Upper limb nerve conduction parameters of healthy young adults

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ABSTRACT

Across sectional study was done among to measure the upper limb nerve conduction parameters in median and ulnar nerves. Age, height, weight and BMI of healthy volunteers were recorded. Nerve conduction study was performed to measure Distal Latency (DL) (ms), Proximal Latency (PL) (ms) and Conduction Velocity (CV) (m/s) in both motor and sensory of Median and Ulnar nerves in 99 individuals at University of Jaffna. The mean ages were 21.4 ± 1.2, 21.7 ± 1 in males and females respectively. There were significant differences between males and females in PL and DL of motor and sensory nerves, but not CV except for left motor ulnar and right sensory ulnar nerves ($p<0.05$). NCS parameters between left and right limbs were not statistically significant. Mean of median motor DL, PL, and CV were 3(±0.4), 7.4(±0.6), 62.7(±4) in males and 2.8(±0.3), 6.8(±0.6), 61.7(±5.4) in females respectively while the respective parameters in Ulnar motor nerves were 2.2(±0.2), 7.4(±0.6), 64.8(±5.5) in males and 2.1(±0.1), 6.9(±0.6), 66.6(±6.3) in females. Mean DL, PL and CV of sensory median were 2.8(±0.2), 6.6(±0.4), 69.7(±4.6) and 2.6(±0.3), 6.9(±0.6), 70.9(±7.9) in males and females respectively while the respective values in Ulnar sensory were 2.4(±0.3), 7.5(±0.6), 67.4(±5) in males and 2.2(±0.3), 6.9(±0.6), 71.9(±6) in females. Height had significant ($p<0.05$) correlation with latencies but not CV. CV was faster in sensory than motor nerves ($p <0.001$).Our results establish normal NCS values for Median and Ulnar nerves in young healthy adults enabling better interpretations of NCS.

Keywords: Motor Distal Latency, Motor Proximal Latency, Motor Conduction Velocity, Sensory Distal Latency, Sensory Conduction Velocity

Introduction

Nerve conduction studies (NCS) play pivotal role in assessing the function of peripheral nerves by localizing the site, severity, progression or prognosis of nerve lesions [1]. Hence it is useful in diagnosing mono neuropathies, poly neuropathies, tunnel syndromes and damage due to injuries or compression. Latency and conduction velocities assess the speed of impulse transmission which is usually altered in demyelinating diseases [2].Compression of median nerve within the carpal tunnel causes carpal tunnel syndrome, which is the most frequent entrapment neuropathy [5]. Ulnar nerve injury is very common [6]. Therefore these two nerves are mostly subjected to NCS in upper limb. Responses due to motor nerve stimulation can be easily recorded at the musle supplied by the same nerve. Sensory nerve responses can be picked up at the nerve itself in a distal place where the antidromic conduction is used. Latency indicates the time gap between the stimulation and the onset of response. Amplitude gives the strength of the response. Conduction Velocities obtained using the distance between two stimulation points and the latency difference between those points. Interpretation of these parameters needs normal values derived from healthy population. Nerve conduction parameters have been reported to vary with age, gender, handedness, skin temperature, height, Body Mass Index [2, 3, 4]. This may lead to differences between various populations and regions. Also it differs between laboratories. Hence, it will be necessary to study nerve conduction parameters in the local populations of each laboratory to facilitate interpretation in clinical practice. Normative values for nerve conduction parameters have been studied in different countries such as Nepal, India, Malaysia, Iraq and USA. In Sri Lanka, median, ulnar and peroneal nerves were studied

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in Galle [7]. In Jaffna NCS are performed for the last two years in neurological investigations. However, normal values have not been studied in the local population to have our own reference values. Therefore this study was undertaken to investigate the upper limb nerve conduction parameters of young adults in our laboratory.

