Introduction

Electrodiagnostic evaluation refers to physiological expansion of the neurological assessment. Clinical electrodiagnostic evaluation constitutes the recording, display, and estimation of action potentials originating from central nervous system (evoked potentials), peripheral nerves (nerve conduction assessments), and muscles (electromyography). Nerve conduction studies (NCSs) are part of electrodiagnostic procedures, which helps in diagnosing abnormalities of nerves. NCSs provide a means of confirming the presence and extent of peripheral nerve damage. These studies can diagnostically aid in patients alleged of experiencing nearly any disorder of peripheral nervous system, comprising disorders of nerve roots, peripheral nerves, and muscle neuromuscular junctions.

Nerve conduction studies (NCSs) include motor conduction studies, sensory conduction studies, and late response studies. Motor conduction studies are a part of electrodiagnostic procedures, which helps in diagnosing abnormalities of nerves. NCSs are conducted prospectively in 250 carefully screened subjects of age group 15–50 years. The study group included equal proportion of male and female subjects. Motor amplitude, distal latency, and motor conduction velocity of median and ulnar nerves were performed. All statistical analyses were done with SPSS software, version 16.

Abstract

Background: Nerve conduction study is a part of electrodiagnostic procedures, which is helpful in diagnosis and prognosis of diseases and in finding out the extent and distribution of peripheral nerve injury. The values of nerve conduction studies may vary between different populations owing to ethnic and environmental factors. So, each electrophysiology laboratory need to establish a normative data for its population. Nerve conduction velocity may be affected by many factors such as temperature, height, age, and gender.

Aims and Objective: To establish normative data for upper limb motor nerve conduction in northern Kerala population and to find out the effect of height on motor nerve conduction velocity.

Materials and Methods: Motor conduction studies were conducted prospectively in 250 carefully screened subjects of age group 15–50 years. The study group included equal proportion of male and female subjects. Motor amplitude, distal latency, and motor conduction velocity of median and ulnar nerves were performed. All statistical analyses were done with SPSS software, version 16.

Result: Motor conduction velocities of all tested nerves in both genders were found to be negatively correlated with height. The correlations obtained were statistically significant.

Conclusion: Normative data for upper limb motor conduction was derived in northern Kerala population. Motor nerve conduction velocities of median and ulnar nerves showed a negative correlation with height.

Key Words: Height; Nerve Conduction Study (NCS); Motor Conduction Study; Motor Conduction Velocity; Compound Muscle Action Potential (CMAP)
Effect of height on upper limb motor nerve conduction velocity

Naseem et al.

Materials and Methods

This study was done to derive a normative data for upper limb motor nerve conduction in northern Kerala population. It was a cross-sectional observational study done in normal individuals of northern Kerala population. The study was done after obtaining approval from the institutional ethics committee. The study was conducted in 250 normal adults (125 male and 125 female subjects) of age 15 to 50 years from north Kerala. The study lasted for 1 year. Study group included carefully screened normal volunteers from north Kerala region. This included some randomly selected bystanders and hospital staffs. Detailed history was taken, and clinical examination was done before being selected as a subject to rule out any systemic or neuromuscular diseases. Height was measured and noted.

Inclusion Criteria: Normal adults of age 15 to 50 years from north Kerala region were included in this study.

Exclusion Criteria: Individuals with systemic or neuromuscular diseases were excluded from the study. Individuals not belonging to northern Kerala region were also not included this study.

Subjects were acclimatized to standard room temperature (27°C ± 2°C) for 10 min. A RMS EMG EP Mark-II machine was used in the electrophysiology laboratory. Filters were set at 2–5 kHz with a sweep speed of 5 ms per division, for duration of 100 μs. Median and ulnar nerves were tested.

Three surface electrodes were used for recording—active electrode, reference electrode, and ground electrode. The active electrode was placed over the muscle belly. The reference electrode was placed on a nearby tendon or bone away from the muscle. The ground electrode was placed between the stimulator and the active electrode. Grounding is important for obtaining a response that is free of too much artefact. Stimulator consists of two metal pad electrodes placed 1.5 to 3 cm apart. When stimulating, the cathode (black or negative pole) is placed toward the direction in which the nerve is to be stimulated. The conduction was used to ensure electrical contact. All measurements made with supramaximal stimulation.

