Physiology Section

Original article

Influence of height on the **nerve conduction study parameters** of the **peripheral nerves**

THAKUR D, JHA S, PANDEY NK, JHA CB, BAJAJ BK, PAUDEL BH

ABSTRACT

BACKGROUND: Nerve conduction studies (NCS) which assess peripheral nerve functions and their parameters, are known to vary with anthropometric measurements.

OBJECTIVE: To study the effect of height on the NCS variables in the peripheral nerves of the limbs.

SETTINGS AND DESIGNS: Department of Physiology, normative.

METHODS AND MATERIAL: This study was done on 34 (age: 31.24±11.57 years) consenting, healthy adults of either sex. The anthropometric factors (height, weight and BMI); the compound muscle action potential (CMAP) and the sensory nerve action potential (SNAP) were recorded by using standard techniques.

STATISTICAL ANALYSIS: The correlation of height with the NCS variables was analyzed by using the Pearson's correlation test.

RESULTS: After the adjustment of other anthropometric factors, height (158.5±10.21cm) showed a positive correlation with the CMAP duration of all the motor nerves: right median ($r=0.734$, $p<0.001$), left median ($r=0.422$, $p<0.05$), right ulnar ($r=0.561$, $p<0.01$), left ulnar ($r=0.661$, $p<0.001$), right tibial ($r=0.372$, $p<0.05$) and the left tibial ($r=0.353$, $p<0.05$). The CMAP amplitudes and the latencies were also positively correlated, with the exception of the ulnar and the right radial nerves. A positive correlation with the F- wave latencies were seen in all the nerves, except in the left common peroneal nerve. However, a negative correlation was seen with the SNAP amplitude of the right sural nerve ($r= -0.442$, $p<0.01$) and the conduction velocity of the ulnar motor nerves: right ulnar ($r= -0.536$, $p<0.01$) and left ulnar ($r= -0.430$, $p<0.05$). The SNAP duration and the conduction velocity did not show any correlation with height.

CONCLUSION: Height showed a significant correlation with the NCS parameters of the motor and few sensory nerves. Diagnostic conclusions which are made from the nerve conduction data without making corrections for the height may be invalid in patients who are taller and shorter than the average individuals. This must be also be considered while developing standard/reference normative data for different nerves.

Key Words: Height, Nerve conduction study (NCS), Compound muscle action potential (CMAP), Sensory nerve action potential (SNAP)

INTRODUCTION

Nerve conduction studies (NCS) are performed to diagnose the disorders of the peripheral nervous system [1], [2]. These enable the clinicians to differentiate the two major groups of peripheral diseases: demyelination and axonal degeneration [3]. These also help in localizing the site of the lesions [4], [5]. NCS consist primarily of the assessment of three types of nerves: motor, sensory and mixed. Motor NCS include the assessment of the compound muscle action potential (CMAP), whereas sensory NCS include the assessment of the sensory nerve action potentials (SNAP) of the accessible peripheral nerves in the upper and lower limbs. The median, ulnar, radial, common peroneal, tibial and the sural nerves are the commonly examined nerves. The commonly measured parameters of the CMAP include latency, amplitude, duration, conduction velocity and late response, e.g., F-waves. Similarly, for SNAP, latency, amplitude and conduction velocity are routinely measured [2]. These parameters are known to vary with demographic profile, anthropometric measurements such as height, BMI, etc of the population which is studied and the laboratory conditions of the test1. Many studies have been done previously to evaluate the influence of the anthropometric factors such as age, height and body mass index on the nerve velocities [6], [7], [8]. However, a majority of these studies were based on the western population. Therefore, this study was designed to find the effect of height on the NCS parameters of the peripheral nerves in the upper and lower limbs among our healthy population.

OBJECTIVE

To study the correlation of height with the NCS variables of the peripheral nerves of the upper and lower limbs.

