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RESEARCH ARTICLE

Impact of height on sensory nerve conduction

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ABSTRACT

Background: Change in height of the limb not only increases the length of nerve but also causes gradual tapering of nerve with decrease in fiber diameter and myelination. **Aim and Objectives:** To study the correlation of height with the nerve conduction study (NCS) variables, i. e., latency, duration, amplitude, and conduction velocity of sensory nerve action potential (SNAP) of the sensory nerves of the upper and lower limbs. **Materials and Methods:** This is cross-sectional study including 37 participants. After taking consent their age, sex, height, weight, and body mass index were noted. NCS test was carried out for median, ulnar, and sural sensory nerves. Pearson's correlation coefficient was calculated. $P < 0.05$ (*) means difference is statistically significant while $P < 0.01$ (**) is highly significant difference. **Results:** Height showed a significant positive correlation with the SNAP latencies of all the sensory nerves: Median sensory ($r = 0.704$, $P < 0.01$), ulnar sensory ($r = 0.350$, $P < 0.05$), and sural ($r = 0.392$, $P < 0.05$). The SNAP duration and amplitude of ulnar and median sensory nerve were negatively correlated with height while that of sural sensory nerve showed insignificant positive correlation with height. However, a significant negative correlation was seen with the SNAP conduction velocity of median sensory ($r = -0.740$, $P < 0.01$) and sural sensory ($r = -0.701$, $P < 0.01$) nerve. For ulnar sensory nerve, correlation of height and conduction velocity ($r = -0.220$) was negative but not statistically significant. Overall, height had an inverse correlation with conduction velocity and positive correlation with latency of SNAP. **Conclusion:** Clinical recognition of this height effect is important as one should not label an individual with mild increase/decrease in peripheral nerve conduction velocity as abnormal which may be solely related to height.

KEY WORDS: Sensory Nerve Conduction Velocity; Median Sensory Nerve; Ulnar Sensory Nerve; Sural Sensory Nerve; Height

INTRODUCTION

Nerve conduction studies (NCS) and needle electromyography (EMG) are commonly performed by physical medicine and rehabilitation or neurology specialists to assess the ability of the nervous system to conduct electrical impulses and to evaluate nerve/muscle function to determine if neuromuscular disease is present. Sensory NCS involve analysis of specific parameters, including latency, conduction velocity, and amplitude. Onset latency is the time it takes for the stimulus to initiate an evoked potential and reflects the conduction along the fastest fibers. The conduction velocity along the nerve also depends on the state of myelination and is often decreased in disorders or trauma that affects nerve myelination, although it may be normal if a few myelinated axons remain intact. Reduction of amplitudes of recorded responses generally indicates a loss of axon.[1,2] Nerve conduction velocity (NCV) is affected by many physiological and technical variables. Physiological variables such as age,

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height, gender, upper limb versus lower limb, temperature affect conduction velocity. Diameter and myelination of the nerve fibers also affect NCV.[2]

Studies which have done to analyze the effect of height on NCS parameters have shown a significant positive correlation of height with distal latency and significant negative correlation of height with conduction velocity.[3-13] They hypothesized that the height influence reflects abrupt rather than gradual tapering of axons distally. In mature rabbit nerves, Williams found that peripheral motor axon diameter was about half that of ventral spinal nerve root fibers and, despite an increase in myelin sheath thickness, there was an overall decrease in total fiber diameter.[14] This mode of tapering may help explain the decrements in conduction velocity from proximal to distal nerve segments and from the upper to lower extremities, which have long been observed in clinical EMG. This study was designed to find the effect of height on the NCS parameters of the sensory nerves in the upper and lower limbs among our healthy Indian population.

Objective

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

MATERIALS AND METHODS

This is a cross-sectional study done in 37 (age: 28.66 ± 5.19 years) healthy adults of either sex in the Neurophysiology laboratory of the Department of Physiology, SVNGMC, Yavatmal. Approval was taken from Institutional Ethics Committee to conduct this study. An informed written consent was taken from the volunteers, and they were screened for any history of thyroid disorders, diabetes, liver diseases, drugs/alcohol intake, or medical illness which was likely to affect the NCS parameters. The anthropometric factors: age, sex, height, and weight were recorded. Body mass index (BMI) was calculated by weight (kg) divided by square of the height in meters. The room temperature of the laboratory was maintained at the thermoneutral zone, i. e., 26 ± 2°C with the help of air conditioner. The sensory nerve action potential (SNAP) of sensory median, ulnar, and sural neves were recorded under standard laboratory conditions using an RMS EMG EP Mark 2 machine (Model: Aleron 201 with 2 channels, Make: Recorders and Medicare system, Delhi).

Sensory Conduction Studies

SNAP is obtained by electrically stimulating sensory fibers and recording the nerve action potential at a point further along that nerve. Once again, the stimulus must be supramaximal. Recording the SNAP orthodromically refers to distal nerve stimulation and recording more proximally (the direction, in which physiological sensory conduction occurs) antidromic testing is the reverse (Figure 1).

