BASICS OF NERVE CONDUCTION VELOCITY

AND

ULNAR NERVE CONDUCTION VELOCITY IN DIFFERENT AGES

NEUROMUSCULAR CONTROL OF MOVEMENT

PROF.: DAVID M. KOCEJA

DAVID RIBERA NEBOT

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INTRODUCTION

Conduction velocity is defined as the distance an impulse travels along a nerve per unit time. The presence of three specific nerve fibers -the efferent nerve fiber, the sensory afferent muscle fiber and the skin sensory afferent nerve fiber (Eccles and Sherrington, 1930), allow us to test respectively (1) motor nerve conduction, (2) monosynaptic reflex and (3) sensory nerve conduction. Lillie (1925) showed that conduction in a myelinated nerve is discontinuous or “saltatory” and that the impulse skips along the nerve fiber from one node of Ranvier to the next. This is nature’s way of obtaining higher speeds of conduction: the greater the distance between nodes of Ranvier in a nerve fiber, the faster its speed of conduction (cited by Smorto and Basmajian).

Nerve conduction velocity may be influenced by several factors as age, sex, physical training, injury states, temperature, dieting, sauna and dehydration. Nerve conduction velocity measurements can be important for evaluating neuropathies, abnormal states of the nervous system and different training states.

This report deals with the analysis of data obtained from a research conducted in Indiana University which aim was to compare the ulnar nerve conduction velocity of young (22.6 years) and elderly (71.4 years) people. Additionally, a few other aspects related to nerve conduction velocity are expounded.

METHODOLOGY

Ulnar motor nerve conduction velocity (NCV) was assessed in 10 young persons (22.6 years) and 10 elderly persons (71.4 years). Double stimulation technique was used for the measurements. Ulnar nerve was stimulated by short electrical square 1ms pulses of constant current applied through skin electrodes at two sites: right above the elbow (proximal site) and right above the wrist (distal site). Proximal and distal latencies were measured as well as proximal and distal distance between stimulation point and the EMG recording point (by a tape measure) in order to calculate the ulnar nerve conduction velocity.

RESULTS

Ulnar motor nerve conduction velocity was significantly higher (no significant correlation and t-Test shows significant differences)in young persons (22.6 years) when compared with elderly persons (71.4). Average young NCV was 63.08 m/s and average elderly NCV was 55.36 m/s. However, individual analysis shows that 5 young persons (62.3, 62.2, 61.3, 61.3 and 60.8 m/s) obtained considerable similar velocities to 2 elderly persons (60.2 and 59 m/s).

Data analysis is shown on the following pages.

ULNAR NERVE CONDUCTION VELOCITY

22.6 YRS	71.4 YRS
63,2	53,4
60,8	60,2
64,2	55,2
61,3	56,2
64,6	59
66,7	52,3
62,2	53,8
61,3	55,5
64,2	53,2
62,3	54,8

22.6 YRS
63,2
60,8
64,2
61,3
64,6
66,7
62,2
61,3
64,2
62,3

22.6 YRS	
Mean	63,08
Standard	0,58553
Median	62,75
Mode	64,2
Standard	1,85161
Sample V	3,42844
Kurtosis	-0,1005
Skewnes	0,64484
Range	5,9
Minimum	60,8
Maximum	66,7
Sum	630,8
Count	10
Largest(1	66,7
Smallest('	60,8
Confidenc	1,14761

71.4 YRS
53,4
60,2
55,2
56,2
59
52,3
53,8
55,5
53,2
54,8

71.4 YRS	
Mean	55,36
Standard	0,80308
Median	55
Mode	#N/A
Standard	2,53955
Sample V	6,44933
Kurtosis	0,14729
Skewnes	0,94949
Range	7,9
Minimum	52,3
Maximum	60,2
Sum	553,6
Count	10
Largest(1	60,2
Smallest('	52,3
Confidenc	1,574

