

# INFLUENCE OF BODY TEMPERATURE TO NERVE CONDUCTION VELOCITY

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*Abstract: The distribution of the conduction velocity (DCV) in peripheral nerve fibers is an important parameter in assessing the condition of nerve fibers during the clinical evaluation of the peripheral nerves. We reported a new method of estimating DCV by using regularized-non-negative-least squares and Fibonacci search for conduction length. Giving supramaximal electrical stimulation at two different sites, we recorded compound action potentials at another site. With the method we estimated DCVs, single fiber action potentials (SFAPs), and the distances between stimulation and recording sites. This method was applied clinically focusing on the effects of body temperature on DCVs and SFAPs. Differences in the effects of temperature were found between the slow and fast conduction components of nerves.*

*Keywords: Regularized Non-Negative-Least Squares, Compound Action Potential, Temperature Influence in Distribution of Conduction Velocity*

## 1 INTRODUCTION

Several diseases, such as heavy metal poisoning, organic solvent poisoning, diabetes mellitus, affect the peripheral nerves, then the distributions of conduction velocity (DCV) change. The conduction study of nerves has become an important and common tool in clinical diagnosis. But the conduction study measures only the maximal conduction velocity, and the severity stages of slower fibers are neglected. The diseases also suffer the slower fibers, and it may be clinically important to obtain information on the velocity distributions of slower fibers, as well.

Estimation of DCV has become a focus of attention in neurodiagnostic laboratories [1 - 3]. Collision method [4], one of the non-invasive approaches was introduced in laboratory DCV analysis for motor nerves. It stimulates nerve trunk at two sites at different time, and observes electromyograph at the different site. By shifting the time difference the cumulative DCV is observed. It requires hundreds times of electrical stimulation. In consequence, the collision method is not applicable for clinical use. Even in laboratory studies the DCV of sensory nerves can not be calculated, because of small amplitudes of compound nervous action potentials (CAPs), which surrounding noise contaminate.

Recent studies estimate DCV from a pair of CAPs, which are the responses of all the nerve fibers in nerve trunk to the external supramaximal stimuli. In this study, we electrically stimulated a sensory median nerve trunk at an elbow and at a wrist, and recorded at an index finger. To demonstrate reproducibility of the estimated DCV and single fiber action potential (SFAP), we also estimated DCV and SFAP from the CAPs recorded at a middle finger. The aim of this study is to know the effects of body temperature on the slow and the fast components of the DCV.

## 2 METHOD AND SUBJECTS

Our new method is formulated as following [5].

$$y(t_i) = \sum_{j=1}^N A_{ij} w(v_j)$$

$$A_{ij} = av_j^2 s(t - l / v_j)$$

$$\begin{aligned} i &= 1, 2, \dots, M \\ j &= 1, 2, \dots, N \end{aligned} \quad (1)$$

where  $y$  is the CAP, and  $s$  is the SFAP. All fibers are classified into  $N$  groups according to their velocities, with the same velocity  $v_j$  in the group  $j$ . The number of fibers in group  $j$  is  $w_j$ . Conduction length  $l$  is the distance between the stimulation and recording electrodes.  $A$  is the SFAP matrix corresponding to different propagation velocities in the columns. The subject is to minimize the squared error between the observed CAPs stimulated at the elbow and at the wrist, and their estimations. I.e., to minimize  $J$  of Eq.(2).

$$J = \sum_{j=1}^N [(CAP_{elbow}^{observed} - CAP_{elbow}^{estimated})^2 + (CAP_{wrist}^{observed} - CAP_{wrist}^{estimated})^2] \quad (2)$$

Eq.(2) was minimized by generalized-nonnegative-least-squares method, and Fibonacci search for the estimation of the conduction length [5].

Three normal males (21 – 23 years old) joined the investigation. They sat on a chair, and put their forearm horizontally on a table. The stimulation electrodes were placed on the elbow and the wrist along the nerve axis. The cathode electrodes were placed distal side, and recording electrodes were placed on an index finger three centimeters apart. The grounding electrode was specially designed to cover the whole hand, except the area of recording electrodes. They were shown in Fig. 1.

