been studied in detail and there

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is a paucity of literature for the same. The time at which NCV is recorded may confound the values recorded if there are diurnal variations in NCV. Hence, in this study, we have investigated diurnal variations in ulnar motor NCV (MNCV) in Indian young healthy subjects.

## MATERIALS AND METHODS

The study was conducted at the Department of Physiology of Institute of Medical Science, Banaras Hindu University in Varanasi, Uttar Pradesh, India. NCSs were performed on 89 healthy volunteers (76 males and 13 females) of age range from 18 to 22 years after obtaining written informed consent of the subjects and ethical clearance from the Institute's Ethical Committee. After explaining the NCV recording procedure to the subject, relevant clinical history was taken and clinical examination was performed. General information such as age and gender and anthropometric parameters such as height (in cm) and weight (in kg) were recorded for all and BMI was calculated from the same. Blood pressure, pulse rate, and body temperatures were recorded after giving rest for 15–20 min in a calm and comfortable setting with room temperature maintained between 25°C and 28°C. For 47 subjects (37 males and 10 females), NCV was recorded in both upper limbs in morning between 8 and 10 am and evening between 4 and 5 pm. Those volunteers who did not turned up for follow-up recordings and in whom NCV could not be recorded in both limbs were excluded from the study. Recruitment of the subjects was done after obtaining detailed history and those falling in the exclusion criteria were not included in the study.

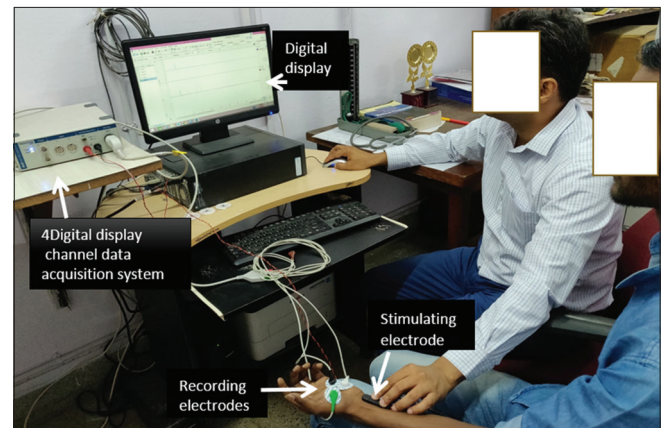
### Exclusion Criteria

The following criteria were excluded from the study:

1. Individuals with neurological disorder or neuromuscular transmission disorder, weakness of the limbs or diagnosed with myopathy or with a history of any neurological illness
2. Individuals suffering from diabetes, hypertension, leprosy, renal disorder, and thyroid disorders
3. Alcoholics and smokers.

NCSs were performed using four-channel data acquisition system "PowerLab 15T" by AD instrument, Australia [Figure 1]. Moreover, the recorded data were analyzed by LabChart 8, software compatible with AD instruments, to calculate duration, latency, and amplitude of compound motor action potential (CMAP). The motor NCSs were performed for ulnar nerve in upper limbs on both sides in morning and evening.

To stimulate ulnar nerve the forearm was rested on arm-chair, arm positioned in a 45° abducted and externally rotated posture with elbow flexed to 90–100° with forearm in neutral position. Nerve was then palpated and the skin over the nerve



**Figure 1:** Nerve conduction studies were performed using four-channel data acquisition system "PowerLab 15T" by AD instrument, Australia

was cleaned with spirit before applying recording electrodes, as mentioned below:

1. Active electrode (A): Placed on the ulnar surface of the hypothenar eminence, halfway between the level of the pisiform bone and the 5<sup>th</sup> metacarpophalangeal joints (MCP)
2. Reference electrode (R): Placed slightly distal to the 5<sup>th</sup> MCP joint
3. Ground electrode (G): The ground electrode was placed on the thenar eminence of the hand, between the stimulating and the recording electrodes
4. Stimulation point 1 (S1): The cathode (c) is placed 3–4 cm proximal to wrist crease in a line measured slightly radial to the tendon of the flexor carpi ulnaris. The anode (a) is proximal
5. Stimulation point 2 (S2): The cathode (c) is placed on ulnar nerve medial to the medial epicondyle, in ulnar groove.