In median nerve motor conduction study, active electrode was placed on the centre of abductor pollicis brevis. Reference electrode was placed at proximal phalanx of thumb 3–4 cm distal to active electrode. Distal stimulation was given 3 cm proximal to distal wrist crease between tendons of flexor carpi radialis and palmaris longus. Proximal stimulation point was at elbow just lateral to the brachial pulsation.

In ulnar nerve motor conduction study, active electrode was placed on the centre of abductor digitii minimi. Reference electrode was placed distally over fifth digit. Distal stimulation was given 3 cm proximal to distal wrist crease just medial to the flexor carpi ulnaris tendon. Proximal stimulation point was at elbow 3–4 cm distal to the medial epicondyle, with the wrist and the elbow in 90° of flexion.

Motor amplitude, distal latency, and motor conduction velocity were the parameters tested.

Motor Latency: The time taken by electrical impulse to travel from site of stimulation to recording site was measured. This is called latency. Proximal latency is the time interval between proximal stimulation and first deflection from baseline. Similarly, distal latency (DL) is the time interval between distal stimulation and first deflection from baseline. DL was measured in this study. Unit of DL is milliseconds (ms).

Motor Amplitude: The height of the CMAP obtained during nerve conduction studies, which is measured from baseline to
peak, is called motor amplitude. Unit of motor amplitude is millivolts (mV).\[3\]

**Motor Conduction Velocity:** By stimulating two or more different locations along the same nerve, nerve conduction velocity was calculated. This was done by dividing the length of the nerve segment between two stimulation points by the difference between proximal and distal latencies. Unit of nerve conduction velocity is meter per second (m/s).\[8\]

All statistical analysis was done with SPSS, version 16. Normal values of motor amplitude, DL, and motor conduction velocity of median and ulnar nerves were found. The correlation of motor conduction velocities with height was studied separately in the two gender groups in each side. Pearson correlation coefficients (r) were calculated. The value of the correlation coefficient varies from -1 to +1. A value near -1 indicates a strong negative correlation, and a value near +1 indicates a strong positive correlation. All correlations were considered to be significant if p value was less than or equal to 0.05.

Correlation of Height With Motor Conduction Velocity:

Average height of male subjects in this study was 170.48 cm with standard deviation of 6.74 cm. Average height of female subjects in this study was 162.3 cm with a standard deviation of 5.93 cm. Pearson correlation coefficient was derived (Table 3). Motor conduction velocities of all tested nerves in both genders were found to be negatively correlated with height. The correlations obtained were statistically significant.

### Table 1: Normative data of upper limb motor conduction in northern Kerala population

<table>
<thead>
<tr>
<th>Nerves</th>
<th>Amplitude (mV), mean ± SD</th>
<th>Distal latency (ms), mean ± SD</th>
<th>Velocity (m/s), mean ± SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Median</td>
<td>9.66 ± 2.32</td>
<td>3.15 ± 0.18</td>
<td>57.0 ± 1.97</td>
</tr>
<tr>
<td>Ulnar</td>
<td>8.06 ± 0.96</td>
<td>2.58 ± 0.14</td>
<td>58.29 ± 1.68</td>
</tr>
</tbody>
</table>

### Table 2: Comparison of this study with other published studies

<table>
<thead>
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</thead>
<tbody>
<tr>
<td>Median</td>
<td>Amplitude (mV)</td>
<td>9.5 ± 2.9</td>
<td>7.0 ± 3.0</td>
<td>9.2 ± 3.1</td>
<td>8.10 ± 2.62</td>
<td>9.66 ± 2.32</td>
</tr>
<tr>
<td></td>
<td>Distal latency (ms)</td>
<td>3.6 ± 0.4</td>
<td>3.49 ± 0.34</td>
<td>3.5 ± 0.5</td>
<td>3.77 ± 0.40</td>
<td>3.15 ± 0.18</td>
</tr>
<tr>
<td></td>
<td>Velocity (m/s)</td>
<td>54.4 ± 3.8</td>
<td>57.7 ± 4.9</td>
<td>54.4 ± 5.4</td>
<td>58.2± 3.76</td>
<td>57.0 ± 1.97</td>
</tr>
<tr>
<td>Ulnar</td>
<td>Amplitude (mV)</td>
<td>8.4 ± 2.1</td>
<td>5.7 ± 2.0</td>
<td>9.9 ± 1.8</td>
<td>8.51 ± 2.03</td>
<td>8.06 ± 2.90</td>
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<tr>
<td></td>
<td>Distal latency (ms)</td>
<td>2.9 ± 0.42</td>
<td>2.59 ± 0.39</td>
<td>2.7 ± 0.3</td>
<td>2.59 ± 0.04</td>
<td>2.58 ± 0.14</td>
</tr>
<tr>
<td></td>
<td>Velocity (m/s)</td>
<td>56.3 ± 6.2</td>
<td>58.7 ± 5.1</td>
<td>61.6 ± 4.1</td>
<td>61.45 ± 5.73</td>
<td>58.29 ± 1.68</td>
</tr>
</tbody>
</table>

