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Effect of Skin Temperature on Nerve Conduction Velocity and Reliability of Temperature Correction Formula in Indian Females

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Abstract

This was an experimental and co relational study done to determine the change in MNCV with variation in skin temperature. It also assessed the reliability of nerve conduction formula in Indian setup. Forty five females between 18-25 years were included in the study. The forearm skin temperatures were varied from 27^0C to 37^0C using hot packs and cold packs and median nerve MNCV was recorded at an interval of 2^0C. The recorded MNCVs were substituted in the temperature correction formula and each of the obtained corrected MNCV was compared with the MNCV recorded at standard temperature of 33^0C. Conclusion: there was a significant variation in MNCV with variation in skin temperature but the temperature correction formula was found to be reliable.

Keywords: MNCV, Temperature Correction Formula, Skin Temperature

Introduction

Nerve conduction studies are being increasingly used in diagnosis and prognosis of various neurological diseases since years. Nerve conduction studies assess the peripheral motor and sensory functions by recording the evoked response to stimulation of peripheral nerves. They have an important role in evaluation of peripheral and entrapment neuropathies by confirming the clinical suspicion of neuropathy. Identifying the predominant pathophysiology such as conduction block, axonal demyelination, and temporal course of the disease i.e. acute, subacute or chronic, the nerve conduction studies provide an objective and qualitative measure of nerve function and also help in predicting the prognosis of neuropathy. With steady improvement of recording apparatus, nerve conduction studies have become a simple and reliable test of peripheral nerve function. *(Aminoff, 1999)*

Another major reason for the increasing value of nerve conduction studies has been the improved quantification of both motor and sensory potentials. Quantification allows precise statements about the severity of the disease process, comparison of findings in patient over time as the disease evolves, and comparison of results obtained by different physicians. Importantly, quantification has demonstrated changes that were not recognized on subjective analysis *(Halar et al, 1981)*

The validity of the calculated nerve conduction velocity depends primarily on the accuracy in determining the latencies and the conduction distances. Several factors may contribute to determination of accurate nerve conduction velocity like age, temperature, height etc. Because of these uncontrolled variables, the calculated values only approximate the true nerve conduction values. Of these, age and temperature have a major influence on nerve conduction studies. Temperature variation

in the tissue surrounding a nerve is an important factor influencing the velocity of the nerve impulse. The distal extremities are constantly exposed to environmental temperature changes and are subjected to significant tissue temperature variation even in healthy subjects *(Halar et al, 1981)*.

Elderly subjects have been found to have reduced ability to respond to cold exposures and are prone to having a lower tissue temperature than younger adults when exposed to same environmental temperatures *(Fox et al, 1973)*. Patients with impaired circulation may have a reduced tissue temperature and additional reduction of nerve conduction velocity. Borderline abnormal nerve conduction velocity values may lead to erroneous diagnosis of peripheral or entrapment neuropathy *(Halar et al, 1981, 1982, 1983)*.

Temperature affects biologic and neurophysiologic processes and is, therefore, always well controlled in vitro experiments. Its role is equally important in the clinical laboratory but has often been neglected. Lower temperature cause slower nerve conduction velocities (NCVs), and increased amplitudes of muscle and nerve potentials *(Dorfman & Bosley, 1994)*. Fibrillations may disappear, and muscle contraction will be slower and weaker and neuromuscular transmission improves. Somatosensory evoked potentials (SEPs) are similarly vulnerable in the peripheral segments, or with changes in central temperature. As a result, abnormalities are artificially created or existing defects are not detected, resulting in false or missed diagnoses. Control of temperature, albeit somewhat time consuming, will result in greater diagnostic accuracy.

Cold temperatures cause slowing of sodium channel opening and also delays its inactivation which probably accounts for the slowing of nerve conduction and the increase in amplitude *(Kimura, 1989)*. With decrease in temperature there is consequent reduction in the sodium permeability of nerve axons during the excitation, resulting in a slower sodium influx and an increased latency (slow neural conduction). Decrease in temperature also increases the resistance to conduction of impulses which increase the latencies and decreases the conduction velocity.

With so much of importance attached to this electro-diagnostic test, the accuracy of results is of extreme importance. A small error like incorrect recording of skin temperature or disregarding it totally can result in disastrous diagnosis. To solve this problem, temperature correction formulae have been devised for various nerves in studies done thence so forth, but clinical imposition of these formulae is not done always.

This study attempts to determine the effect of skin temperature on motor nerve conduction velocity on normal subjects in Indian population and to examine the reliability of temperature correction formulae.

Material & Methods:

Eighty (N=80) girls aged between 18 years to 25 years of Mata Gujri Girls Hostel who fulfilled the inclusion and exclusion criteria constituted the population. The study was conducted in the research laboratory of the Department of Physiotherapy, Sardar Bhagwan Singh Post Graduate Institute of Bio-Medical

Sciences and Research, Balawala, Dehradun.