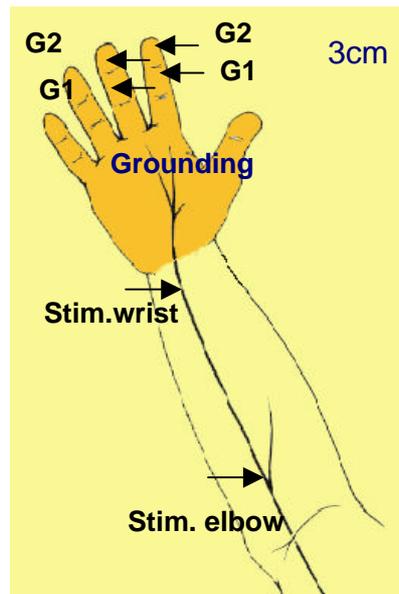


Fig.1 Placement of electrodes

The median nerve was supramaximally stimulated at the wrist and the elbow. The CAPs were recorded at the index finger, and additionally at the middle finger to demonstrate the reproducibility of DCVs. Room temperature was 27 degree throughout the experiment.

CAPs were recorded by a Neuropack MEB-4300 (Nihon Kohden Co. Ltd., Japan) in response to median nerve stimulation at the wrist and the elbow while the temperature in the palm was changed from 20.8 to 35.8 degree centigrade by soaking the whole forearm and the hand in a cold bath. The temperature was monitored with a deep temperature monitor (CTM-205, Terumo Co. Ltd., Japan).

DCV was estimated for each temperature. Temperature was plotted against the mean and two extreme velocities of the DCVs (i.e. at 5, 50, and 95 percent of accumulated DCVs. They were named  $V_5$ ,  $V_{50}$ , and  $V_{95}$ , respectively.) to analyze the relationship between temperature and velocity.

The observed CAPs were bi-phasic. The time differences between the positive and the negative peaks, and voltages between them were measured. Then, the DCVs and SFAPs were estimated by the above-mentioned method.

### 3 EXPERIMENTAL RESULTS

Figure 2 shows temperature dependency of the peak durations and peak amplitudes of CAPs, which are stimulated at the wrist (upper trace) and the elbow (lower trace). The peak durations decrease as temperature increases, while peak voltages remain steady.

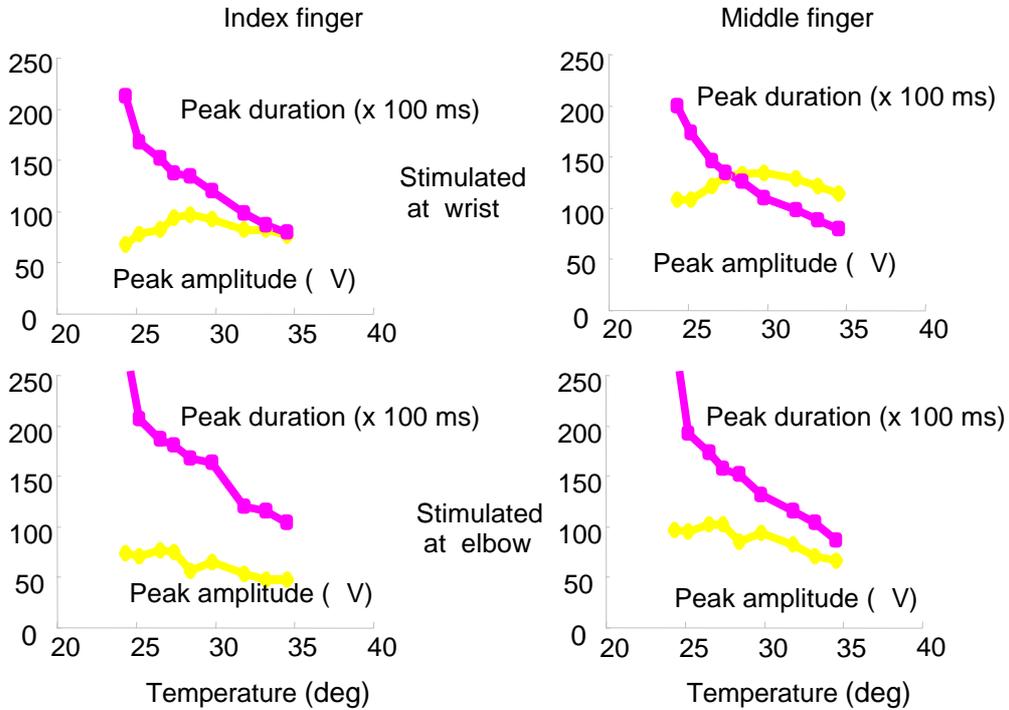


Fig. 2 Temperature dependence of peak duration and peak amplitude (22-y-o )