22.6 YRS	71.4 YRS
63,2	53,4
60,8	60,2
64,2	55,2
61,3	56,2
64,6	59
66,7	52,3
62,2	53,8
61,3	55,5
64,2	53,2
62,3	54,8

Correlatio	*22.6 YRS*	*71.4 YRS*
22.6 YRS	1	
71.4 YRS	-0,4572	1

t-Test: Two-Sample Assuming Equal Var

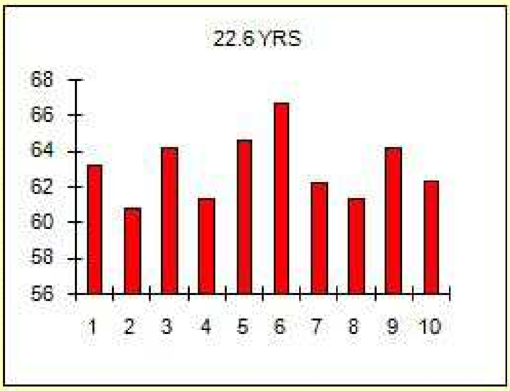
	22.6 YRS	71.4 YRS
Mean	63,08	55,36
Variance	3,42844	6,44933
Observati	10	10
Pooled Va	4,93889	
Hypothes	0	
df	18	
t Stat	7,76761	
P(T<=t) or	1,9E-07	
t Critical o	1,73406	
P(T<=t) tv	3,7E-07	
t Critical tv	2,10092	

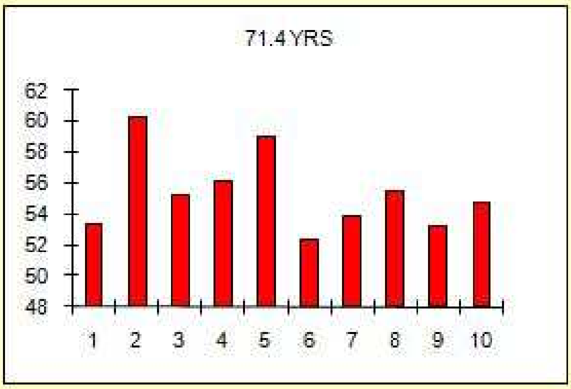
22.6 YRS	71.4 YRS
63,2	53,4
60,8	60,2
64,2	55,2
61,3	56,2
64,6	59
66,7	52,3
62,2	53,8
61,3	55,5
64,2	53,2
62,3	54,8

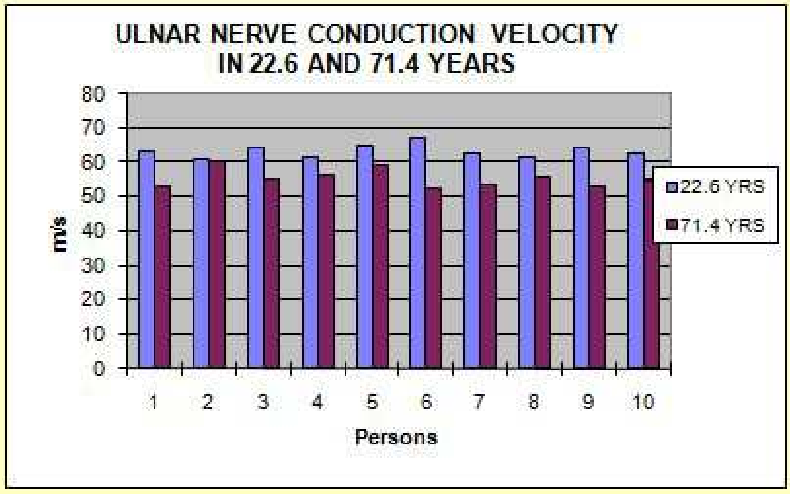
t-Test: Two-Sample Assuming Unequal Variances