### Table 3: The correlation of height with motor conduction velocity

<table>
<thead>
<tr>
<th>Nerves</th>
<th>Male subjects</th>
<th>Female subjects</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>r</td>
<td>p</td>
</tr>
<tr>
<td>Right median</td>
<td>-0.630</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td>Left median</td>
<td>-0.629</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td>Right ulnar</td>
<td>-0.706</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td>Left ulnar</td>
<td>-0.691</td>
<td>&lt;0.001*</td>
</tr>
</tbody>
</table>
Normative data of motor conduction parameters was derived in northern Kerala population. The values obtained were compared with nerve conduction parameters derived in different populations. The results of this study showed many similarities and some dissimilarity with the reported motor conduction variables; the probable reasons could be the true differences among populations and small sample size. The difference among different populations may be owing to technical factors such as difference in room temperature and physiological factors such as difference in average height and age of the population studied. This emphasises the necessity of normative electrophysiological data for every laboratory.

References from literature show that age affects electrophysiological studies only in extremes of age. The effect of age is most significant from birth to 1 year when myelination is incomplete. In the newborn, nerve conduction velocities are approximately 50% of adult values. By 1 year of age, the velocities reach 75%, and by 3–5 years, myelination is complete and nerve conduction velocities are comparable with adult normative data.[1] Nerve conduction velocity decreases with age owing to decreased number of nerve fiber, a reduction in fiber diameter, and changes in the fiber membrane.[2] But, the values normally change by less than 10 m/s by the sixth year or even the eighth year.[3] The amplitude of the sensory nerve action potential (SNAP) and CMAP may also be affected by age. The reduced amplitude is best related to loss of axons.[4] It is estimated that the SNAP amplitude may decrease by as much as 50% in a 70-year-old patient.[5] Motor CMAP amplitudes decline with aging, although this decrease is much less marked than that seen with SNAP.[6] So, considering the age group selected in this study, age did not exhibit much effect.

Motor conduction velocities of tested nerves were found to be negatively correlated with height, which means that nerve conduction is slower in taller individuals. Many studies in the literature support the observations obtained in the current study. The study done by Campbell et al.[7] showed that peroneal and sural conduction velocities varied inversely with height. The study conducted by Bodofsky et al.[8] showed that ulnar motor conduction velocity appears to be inversely proportional to the square root of height. The studies done by Thakur et al.[9] showed motor conduction velocity of ulnar nerve is negatively correlated with height. The study of Patel et al.[10] pointed out a negative correlation between upper limb motor conduction velocity and height.[11]

The nerve impulse propagates faster in the proximal than in the distal nerve segment. Nerve conduction is faster in upper limb nerves compared with lower limb nerves. It suggests that shorter nerves conduct faster than longer nerves. The reason for this physiological difference may be abrupt distal tapering of axons, shorter internodal distance, and progressive reduction in axonal diameter.[12] This mode of tapering may help in explaining the decrements in conduction velocity from proximal to distal nerve segments and from upper to lower extremities, which have been observed in clinical electromyography long back. Clinical recognition of this height effect is important, or else, one would label an individual as abnormal with mildly slowed peripheral nerve conduction velocity solely related to large stature.

Over the years, electrophysiological methods have provided chief contributions to the knowledge of peripheral nerve function in health and disease states. Although there are certain constraints, these procedures can provide diagnostically relevant data if used sensibly in suitable clinical contexts. The reference values obtained in this study can be used to diagnose nerve conduction abnormalities of this population.

Limitations of the study: As age is an important factor, which affects motor nerve conduction parameters, it would have been better to report the nerve conduction parameters in different age groups. Even though a negative correlation was established between height and nerve conduction velocity, an age-adjusted reference data was not created in this study. If sample size was more, a more representative data would have been obtained.

References


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