Ulnar nerve was stimulated at both the sites as mentioned above by a mild and brief electrical shock (20 mA for 0.05 ms) given through the stimulating bar electrode. The subjects experienced little tingling sensation as explained before the procedure. The point of nerve stimulus is displayed in one recording channel while the detected response (CMAP) was displayed in another channel record on the monitor of digital data acquisition system which converts the analogue signal to digital beforehand [Figure 2]. A record of 50 ms is captured after switching on the record button. The time of stimulus was set after a delay of 5 ms from the start of record and is displayed on the above trace while CMAP is displayed as a waveform in another channel record as depicted in another trace below that of electrical stimulus in the same figure.

### Statistical Analysis and Calculation

Statistical analysis was performed using Statistical Package for the Social Sciences version 25.0,  $P < 0.05^*$  was considered as statistically significant and R value (Pearson's

correlation coefficient) to show an association. Proximal and distal latencies were measured from recorded CMAP traces. MNCV was calculated by dividing the distance between two points of stimulation by time difference in the latencies for the two points.

$$CV = \frac{D}{L_2 - L_1}$$

Conduction velocity or m/sec, where:

D = Distance between two points of stimulation.

$L_2$  = Proximal latency.

$L_1$  = Distal latency.

## RESULTS

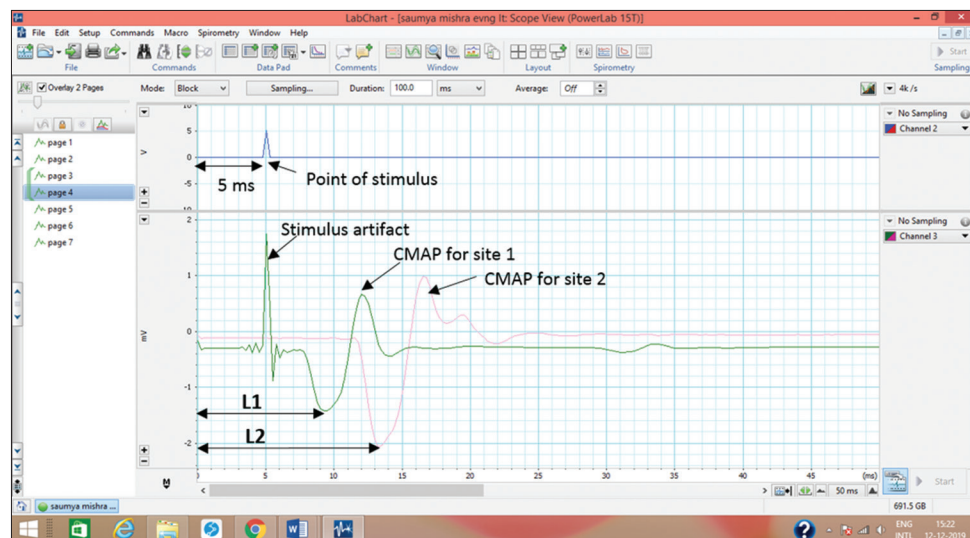
The mean age, height, weight, and BMI of our study group were  $20.68 \pm 1.77$  years,  $168.02 \pm 8.03$  cm,  $59.57 \pm 10.31$  kg, and  $21.11 \pm 3.11$  kg/m<sup>2</sup>, respectively. Details of gender-wise

subdivisions of the same are presented in Table 1. Motor nerve conduction studies for ulnar nerve revealed no statistically significant diurnal variation in both upper limbs and MNCV was also found to be similar in males and females [Figures 3 and 4]. Ulnar nerve MNCV and latencies are summarized in Table 2.