	22.6 YRS	71.4 YRS
Mean	63,08	55,36
Variance	3,42844	6,44933
Observati	10	10
Hypothes	0	
df	16	
t Stat	7,76761	
P(T<=t) or	4,1E-07	
t Critical o	1,74588	
P(T<=t) tv	8,1E-07	
t Critical tv	2,1199	

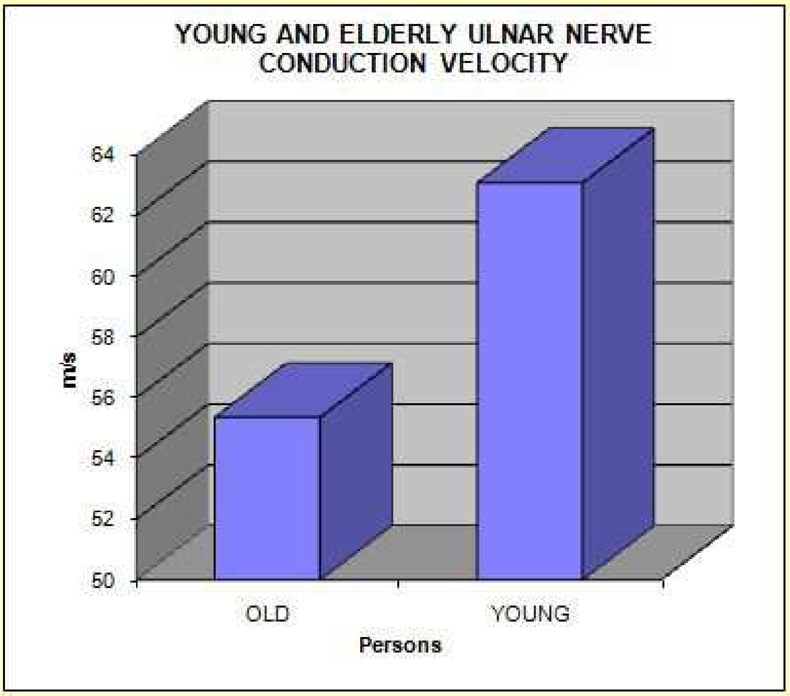
22.6 YRS	71.4 YRS
63,2	53,4
60,8	60,2
64,2	55,2
61,3	56,2
64,6	59
66,7	52,3
62,2	53,8
61,3	55,5
64,2	53,2
62,3	54,8







OLD	YOUNG
55,36	63,08



DISCUSSION

Age and Nerve Conduction Velocity

Based upon the statistical analysis of NCV IU results, there are significantly differences between young and elderly people. Campbell et *al.* (1973) showed that in some old subjects the maximum conduction velocities were reduced in motor nerves; there was also evidence that slowing in impulse conduction was particularly marked in distal regions of axons. Further, they found that within the elderly population a number of motor units were often enlarged and tended to have relatively slow twitches. Lascelles and Thomas (1966) observed that, in nerves from subjects under the age of 65, internodal length was closely correlated with the fiber diameter (approximately linear relationship). Over the age of 65, irregularities of internodal length were common and appeared to be the result both of segmental demyelination and remyelination and of regeneration after complete degeneration of nerve fibers. These authors attempted to explain the significance of their finding in relation to the slowing of nerve conduction found in later life and to the loss of ankle jerks and vibration sense in the legs of the elderly.

According to Baer and Johnson (1965), the nerve conduction velocities values of the motor fibers of the ulnar, median, peroneal and posterior tibial nerves in the newborn are roughly 50% of adult values and during the fourth year they reach adult values. Most interesting, from the ages of 4 to 16 years the values for conduction velocity slightly exceed those for adults. Data from LaFratta and Smith (1964) indicates a systematic negative correlation, but low, between age and conduction velocity in 128 male subjects, but the authors did not deem it clinically applicable. Their findings are contrary to the general impression that there is a marked diminution of nerve conduction velocity in the higher age groups. De Lorme and Watkins (1951) hypothesized a two-stage process for strength gain: increased nerve activity followed by muscle hypertrophy. Moritani (1981) trained both young and old men in an eigth-week isotonic strength-training regimen. Young subjects increased both neural activity and muscle mass; older subjects increased neural function only. Thus, neural activity is quite changeable in all ages (Everett, Smith, Sally and Zook, 1986).