Methodology

Ethical clearance was obtained from Ethical Review Committee, Faculty of Medicine, University of Jaffna. Volunteers among the medical students were included in this study. An interviewer administered questionnaire was used to get basic information of volunteers. Those who had symptoms of compression neuropathy (pain, numbness, tingling or abnormal sensations of upper limb) or nerve injury in the upper limb were excluded from the study. Individuals with already diagnosed peripheral neuropathy, neuro muscular disorder, hereditary neuropathy, radiculopathy, Carpal tunnel syndrome, Diabetes Mellitus, Gout, Rheumatoid arthritis, Thoracic outlet syndrome, and Thyroid dysfunction also were excluded from the study. Informed written consent was obtained from each participant. Age was calculated in years as on last birthday. Height and weight were measured to the nearest 0.1 cm and 0.1 kg using the Seca (Germany) scale. Nerve conduction study was carried out on Neuro pack S1 EMG/EP measuring system MEB 9400 (Nihon Kohden, Japan). Stimulation and recording areas were cleaned with 70 % alcohol and electrical Skin pure skin preparation was applied. Median and ulnar conduction studies were performed in both limbs with minimum possible surface stimulation. It was confirmed that the instrument was earthed and no harm was caused to the subject. In Stimulating electrode, the distance between anode and cathode was 20 mm. Disc electrodes were used to record the response on muscle belly during motor nerve stimulation. Antidromic sensory conductions were recorded in appropriate fingers by placing spring loaded stainless steel ring electrodes which will fit around the digit. Stimulations were given in two places. For median nerve, proximal stimulation was given at the elbow where the brachial artery becomes palpable and distal stimulation was given between the tendons of the Flexor Carpi Radialis muscle and Musculus Palmaris Longus at the wrist. For ulnar nerve, proximal stimulation was given behind the medial epicondyle of the humurus at the elbow and distal stimulation was posterior to the Flexor Carpi Ulnaris tendon at the wrist. In median motor conduction, cathode end of the recording electrode was kept on belly of the Abductor Pollicis Brevis muscle and the anode end was kept on its tendon. In ulnar motor conduction cathode end of recording electrode was kept on the belly of Abductor Digiti Minimi muscle and the anode on its tendon.Stimulation sites for sensory nerves were same as motor nerves. In sensory nerve conduction recording cathode and anode ring electrodes were placed around proximal and distal inter phalangeal joints of second and fifth fingers for median and ulnar nerves respectively.Latency and amplitude were displayed by the equipment following each stimulation. Distance between the cathode ends of distal and proximal stimulation points was measured with a non elastic measuring tape to the nearest centimeter (cm). It was fed on the machine to calculate the conduction velocity in m/s. This measurement was taken by the same trained technician in all the participants. All the tests were performed by one of the investigators. Recording on each nerve was repeated until the best possible response was obtained. The best response in each component was kept in the computer memory and printed. All the printed records were checked by Consultant Neurologist to select the correct tracings for analysis. Proximal Latency (PL), Distal Latency (DL) and Conduction Velocity (CV) of both motor and sensory nerves were analyzed.

Results

This study was carried out in 99 volunteers (43males, 56females). The mean age was 21.4 ± 1.2 in males and 21.7 ± 1 in females. The mean height was 171 ± 6.7 cm in males and 158 ± 5.3 cm in females. In males the mean weight was 61.6 ± 10.8 kg. In females it was 52± 8.6 kg. Males had a mean BMI 21 ± 3.5kg/m^2. In females it was 20 ± 3 kg/m^2. Nerve conduction parameters were calculated based on the number of limbs analyzed for each parameter after the selection of correct records by consultant neurologist.Mean and standard deviation of nerve conduction parameters were calculated for both hands separately in males and females (Table 1& 2).

Table 1*:* Motor nerve conduction parameters of males and females

Parameter	Side	Sex	No	Mean ± SD (ms)	P value
Median nerve					
Latency- Wrist	R	M	41	3±0.4	*0.001**
	R	F	54	2.8±0.3	
	L	M	43	3±0.4	*0.001**
	L	F	51	2.8±0.3	
Latency - Elbow	R	M	41	7.4±0.6	*0.000**
	R	F	54	6.8±0.6	
	L	M	43	7.4±0.6	*0.000**
	L	F	51	6.8±0.6	
Conduction Velocity	R	M	41	62.7±4	0.339
	R	F	54	61.7±5.4	
	L	M	43	62±5	0.711
	L	F	51	62.4±5.8	
Ulnar nerve					
Latency- Wrist	R	M	27	2.2±0.2	*0.003**
	R	F	39	2.1±0.1	
	L	M	27	2.3±0.3	*0.001**
	L	F	35	2.1±0.1	
Latency – Elbow	R	M	27	7.4±0.6	*0.001**
	R	F	39	6.9±0.6	
	L	M	27	7.7±0.8	*0.000**
	L	F	35	6.9±0.6	
Conduction Velocity	R	M	27	64.8±5.5	0.252
	R	F	39	66.6±6.3	
	L	M	27	61.3±6	*0.013**
	L	F	35	65.4±6.5	

R- Right , L- Left, M- Male, F- Female
P value- P of mean difference between both sexes
*- significant at p<0. 05 level