Figure 3 shows a series of estimated DCVs (left two histograms) and SFAP (right two waveforms) at different palm temperatures in the subject. The top is estimated from the CAPs at 35.8, the middle at 29.3, and the bottom at 20.8 degrees centigrade. Not only did the range of conduction velocity change with temperature, but the shape of the DCV as well. The estimation DCVs and SFAPs from the CAPs recorded at the index finger and the middle finger are very close to each other. The estimated distances between the wrist and the index finger was 136 mm, the elbow and the index finger was 416 mm, the wrist and the middle finger was 142 mm, the elbow and the middle finger was 422 mm, which were reasonable.

Figure 3 also shows that the conduction velocity of every fiber decreases when the temperature of nerve decreases. The distribution width of the conduction velocity becomes narrow when the temperature decreases. The SFAP becomes dull when the temperature decreases. For the further analysis of the temperature dependency of the DCV, we calculated the median and two extreme velocities of the DCVs, i.e. the velocity at 5 percent, 50 percent and 95 percent of cumulative DCVs. They are named  $V_5$ ,  $V_{50}$ , and  $V_{95}$ , respectively. They are arranged as shown in Fig. 4.

Three lines in the upper figures show  $V_{95}$ ,  $V_{50}$ , and  $V_5$ , from the top, respectively. From the figure we can find that the faster fibers are more sensitive to the temperature.