Nevertheless, if one weights the pros and cons when analyzing the IU results individually, one should consider that other factors might be more determinant of NCV change than age. Ideally, we should rely on longitudinal studies.

It should be mentioned in passing that brain mass reach 90% of definitive at 6 years old and at 12-13 years old it is definitive and functional and morphological maturation or nervous cells also reach a maximum at 10-12 years old, approximately, following until the adolescent final maturity (16 and 18 years old for girls and boys, respectively). Thus, the central nervous system is the first mature system of the person and children 10-12 years old possess an extraordinary plasticity of the central nervous system that imply a high excitability of director nervous processes and, on the other hand, a low differentiated inhibition. The high excitability leads to fast reactions, elevated frequency capacity and almost perfect motor learning (Grosser, 1982). This reality was also reported by Hollmann and Hettinger (1980).

Sex and Nerve Conduction Velocity

LaFratta and Smith (1964) carried out a total of 187 determinations of nerve conduction velocity on the ulnar nerve of 149 subjects, 21 of whom were female. They observed systematic differences in motor nerve conduction velocity between the sexes, being faster in the female than in the male on the basis of bilateral measurements.

Sauna and Nerve Conduction Velocity

Gieremek (1990) carried out a research which aim was to examine influence of sauna upon time of the simple reflex as reaction to sensory and light stimuli, Achilles tendon reflex (T reflex), Hoffmann reflex (Hreflex) and velocity of nerve conduction and the work capacity of muscle. 15 judo fighters and a control group of 15 men were examined. The measurements were carried out just before and 15 minutes after the sauna bathing. According to the findings, a sauna lowers the functional efficiency of the cerebral and spinal cord nervous centers and at the same time increases the peripheral motor neuron activity. Immediately after the experimental procedure a muscle capability was lowered as well. Furthermore, it was proved that the level of the subjects' physical activity involvement (competitors versus non-athletes) had no significant influence on a change trend in the examined reflex actions neither on the intensity of these physiological reactions.

Temperature and Nerve Conduction Velocity

Bicknell et *al.* (1982) investigated peroneal nerve conduction velocity before and after a marathon race. The authors concluded that endurance exercise does not alter NCV except by changing body temperature.

Dehydration and Nerve Conduction Velocity

The effect of dehydration on spontaneous muscular activity and nerve conduction velocities in elite power athletes was investigated by Nousiainen et *al.* (1983). Dehydration, especially such as that caused by a diuretic, caused a significant amount of motor neuron hyperexcitability. Acute dehydration did not affect conduction velocities of the neurons studied.

Dieting and Nerve Conduction Velocity

Komi and his associates studied several measures of neuromuscular performance including ulnar NCV in monozygous and dizygous twin pairs. The authors indicated that one twin pair was excluded from the study since the loss of 20% of body weight through dieting in one twin was accompanied by a 20% decrease in nerve conduction velocity of the ulnar nerve, suggesting that environmental influences may have a significant effect upon several neuromuscular parameters including nerve conduction velocity.

Injured State and Nerve Conduction Velocity

Some injures are also associated with changes in NCV. For example, atrophy of the infraspinatus muscle and decreased strength in external rotation and abduction of a healthy 20-year-old highly competitive baseball pitcher revealed decreased suprascapular nerve conduction to the infraspinatus muscle (Smith, 1995), and the injured leg 4-8 days post trauma motor nerve conduction velocity in the knee-caput fibulae segment of the superficial peroneal nerve was significantly smaller when compared with the contralateral leg and the control group -five weeks post trauma these values were normal again- (Kleinrensink et *al.*, 1994).