METHODS

This study was done in 34 (age: 31.24±11.57 years) healthy adults of either sex in the Neurophysiology lab of the Department of Physiology, BPKIHS, Nepal. An informed written consent was taken from the volunteers and they were screened for any history of drugs/alcohol intake or medical illness which was likely to affect the nerve conduction study parameters on the basis of clinical history and physical examination, including a detailed neurological assessment. The room temperature of the laboratory was maintained at the thermo neutral zone i.e. 26±2 degree celsius. Further, the subjects were made comfortable with the laboratory set up and conditions and were advised to relax completely during the recording. The CMAP and SNAP were recorded under standard laboratory conditions by using a Nihon Kohden machine (NM-420S; H36, Japan).

The recorded anthropometric and nerve conduction study variables [1], [2]

The Anthropometric factors: age, sex, height, weight, body mass index and body surface were recorded.

The Motor NCS variables: For each stimulation site, CMAP latency, amplitude, duration, conduction velocity and F-waves of the median, ulnar, radial, common peroneal and the tibial nerves were recorded.

The Sensory NCS variables: For each stimulation site, SNAP latency, duration, amplitude, and the conduction velocity of the median, ulnar, radial and the sural nerves were recorded.

The recording procedure

1. The motor nerve conduction study variables [1], [2]

For the motor nerve conduction studies, the stimulator with water soaked felt tips, was placed on the skin overlying the nerve at two or more sites [Table/Fig 1].

Motor nerves	Site of stimulation				Recording site
	Proximal 3	Proximal 2	Proximal 1	Distal	
Median	-	-	Antecubital fossa	Wrist	Abductor pollicis brevis
Ulnar	Axilla	Above elbow	Below elbow	Medial wrist	Abductor digiti minimi
Radial	-	Below spiral groove: lateral midarm	Elbow	Forearm: over the ulna	Extensor indicis proprius
Common peroneal	-	Lateral popliteal fossa	Below fibular head: lateral calf	Anterior ankle	Extensor digitorum brevis
Tibial	-	-	Popliteal fossa	Medial ankle	Abductor hallucis brevis

[Table/Fig 1]: Stimulation and recording sites of motor nerves [1]

The recording and the reference electrode were placed by using a belly tendon montage. The stimulation of the nerve which was being studied was accomplished by using a brief burst of direct electric current. The gain was set at 2-5 mV per division. The stimulation duration was in the range of 50-300 micro seconds and the amount of current never exceeded more then 50 mA because that was its upper limit which was available in the machine. The current of the stimulator was initially set to zero and it was then gradually increased, with successive stimuli. A CMAP appeared, that grew larger with the increasing stimulus strength. The current was increased to a point when the CMAP no longer increased in size and from that point the current was increased by another 20% to ensure the supra-maximal stimulation.

2. The sensory nerve conduction study variables [1], [2]

In the sensory nerve conduction studies, the orthodromic method of stimulation was used to record the SNAP of the median, ulnar, and the radial nerves [Table/Fig 2].

Sensory nerve	Method of stimulation	Stimulation site	Recording site
Median	Orthodromic	Index finger	Middle of the wrist
Ulnar	Orthodromic	Little finger	Medial wrist
Radial	Orthodromic	Thumb	Distal- mid radius
Sural	Antidromic	Posterior-lateral calf	Posterior ankle

[Table/Fig 2]: Stimulation and recording sites of sensory nerves [1]

The gain was set at 10-20 mV per division. A stimulating or recording electrode was placed on a purely sensory portion of the nerve. The ring electrodes were used to stimulate the digital nerve. An electrical pulse of either 100 or 200 micro seconds of duration was used and most of the nerves required a current in the range of 16 to 30 mA to achieve the supra-maximal stimulation. The current was slowly increased from a base line of 0 mA, usually by 3-5 mA at a time, until the recorded sensory nerve potential was maximized.

ETHICAL APPROVAL

This study was approved by the ethical review committee of the B. P. Koirala Institute of Health Sciences, Ghopa Camp, Dharan.