Increasing height of the subjects was associated with decrease in MNCV for ulnar nerve. MNCV for the left limb showed a significant negative correlation with height for morning records ( $P = 0.004$ ) [Figure 5]. MNCV was seen increasing with increasing pulse rate with the exception of morning record for the right limb conduction velocity. The left limb MNCV recorded in evening showed a significant positive correlation with pulse rate ( $P = 0.026$ ) [Figure 6].

## DISCUSSION

Most physiological and biological parameters such as body temperature, blood pressure, respiration, and certain



**Figure 2:** A sample record for NCV calculation with LabChart 8 software

**Table 1:** Anthropometric variables of the volunteers ( $n=47$ )

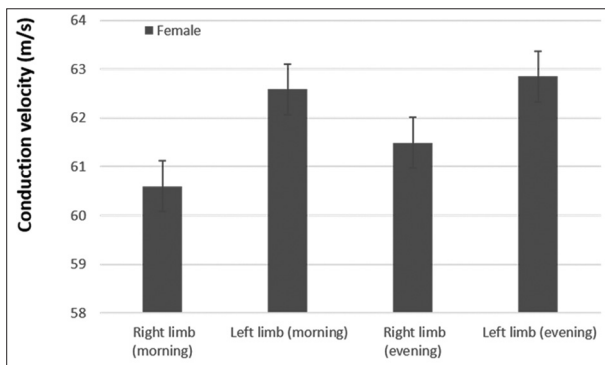
| Subjects           | Age (years) Mean $\pm$ SD | Height (cm) Mean $\pm$ SD | Weight (kg) Mean $\pm$ SD | Body mass index (kg/m <sup>2</sup> ) Mean $\pm$ SD |
|--------------------|---------------------------|---------------------------|---------------------------|----------------------------------------------------|
| Males ( $n=37$ )   | 20.67 $\pm$ 1.70          | 169.69 $\pm$ 7.34         | 60.73 $\pm$ 9.73          | 21.15 $\pm$ 2.73                                   |
| Females ( $n=10$ ) | 20.70 $\pm$ 2.11          | 162 $\pm$ 7.67            | 55.3 $\pm$ 13.05          | 20.99 $\pm$ 4.44                                   |
| Total ( $n=47$ )   | 20.68 $\pm$ 1.77          | 168.02 $\pm$ 8.03         | 59.57 $\pm$ 10.31         | 21.11 $\pm$ 3.11                                   |

SD: Standard deviation

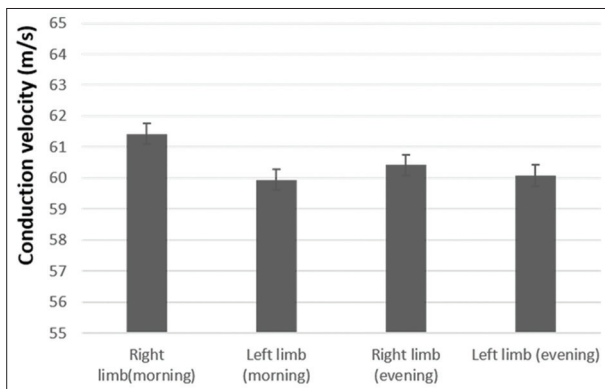
**Table 2:** Motor nerve conduction velocity and latencies for ulnar nerve ( $n=47$ )