Training and Nerve Conduction Velocity

According to studies of Reid et *al.* (1986), slower tibial nerve conduction velocities were indicative of greater abilities in neuromsucular functioning to produce higher outputs in power in the vertical jump, and faster tibial nerve conduction velocities were indicative of lack of neuromuscular abilities to produce higher levels of vertical jump power in college football linemen. Explanations for this relationship centered on muscle function and adaptive abilities by individual subjects to compensate for physiological limitations. Supraspinal function may have a greater influence than NCV for power development.

Kamen et *al.*(1984) assessed ulnar and posterior tibial motor nerve conduction velocity in 91 athletes and non-athletes. The athletes included male weight lifters, swimmers, jumpers and male and female track sprinters and distance runners. NCV of the weight lifters was significantly faster than that of the other groups for both motor nerves. The male marathoners had the slowest posterior tibial NCV of all subject groups. Jumpers and male sprinters had slower NCV than the mean for all subjects in both motor nerves.

There is some evidence that data presented here could represent training-induced changes in NCV. Lastovka (1969) of Prague examined the conduction velocity of the ulnar nerve and posterior tibial nerves in 32 healthy apprentices, 16 of whom had been training in different sport disciplines in the previous five to eight years. The others had received no special physical training. Significantly faster posterior tibial NCV were found in the trained subjects than in the untrained group. There were no significant differences in ulnar NCV between the two groups. The author attributed the faster posterior tibial NCV in the trained group to long-term physical exercise and suggested that the lack of a difference in the ulnar nerve could be attributed to the similar manual work performed by all apprentices.

Buchberger and Novozamsky (1971) found that physical training in children between 12 and 14 years (9 hours of gymnastics weekly) increases excitability of motor nerve fibers. The effect is highly significant for motor fibers to the biceps brachii of boys. According to the authors, two explanations are possible: (1) a decreased conductance of shunt pathways through nonnervous tissue; and (2) changes of electrical parameters of motor nerve fibers.

Fourteen badminton players, twelve swimmers and twelve sedentary subjects were studied by Hoyle and Holt (1983). Swimmers were found to have the fastest reaction, response and movement times. Badminton players were found to be the fastest group in the agility test, in movement speed and in nerve conduction velocity. Factors involving voluntary motor ability rather than reactive capability appeared to distinguish the three groups.

Wilmarth and Nelson (1988) compared the distal sensory latency period of the ulnar nerve in 15 controls and 10 long distance cyclists. Results showed that there was a statistically significant difference in distal sensory latencies between long distance cyclists and the control group. However, there was no significant correlation between distance bicycled and latency. Results of this study lead to the belief that there may be adaptive changes in long distance cyclists which could account for changes in sensory nerve conduction velocity of the ulnar nerve.

Ringel et *al.* (1990) assert that some studies in healthy pitchers during spring training and again at midseason demonstrate that slowing of suprasxcapular nerve conduction is detectable in some cases as the season progresses.

Data from LaFratta and Smith (1964) indicate that when both right and left ulnar nerves were tested (in 31 men-the sex factor eliminated) more subjects exhibited a higher nerve conduction velocity on the dominant side than on the nondominant side. The actual numerical differences were not believed to be significant or deemed applicable clinically.

Other evidence points to the possibility of training-induced changes in motor NCV. It has been reported that functionally overloading a muscle increases, decreases or causes no change in motor nerve axon diameters. Since nerve axon diameter is very highly related to conduction velocity, any change in diameter would cause a concomitant change in conduction velocity. Histochemical changes in ventral motoneurons following long-term exercise have been observed, suggesting that there is indeed dynamic metabolic activity occurring in motoneurons following chronic exercise.

The issue under consideration can be summed up thus: there appear to be differences in motor nerve conduction velocity among athletes trained for various athletic endeavors; current evidence indicates that both hereditary and environmental influences are important determinants of NCV.

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