Forty five (n=45) subjects out of the population were selected for the study on the basis of inclusion and criteria.

Before beginning with the procedure, the subjects who were selected on the basis of inclusion criteria were explained the entire procedure in detail and their consent was taken. They were then assessed according to the assessment chart. The subject was made to sit comfortably on a chair with the right arm supported on the armrest. Metallic ornaments on the limb were removed. The right arm was exposed from mid arm to the hand. The resistance of the skin of forearm was reduced using cotton dipped in alcohol. The recording electrodes were placed in the hand with the cathode placed over the belly of abductor pollicis brevis muscle and the anode on the belly tendon montage. The ground electrode was strapped to the forearm. A point was marked 8 cm proximal to the distal wrist crease. The skin temperature was measured at this point and noted. Cold pack was applied over the forearm for about 5-10 minutes, till the skin temperature reduced to 27^0C. The pack was removed and the area was gently patted dry. Once the required temperature was achieved, the stimulation was given after one minute to allow the skin temperature to stabilize. First, the supramaximal stimulus was given to the median nerve distally at the wrist. The wave and the distal latency were recorded. The second supramaximal stimulus was given to the median nerve proximally at the flexor crease at the elbow. The wave and proximal latency were recorded. The distance between the proximal and the distal stimulating sites was measured using a flexible measuring tape *(Mishra & Kalitha, 2005)*. The MNCV was then calculated as follows:

$$\text{MNCV} = \frac{D}{PL - DL}$$

Where,

D = distance in meters
PL= proximal latency in milliseconds
DL= distal latency in milliseconds

The skin temperature which was measured and the value of MNCV obtained was then put in the temperature correction formula and the temperature corrected MNCV was calculated.

$NCV_{TC} = CF\ (T_{st} - T_m) + \text{obtained NCV}$

NCV_{TC} = Temperature Corrected NCV
CF = correction factor for median nerve = 1.5
T_{st} = standard skin temperature = 33^0C
T_m = measured skin temperature.

The part was then allowed to warm gradually to subsequent temperatures of 29^0C, 31^0C, 33^0C. At each temperature the latency and the MNCV were recorded as described above. The part was then warmed to 35^0C and then to 37^0C by wrapping a hot water bottle around the limb. The hot water bottle was removed and the area was gently patted dry. Again Latencies and MNCVs were calculated at both the temperatures as per the procedure explained above. Temperature corrected MNCV obtained at each temperature was compared with recorded MNCV value obtained at 33^0C.

The data was analyzed, initially using mean and standard deviation to analyze the MNCV at various temperatures (27ºC, 29ºC, 31ºC, 33ºC, 35ºC, 37ºC). Then One Way Anova was applied to analyze the change in MNCV

at various temperatures in different subjects.

Later Karl Pearson Correlation and Paired t-test was used to find out correlation between temperature corrected MNCV at various temperatures with MNCV at standard temperature and reliability of the formula was determined.

The significant value was fixed at $p<0.05$ with confidence interval of 95%.

Results & Discussion

Table 1 describes the mean and standard deviations of all the MNCV's recorded at various skin temperatures from 27^0C to 37^0C. The values indicate a general trend of increase in the conduction velocity of median nerve with increase in the temperature.

Table 1: Mean and Standard deviations of all the MNCV values (meters/sec) recorded at various temperatures.

TEMPERATURE	MEAN	±S.D.
27^0C	54.91	2.94
29^0C	54.39	2.89
31^0C	54.94	2.76
33^0C	55.35	3.08
35^0C	56.42	3.70
37^0C	56.86	3.46

Table 2: ANOVA

Variables	Sum Of Squares	Df	Mean Square	F-Value	Sig
Between groups	206.406	5	41.281	4.159	.001
Within groups	2620.160	264	9.925		

Table 2 describes the values for One Way Anova for the temperatures from 27^0C to 37^0C. The F value of 4.159 was significant at $p<.001$ for within the six different temperatures used.

Having calculated a one-way ANOVA for same subject design on the data and obtained significant results throughout the temperature range ($F=4.159$, $p=.001$), comparisons of the means were performed using the Scheffe' multiple range test. The results indicated that MNCV values observed at 29^0C and 37^0C were significantly different.

Table 3: Correlation between the temperatures corrected MNCV's at various temperatures with the MNCV value recorded at 33 ºC

Variables	r-value	Significance
NCV_{TC} at 27 ºC and NCV at 33 ºC	0.643	.000
NCV_{TC} at 29 ºC and NCV at 33 ºC	0.688	.000
NCV_{TC} at 31 ºC and NCV at 33 ºC	0.716	.000
NCV_{TC} at 35 ºC and NCV at 33 ºC	0.419	.000
NCV_{TC} at 37 ºC and NCV at 33 ºC	0.672	.000

Table 3 shows the correlation between the temperatures corrected MNCV's obtained at various temperatures with the MNCV value recorded at 33 ºC using the Karl Pearson Correlation Formula. Significant correlation was observed.