STATISTICAL ANALYSIS

The data which were collected were first entered into a Microsoft Excel sheet and were then statistically analyzed by using the SPSS 10.0 version. A Pearson's correlation test was applied to find the correlation of height with the NCS variables, while adjusting for other parameters. A significant difference was considered at p values which were less than 0.05 and it was indicated at appropriate places, if it was present in any of the parameters.

RESULTS

1. The Anthropometric variables [Table/Fig 3]:

	Age (yrs)	Ht (cm)	Wt (Kg)	BMI (Kg/m2)	BSA (m2)
Mean	31.24	158.5	57.09	21.8	555.6
SD	11.57	10.21	8.002	2.11	53.1

[Table/Fig 3]: Physical/anthropometric variables of subjects (n= 34)

Abbreviations

Ht: Height BMI: Body mass index

Wt: Weight BSA: Body surface area

The average age, height and BMI were 31.24± 11.57 (yrs), 158.5± 10.21 (cm) and 21.8± 2.11 (Kg/m2) respectively.

2. The Motor NCS variables [Table/Fig 4]:

Motor nerves	Anthropometric variables	CMAP				F-wave Latency
		Duration	Amplitude	Latency	CV*	
Rt. median	Height	r=0.734, p<0.001	r=0.545, p<0.01	r=0.484, p<0.01	NS†	r=0.523, p<0.01
Lt. median	Height	r=0.422, p<0.05	r=0.389, p<0.05	r=0.536, p<0.01	NS†	r=0.506, p<0.01
Rt. ulnar	Height	r=0.561, p<0.01	NS†	r=0.431, p<0.05	r= -0.536, p<0.01	r=0.506, p<0.05
Lt. ulnar	Height	r=0.661, p<0.001	NS†	r=0.718, p<0.001	r= -0.430, p<0.05	r=0.663, p<0.001
Rt. radial	Height	r=0.521, p<0.01	r=0.386, p<0.05	NS†	NS†	NA‡
Lt. radial	Height	r=0.383, p<0.05	NS†	r=0.570, p<0.001	NS†	NA‡
Rt. tibial	Height	r=0.372, p<0.05	r=0.393, p<0.05	r=0.382, p<0.05	NS†	r=0.560, p<0.05
Lt. tibial	Height	r=0.353, p<0.05	r=0.349, p<0.05	r=0.658, p<0.01	NS†	r=0.393, p<0.01
Rt. cp§	Height	r=0.593, p<0.01	r=0.345, p<0.05	r=0.676, p<0.01	NS†	r=0.487, p<0.01
Lt. cp§	Height	r=0.489, p<0.01	r=0.366, p<0.05	r=0.702, p<0.01	NS†	NS†

[Table/Fig 4]: Correlation of height with motor nerve conduction study variables

* Conduction velocity
† Not significant
‡ Not applicable

§ Common peroneal

Height showed a significant positive correlation with the CMAP duration of all the motor nerves: right median (r=0.734, p<0.001), left median (r=0.422, p<0.05), right ulnar (r=0.561, p<0.01), left ulnar (r=0.661, p<0.001), right tibial (r=0.372, p<0.05) and left tibial (r=0.353, p<0.05). The CMAP amplitudes and the latencies of the motor nerves were also positively correlated, with the exception of the ulnar and the right radial nerves. A positive correlation with the F- wave latencies were seen in all the nerves, except in the left common peroneal nerve. However, a negative correlation was seen with the CMAP conduction velocity of the ulnar motor nerves: the right ulnar (r= -0.536, p<0.01) and the left ulnar (r= -0.430, p<0.05).

3. The Sensory NCS variables [Table/Fig 5]:

Sensory nerves	Anthropometric Variables	SNAP			
		Duration	Amplitude	Latency	CV*
Rt. radial	Height	NS†	NS†	r=0.367, p<0.05	NS†
Rt. sural	Height	NS†	r= -0.442, p<0.01	r=0.449, p<0.01	NS†

[Table/Fig 5]: Correlation of height with sensory nerve conduction study variables

* Conduction velocity
† Not significant

The SNAP amplitudes of the right sural (r= -0.442, p<0.01) nerve showed a negative correlation with height. Also, the SNAP latencies of the right radial and the sural nerves were positively correlated with height. But, the SNAP duration and the conduction velocity did not show any correlation with height.