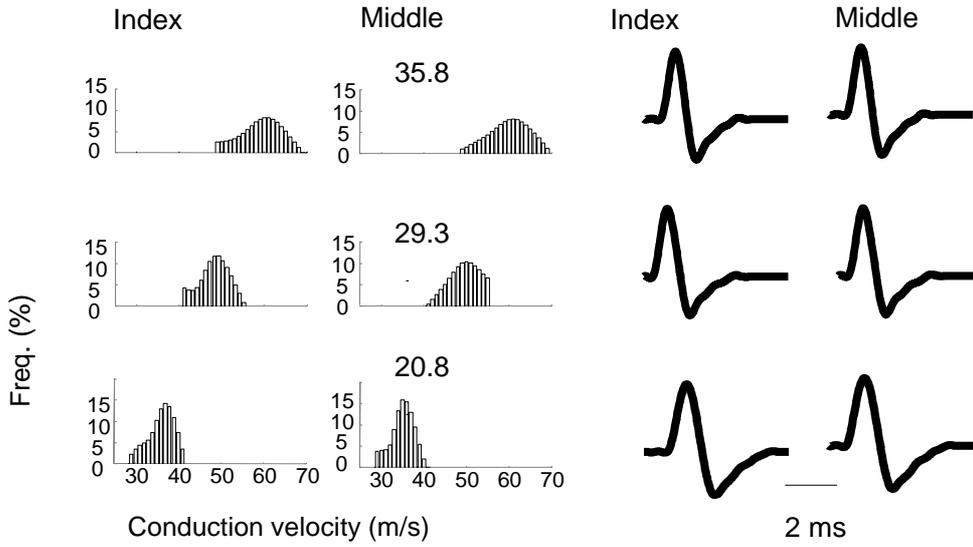


Fig.3 Estimated DCV and SFAP at different temperature

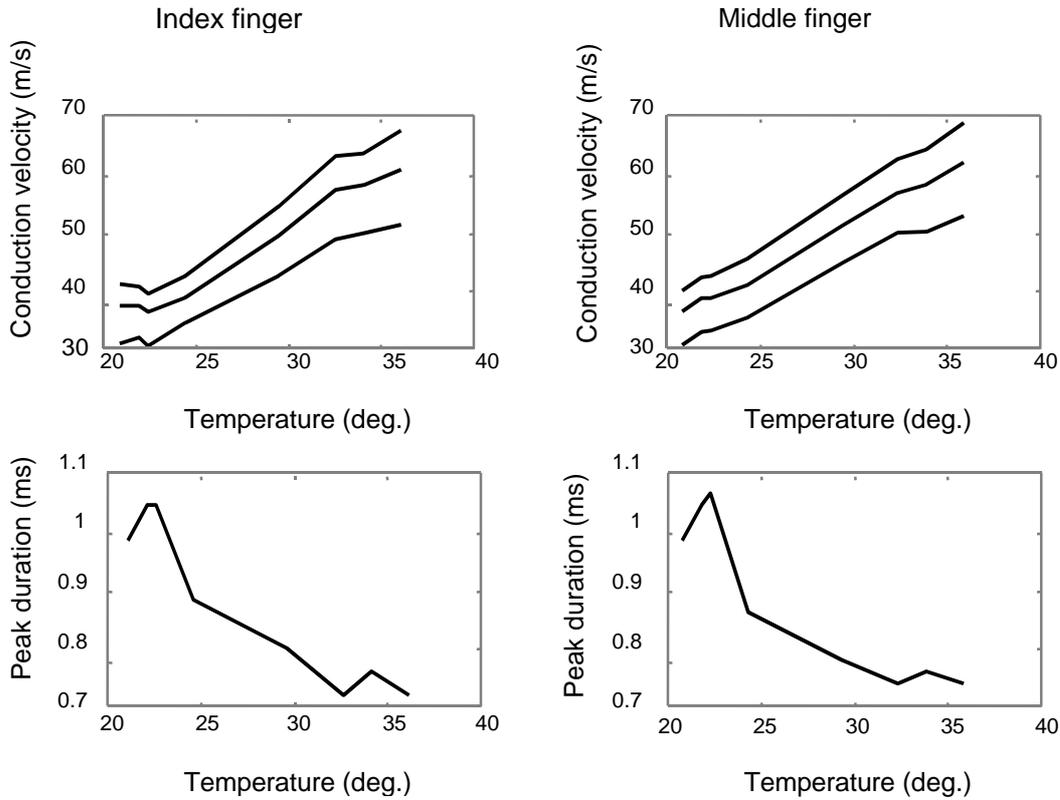


Fig. 4 Temperature dependency of DCV and peak duration

## 4 DISCUSSIONS

With our new estimation method, we found that the DCVs and SFAPs changed with temperature. Body temperature is known to be a major determination of the conduction study. The body temperature varies even among healthy subjects. Bolton et al studied the relationship between the limb temperature and the maximum conduction velocity, which was calculated from the difference of onset latencies of the CAPs [6]. According to their report the sensory conduction velocity of the median nerve changes at the rate of 1.64 to 2.13, to which the present result agreed well. The limb temperature of elderly subjects may be lower than that of young subjects. Thus, we have to be alert to the body or limb temperature when we evaluate the nerve conduction velocity.

Using the present method of DCV and SFAP estimation, we also found that the faster conduction component of the nerve fiber became faster with increase in body temperature than the slower component in this study. A report is available as to difference in the rate of conduction velocity to body temperature between the slower and faster conduction nerve fibers [7].

## 5 CONCLUSION

The DCVs and the SFAPs were estimated by minimizing Eq.(2) with a regularized-nonnegative-least squares method. The median sensory nerve was stimulated at the elbow and at the wrist, and the CAPs were anti-dromically recorded at the index finger. To demonstrate the reproducibility CAPs were also recorded at the middle finger.

The temperature dependency of the DCV and SFAP, and their reproducibility were examined with three normal males. The CAPs became broad as the body temperature decreased, while the peak amplitude remained steady. The SFAP became broad as the body temperature decreased, while the peak amplitude remained steady. The DCVs shifted to slower region as the body temperature decreased. The shape of DCVs also changed. It became narrow distribution when the body temperature decreased. The DCVs and the SFAPs estimated with the CAPs recorded at both fingers agreed well, and the reproducibility was validated.

It may be possible to make some compensation to DCV when body temperature varies large. Besides, the temperature characteristics would give good suggestion for clinical application, such as the attempt to of keeping room temperature etc.

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