| Parameters                           | Morning Mean $\pm$ SD |                  | Evening Mean $\pm$ SD |                  |
|--------------------------------------|-----------------------|------------------|-----------------------|------------------|
|                                      | Right limb            | Left limb        | Right limb            | Left limb        |
| Proximal latency (from S2)           | 6.79 $\pm$ 0.59       | 6.91 $\pm$ 0.62  | 6.85 $\pm$ 0.74       | 6.92 $\pm$ 0.72  |
| Distal latency (from S1)             | 2.43 $\pm$ 0.42       | 2.44 $\pm$ 0.37  | 2.40 $\pm$ 0.48       | 2.49 $\pm$ 0.46  |
| Latency difference (proximal-distal) | 4.36 $\pm$ 0.47       | 4.47 $\pm$ 0.48  | 4.45 $\pm$ 0.55       | 4.43 $\pm$ 0.54  |
| Conduction velocity (ms)             | 61.43 $\pm$ 5.84      | 59.93 $\pm$ 4.91 | 60.42 $\pm$ 5.27      | 60.07 $\pm$ 5.44 |

SD: Standard deviation



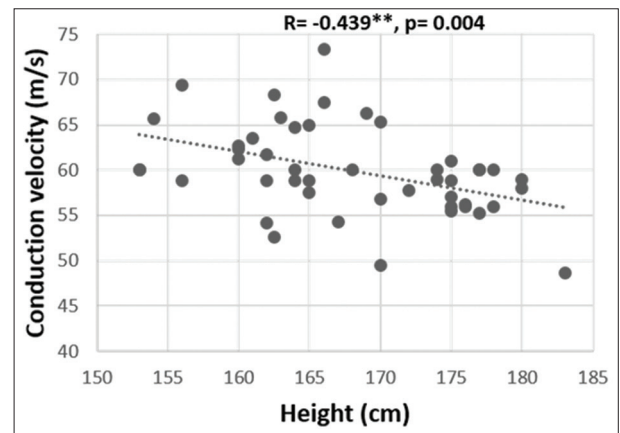
**Figure 3:** Gender-wise comparison of motor nerve conduction velocity



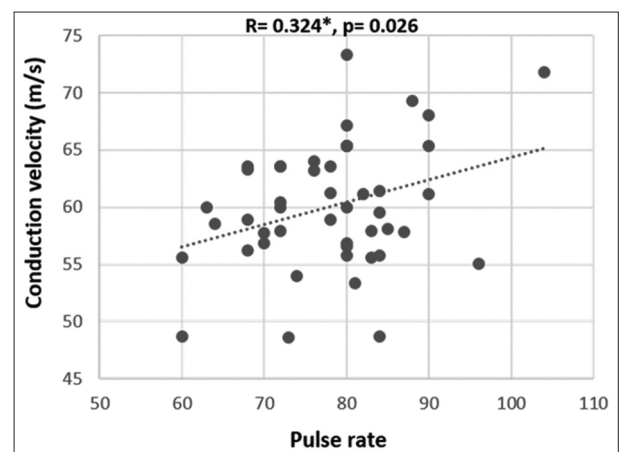
**Figure 4:** Diurnal variation in motor nerve conduction velocity

hormones show fluctuation with circadian rhythm. Literature on the effect of time of the day on nerve conduction parameters is scant and marred by very small sample sizes. Even few reported ones have investigated it on sensory NCVs (SNCVs). This paucity of literature on diurnal variations in MNCV prompted us to investigate the same. We recorded MNCV in ulnar nerves of both upper limbs in morning and evening hours to investigate the effect of time of the day on the same and as described in results, there was no statistically significant diurnal variation in ulnar MNCVs in either of the limbs. In our study group, gender-wise variation in MNCVs was also not different significantly. There was a significant negative correlation of the left limb MNCV with the height of the subjects in morning records while a significant positive correlation of the left limb MNCVs with pulse rate of the subjects in evening hours.