Statistical Analysis

The data collected was first entered into a Microsoft Excel sheet and was then statistically analyzed using the SPSS 16.0 version. A Pearson's correlation test was applied to find the correlation of height with the NCS variables. A significant difference was considered at $P < 0.05$.

RESULTS

As shown in Table 1, the average age, height, weight, and BMI of study population were 28.66 ± 5.19 (years), 156.02 ± 21.49 (cm), 45.53 ± 15.59 (kg), and 18.77 ± 2.94 (kg/m^2), respectively. Table 2 shows the correlation of height with NCS variables of sensory nerves of the upper and lower limb. Height showed a significant positive correlation with the SNAP latencies of all the sensory nerves: Median sensory ($r = 0.704$, $P < 0.01$), ulnar sensory ($r = 0.350$, $P < 0.05$), and sural ($r = 0.392$, $P < 0.05$). The SNAP duration was negatively correlated with height which was significant for ulnar sensory ($r = -0.441$, $P < 0.01$) and insignificant for median sensory nerve ($r = -0.339$). The SNAP amplitude also showed significant negative correlation with height in median sensory ($r = -0.372$, $P < 0.05$) and ulnar sensory ($r = -0.416$, $P < 0.01$) nerves. The SNAP duration ($r = 0.119$) and amplitude ($r = 0.030$) of sural sensory nerve showed insignificant

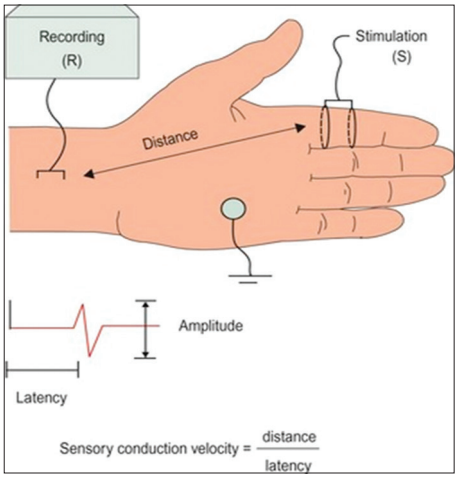

Figure 1: Orthodromic type of median sensory nerve conduction study

Table 1: The anthropometric variables of study sample

Parameters	*n*	Mean±SD
Age	37	28.66±5.19
Height	37	156.02±21.49
Weight	37	45.53±15.59
BMI	37	18.77±2.94

SD: Standard deviation, BMI: Body mass index

positive correlation with height. However, a significant negative correlation was seen with the SNAP conduction velocity of median sensory ($r = -0.740$, $P < 0.01$) and sural sensory ($r = -0.701$, $P < 0.01$) nerve. For ulnar sensory nerve, correlation of height and conduction velocity ($r = -0.220$) was negative but not statistically significant. Overall, height had an inverse correlation only with SNAP conduction velocity while it showed positive correlation with latency of SNAP. Same inverse correlation of height with SNAP conduction velocity of median, ulnar, and sural sensory nerves is represented in the form of scatter diagram labeled as Figures 2-4, respectively.

DISCUSSION

This study aimed to investigate the effect of height on the NCS variables in the healthy adults of our population. We found a significant negative correlation between height and the SNAP amplitudes of median ($P < 0.05$) and ulnar ($P < 0.01$) sensory nerves, except the sural nerve, showed insignificant positive correlation. This was contrary to that which was seen in a previous report.[4,5] A negative correlation between the distal fiber diameter and height may best explain the decreased SNAP amplitude of these nerves. Hennessey et al. and Kokotis et al. also reported height to be negatively associated with the sensory amplitude.[6,7] Height showed negative correlation with the SNAP duration of the median and ulnar ($P < 0.01$) sensory nerves.

The SNAP latencies of the median, ulnar as well as sural sensory nerves showed a statistically significant ($P < 0.05$) positive correlation with height. Logically, taller subjects have longer latencies, because of a longer conduction distance. Stetson et al. and Hennessey et al. reported height to be positively associated with the sensory latencies.[4,6] Rivner

Table 2: Sensory NCS variables

Sensory nerve	NCS variable	Mean±SD	Correlation with height	
			r value	*P* value
Median (S)	Latency (ms)	2.64±0.93	0.704**	0.01
	Duration (ms)	2.16±0.94	−0.339	NS
	Amplitude (mv)	63.14±29.23	−0.372*	0.05
	Conduction velocity (m/s)	49.15±8.11	−0.740**	0.01
Ulnar (S)	Latency (ms)	2.43±0.81	0.350*	0.05
	Duration (ms)	1.82±1.53	−0.441**	0.01
	Amplitude (mv)	41.92±21.63	−0.416**	0.01
	Conduction velocity (m/s)	46.67±10.62	−0.220	NS
Sural (S)	Latency (ms)	3.21±0.79	0.392*	0.05
	Duration (ms)	1.61±0.53	0.119	NS
	Amplitude (mv)	22.92±21.37	0.030	NS
	Conduction velocity (m/s)	46.76±3.18	−0.762**	0.01

r: Karl Pearson's correlation co-efficient, *Correlation is significant at the 0.05 level (2-tailed), **Correlation is significant at the 0.01 level (2-tailed), NCS: Nerve conduction study, SD: Standard deviation