DISCUSSION

This study aimed to investigate the effect of height on the NCS variables in the healthy adults of our population. We found a positive correlation between height and the CMAP amplitudes in most of the motor nerves, except in the bilateral ulnar and the left radial nerves. However, a negative correlation was seen with the SNAP amplitudes of the right sural sensory nerve, which was similar to that which was seen in a previous report [7]. A negative correlation between the distal fiber diameter and height may best explain the decreased SNAP amplitude of the sural nerve. Hennessey WJ et al and Kokotis P et al also reported height to be negatively associated with the sensory amplitude [9], [21]. Contrary to the reports of our study, Stetson DS found height to be negatively associated with the sensory amplitudes of the median and the ulnar nerves [7].

Height showed a positive correlation with the CMAP duration in all of the motor nerves, but it did not show any correlation with the SNAP duration of the sensory nerves. It showed a positive correlation with the CMAP latencies of most of the motor nerves, except the right radial nerve. The SNAP latencies of the right radial and the sural sensory nerves showed a positive correlation with height. Hennessey WJ et al and Stetson DS et al reported height to be positively associated with the sensory latencies [7], [9]. As in our study, S. Saeed et al in their study, found an increase in the latency of the sural sensory nerve with increasing height [10].

Rivner MH et al found that height was positively correlated with the latencies of the sural, peroneal, tibial, and the median nerves which were studied, which was similar to that which was found in our study [11]. It showed a negative correlation with the conduction velocities of the bilateral ulnar motor and the left median sensory nerves. Takano K et al and Gutjahr L et al supported the possibility of an inverse correlation of the conduction velocity of the ulnar nerve with height [12], [17]. But, Wagman IH et al, Soudman R et al, Hyllienmark L, and Kato M et al did not find any correlation between height and the conduction velocity of the ulnar nerve [18-20], [22]. Conversely, no correlation was seen with the lower limb nerves, which was contradictory to the previous reports of a negative correlation with them [11], [19], [28-30]. This may be due to the small sample size of our study. However, Awang MS et al's findings showed an absence of correlation in the median and the sural nerves, which was similar to that which was found in our study [31]. Rivner MH et al and Soudman R et al also found that the median conduction velocity was not correlated with height [11], [19].

Our results showed a substantial positive correlation between height and the F-wave latencies of all the motor nerves, except the left common peroneal nerves [23-27]. Logically, taller subjects have a longer conduction time of late response, because of a longer conduction distance. Peioglou HS et al and Lin KP et al found a strong correlation between the F latencies and height [13], [14]. Likewise, in the study which was done by Puksa L et al and Toyokura M et al, the minimal latency of the F-wave study was found to increase with height in studies on the upper and lower limbs [15], [16]. In summary, this study shows that anthropometric factors such as height influence the nerve conduction study parameters of both the motor and the sensory nerves. Diagnostic conclusions which are made from the nerve conduction data without making corrections for height may be invalid in patients who are taller and shorter than average individuals. This study has many similarities and some dissimilarities with the earlier reported NCS variables. The probable reasons could be the true difference among the populations and the small sample size. A study with a larger sample size will certainly add more strength. Nevertheless, this study may be used as a preliminary working reference while reporting the clinical NCS findings and for further research in this field. In this way, this study has a place of significance.

CONCLUSION

Height showed a significant correlation with the nerve conduction parameters of most of the motor nerves and a few sensory nerves. Diagnostic conclusions which were made from the nerve conduction data without making corrections for height may be invalid in patients who are taller and shorter than average individuals. This must be also considered while developing standard/reference normative data for different nerves.

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