Of the very few and earliest literature on diurnal variation in NCVs, Montagna *et al.* recorded sequential rectal temperature and SNCV every 2 hourly starting from morning 8 am to evening 8 pm and reported SNCV to show diurnal variation along with rectal temperature.<sup>[5]</sup> Although their study group was very small consisting of only 14 subjects, it provided valuable insight and open a dimension for exploration. Our results which are for MNCV do not corroborate findings of Montagna *et al.* as reported for SNCV. Our study supports the finding of Wilson-MacDonald *et al.* who reported no



**Figure 5:** Correlation between height and left limb motor nerve conduction velocity in morning



**Figure 6:** Correlation between pulse rate and left limb motor nerve conduction velocity in evening

statistically significant diurnal variations in MNCVs in median nerve of patients with carpal tunnel syndrome.<sup>[6]</sup> Years later, another group suggested a significant decrease in median motor latencies in morning compared to evening in patients with carpal tunnel syndrome findings contradictory to ours.<sup>[7]</sup> Height of the subjects and limb length have been shown to affect NCV.<sup>[8-10]</sup> Longer nerves generally conduct more slowly than shorter nerves.<sup>[11]</sup> Most of the studies found a significant negative correlation between height and limb length with SNCV. In our studies, MNCV was found to decrease with increasing height of the subjects which are in line with the findings suggested earlier. This negative correlation was highly significant ( $P = 0.004$ ) for the left limb ulnar nerve MNCV when recorded in morning. The reason for decreasing MNCV could be abrupt tapering of axon after certain length.<sup>[12,13]</sup> Although average nerve conduction velocity was found to be higher in female as compared to males, it was not statistically significant. This could be due to shorter stature of females compared to males as discussed above. However, for the same height, conduction velocity is reported to be slower in women than that in men.<sup>[12,14]</sup> Obesity has been suggested to affect NCV

by deterioration of nerve function or subcutaneous fat pad causing hindrance in conduction recordings.<sup>[2,15]</sup> Small increase in BMI tends to increase NCV due to maintained epineural fat which acts as insulator for the nerve and thus maintains the optimum temperature, most important factors affecting nerve conduction parameters.<sup>[16]</sup> Our study group comprised healthy young adult students of age range from 18 to 22 years. None of our subjects was obese and young healthy adults of age range 18 to 22 years usually have less variations in BMI. The mean BMI of our study group was  $21.11 \pm 3.11$ . We did not find any association between MNCV and BMI.

In our study, MNCV was found to be associated with pulse rate. This association was statistically significant for the left ulnar MNCV. This was our unique finding as none of the literature has reported such an association. Higher pulse rate is could be associated with increased metabolic activity which tends to be higher in evening, higher sympathetic, and/or lower parasympathetic stimulation or higher levels of circulating catecholamines.<sup>[17,18]</sup> Core body temperature also rises in evening, this may reflect increased basal metabolic rate. This increased NCV is not attributed to higher body temperature in evening because had that been the case there should have been diurnal variations in NCVs, which we did not found. Measurement of serum levels of catecholamines along with recording autonomic functions could be helpful to understand the mechanisms of such an association.

We did not compare CMAP amplitudes as they are highly variable even when repeated for the same subjects. Slight change in positioning of stimulating electrodes causes large variability in amplitudes of CMAP recorded, thus comparing these could be highly subjective. Our ability to detect associations with time of the day was limited by the fact that we recorded body temperature from axilla with mercury thermometer having lowest count of  $0.5^{\circ}\text{C}$ . Skin temperature was not measured although the room temperature was maintained in narrow range of  $25^{\circ}\text{--}28^{\circ}\text{C}$ . Due to inconvenience caused to subjects in recording anal temperature, core body temperature was not be recorded. We suggest larger sample size along with recording core body temperature to further investigate this association. To investigate the gender-wise variability, our study was restricted by small number of female volunteers (10 females compared to 37 males). We intend to further investigate the association of MNCV with gender by recruiting more female volunteers and increasing total sample size.

## CONCLUSION

The findings of our study suggest that there are no statistically significant diurnal variations in ulnar MNCVs. Height of the subjects has negative correlation with nerve conduction

velocity. Causal association of increased pulse rate with increased NCV, as found in our study, needs to be investigated further.

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