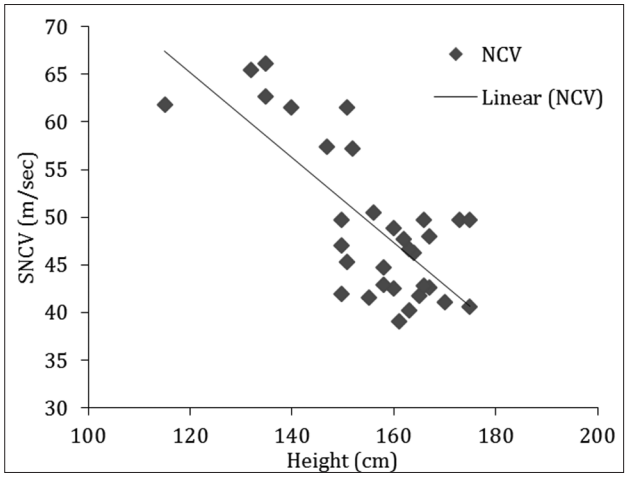

Figure 2: Correlation of height with nerve conduction velocity of median sensory nerve

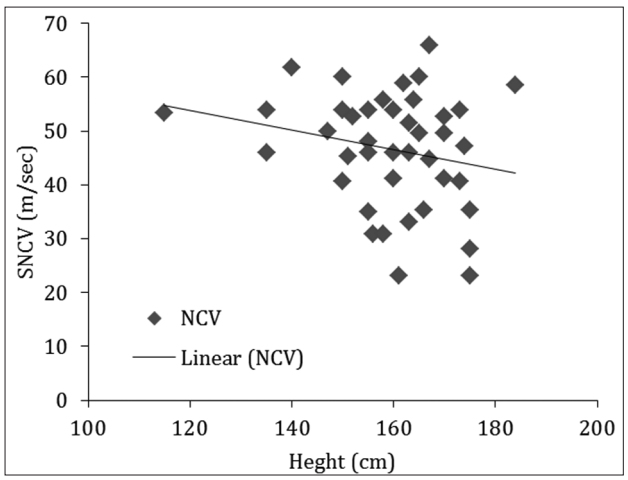

Figure 3: Correlation of height with nerve conduction velocity of ulnar sensory nerve

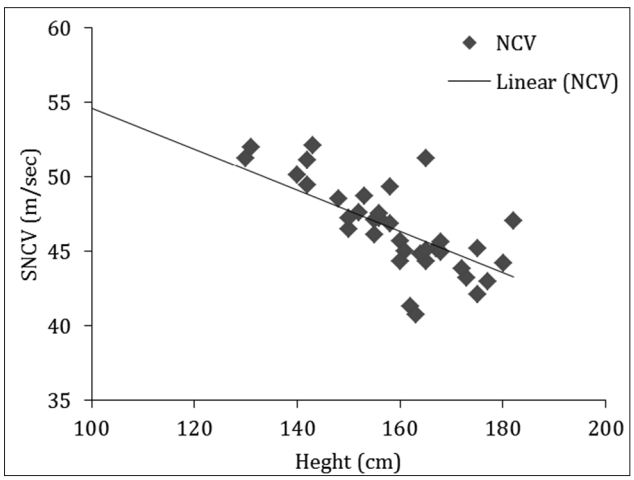

Figure 4: Correlation of height with nerve conduction velocity of sural sensory nerve

et al. found that height was positively correlated with the latencies of the sural and the median sensory nerves which were studied, which was similar to that which was found in our study.[8]

It showed a statistically significant ($P < 0.01$) negative correlation with the conduction velocities of all sensory nerves except ulnar sensory nerves. Takano et al. supported the possibility of an inverse correlation of the conduction velocity of the ulnar nerve with height.[9] Awang et al. findings showed an absence of correlation in the sural nerve, which was contrary to that which was found in our study.[10] Rivner et al. and Soudmand et al. also found that the median conduction velocity was not correlated with height.[11,12] Campbell et al found that sural conduction velocities varied inversely with body height ($P < 0.001$). They hypothesized that the height influence reflects abrupt rather than gradual tapering of axons distally.[13] In mature rabbit nerves, Williams found that peripheral motor axon diameter was about half that of ventral spinal nerve root fibers and, despite an increase in myelin sheath thickness, there was an overall decrease in total fiber diameter.[14] This mode of tapering may help explain the decrements in conduction velocity from proximal to distal nerve segments and from upper to lower extremities, which have long been observed in clinical EMG.[13] Robinson et al. also have hypothesized in their study that most gender differences in NCV can be largely explained by height, whereas amplitude differences persist despite correction for height, temperature, and age.[15]

CONCLUSION

In summary, this study shows that anthropometric factors such as height influence the NCS parameters of 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 dissimilarity with the earlier reported NCS variables. The probable reasons could be the true difference among the populations, or it may be the procedural lacunae in specifications.[16]

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