Discussion

The results of the study reveal that temperature have an effect on the ability of the nerve to conduct impulses and the greatest change in NCV was seen when NCV values were compared at temperatures of 29ºC and 37ºC (Table 1). Similar results have also been reported by *De Jesus et al (1973)* and *Lowitzsch et al (1977)*. The probable explanation for the increase in MNCV with increase in temperature is that on warming of the nerve there is a transient hyper polarization by acceleration of the electrogenic sodium pump (*Stetson et al, 1992)*. Observations of some other investigators show that the conduction velocity increases by approximately 5% per degree Celsius increase in the temperature of the nerve from 29°C to 38°C (*Johnson and Olsen, 1960; De Jesus et al, 1973; Lowitzsch et al, 1977)*. Along with the increase in the NCV, the amplitude of nerve and muscle action potentials have been reported to decrease

(*Bolton et al, 1981 and Lang and Puusa, 1981)*. According to *Downey (2002)*, lowering of the temperature on the other hand prolongs the open time of the voltage gated sodium channel, thereby generating a larger and longer action potential, and reducing the nerve conduction velocity and increasing the latency. A decrease in temperature is found to alter conduction differently in nerves because of the wide variation on fiber diameters. The large-diameter fibers comprising the A group require less of a drop in temperature to produce action potential blockade than in C fibers. As per Downey large fibres are more responsive to cooling. He further is of the view that decreases in temperature increases the skin surface resistance which may also account for an increase in latency and therefore decrease in the conduction velocity. *Halar et al (1982)* in their study obtained a 1.5 m/sec/^{0}C change in median nerve conduction velocity and of 1.4 m/sec/^{0}C change in ulnar nerve conduction velocity. The recordings were done at volar mid wrist region and the standard temperature was taken as 33ºC.

One of the reasons for the lesser variation in MNCV with variation in skin temperature in the present study could be due to difference in the technique used to vary the skin temperature. In the existing study the skin temperature was varied by wrapping hot water bottle and cold pack around the volar aspect of the forearm. Moist packs were not used as it was difficult to obtain a controlled rise in skin temperature at the time of pilot study. In previous studies the skin temperature of the extremity was varied using cold and hot water bath, infra red lamps or hot packs. The hot and cold packs were placed for 10 minutes to get a change in the skin temperature from 33ºC to 37ºC. In the study done by *Halar et al (1982)* it took about 20-25 minutes for the limb temperature to gradually increase from 26ºC to 30ºC, when the limb was allowed to warm normally.

Although skin temperature is a quick and a reliable method of temperature determination in the extremities, it varies with the site of measurement along the same extremity. So to standardize the temperature correction for NCV and DL measurement, in this study the average skin temperature was measured at 8 cm proximal to the distal wrist crease, which was in accordance with the study done by *Halar et al (1982)* who showed that the volar mid-wrist site and the site 8 cm proximal to the wrist crease had the best correlation to NCV. They also suggested that volar mid-wrist be used as the standard site because effects of decreased temperatures are more likely to occur distally. The skin temperature in palms did not fall by the same magnitude as the finger skin temperatures due to better palmer blood supply and better capability to respond to the tissue temperature changes caused by environmental factors. The results support the use of skin temperature correction factors to correct for temperature-induced NCV and DL changes.

The reliability of temperature correction formula in the Indian set up was assessed using Karl Pearson Correlation and Paired t- test. The correlation was performed between each of the temperature corrected MNCV at 27ºC, 29ºC, 31ºC, 35ºC, 37ºC with MNCV recorded at 33ºC. All the values showed significant correlation which showed a strong association. This indicates that each temperature corrected MNCV's did match the recorded MNCV

value at 33ºC. Thus there is significant correlation between the temperature corrected MNCV's and the MNCV value recorded at 33ºC. Results of the present study are in accordance with the study of *Bjorkovist (1977)* who found that preheating the limb to the normal temperature before the NCV measurement did not produce variability in repeated NCV determinations and that preheating of limb appeared to be time consuming and an uncertain method for controlling temperature influence on NCV. Since the length of time varied from patient to patient to achieve the required skin temperature, it was better to use the temperature correction formula for each nerve to get a more consistent response.

Conclusion

The study results indicated variation in MNCV with changes in skin temperature in normal population as shown by One Way ANOVA.

The results of mean and standard deviation indicated that MNCV at 37ºC showed the highest values and the MNCV at 27ºC showed the minimum values which indicate an increase in the MNCV values with increase in temperature.

The study showed that the temperature correction formula is reliable in the Indian context.

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