Table 2*:* Sensory nerve conduction parameters of males and females

Parameter	Side	Sex	No	Mean ± SD (ms)	P value
Median nerve					
Distal Latency	R	M	38	2.8±0.2	*0.000**
	R	F	48	2.6±0.3	
	L	M	36	2.8±0.3	*0.000**
	L	F	44	2.5±0.3	
Proximal Latency	R	M	38	6.6±0.4	*0.000**
	R	F	48	6±0.5	
	L	M	36	6.6±0.5	*0.000**
	L	F	44	6±0.4	
Conduction Velocity	R	M	38	69.7±4.6	0.402
	R	F	48	70.9±7.9	
	L	M	36	69.9±4.8	0.342
	L	F		71±6	
Ulnar nerve					
Distal Latency	R	M	36	2.4±0.3	*0.006**
	R	F	43	2.2±0.3	
	L	M	32	2.4±0.3	*0.001**
	L	F	35	2.2±0.2	
Proximal Latency	R	M	36	7.5±0.6	*0.000**
	R	F	44	6.9±0.6	
	L	M	32	7.4±0.6	*0.000**
	L	F	35	6.7±0.6	
Conduction Velocity	R	M	36	67.4±5	*0.001**
	R	F	43	71.9±6	

	L	M	32	68.5±5.6	0.113
	L	F		70.9±6.4	

R- Right , L- Left, M- Male, F- Female
P value- P of mean difference between both sexes
*- significant at p<0. 05 level

Lower proximal and distal latencies of both median and ulnar nerves in females than males were statistically significant (p<0.05). However conduction velocities were faster in females than males but did not differ significantly (p>0.05) except right ulnar motor (Table 1) and left ulnar sensory (Table 2).The differences between left and right sides were obtained from the subjects who had both right and left parameters of the same nerve. There was no statistically significant difference (p<0.05) except ulnar motor velocity in males. There was no statistically significant (p< 0.05) difference between ulnar and median sensory conduction velocities. But higher ulnar motor conduction velocity than that of median was statistically significant (p<0.05) in both sides of females. Sensory conduction velocities were significantly (p<0.001) faster than motor conduction velocities of the same nerve in same side.Correlation analysis was done to determine the correlation between anthropometric and nerve conduction parameters (Table 3).

Table 3:Correlation co-efficient between height and nerve conduction parameters

Parameter	Variable	DL(ms)		PL(ms)		CV(m/s)	
		Male	Female	Male	Female	Male	Female
Right Median Motor	Height	*0.308**	0.158	*0.579**	*0.357**	-0.168	-0.106
Left Median Motor	Height	0.181	0.161	*0.521**	*0.467**	-0.189	- 0.242
Right Ulnar Motor	Height	0.225	0.109	*0.493**	*0.366**	-0.082	-0.068
Left Ulnar Motor	Height	*0.438**	0.000	*0.478**	*0.457**	-0.152	-0.245
Right Median Sensory	Height	*0.514**	*0.238**	*0.725**	*0.371**	-0.305	-0.040
Left Medain Sensory	Height	*0.474**	*0.438**	*0.664**	*0.561**	-0.315	-0.016
Right Ulnar Sensory	Height	*0.383**	*0.318**	*0.614**	*0.431**	-0.132	0.003
Left Ulnar Sensory	Height	*0.374**	0.162	*0.658**	*0.480**	-0.137	0.134

*- significant at p<0.05 level
DL- Distal Latency, PL- Proximal Latency, CV- Conduction Velocity

Statistically significant correlation (p< 0.05) was obtained for with most of the latencies with height. There was no correlation between height and conduction velocities (Table 3). Weight and BMI had no statistically significant correlation with nerve conduction parameters.

Table 4: Comparison of motornerve conduction parameters with other studies

Study	Sex	Age (yrs)	n	Median		Ulnar	
				DL(ms)	CV(m/s)	DL(ms)	CV(m/s)
Garg2013(8)	M, F	20-60	100	3.4±0.2	55.6±2.5	2.3±0.2	63.4±3
Chouhan-2010(9)	M, F	17-20	50	3.5±0.4	58.8±3.6		
Awang -2006(10)	M, F	20-29			57.5±5.7		62.1±4.7
Karnain-2013(1)	M	17-35	50	3±0.4	59.5±1.2	2.6±0.4	59.3±1.5
	F	17-35	50	2.8±0.3	60.1±1.2	2.3±0.2	60.4±1.3
Pawar- 2011(11)	M	18-66	144	3.3±0.5	56.3±4.6	2.3±0.4	58±4.6
	F	18-66	144		56.3±4.7		59±5.2
Shahabuddin-2013(2)	M	27-73	45	3.5±0.5	53.6±0.5	2.4±0.4	55.6±3.3
	F	33-73	45	2.8±0.7	53.6±0.7	2.5±0.3	55.9±3.2
Jayasinghe -2010(7)	M, F	33±12		3.4±0.5	56.6±3.6		56.2±4.4
Balasubramaniam-2014 (14)	M	47.8±13	71			2.3±0.5	57 ±8.7
	F	48± 12.5	201			2 ±0.3	60±8.7
Present study	M	21.4 ± 1.2		3±0.4	62.7±4	2.4±0.3	64.8±5.5
Present study	F	21.7 ± 1		2.6±0.3	61.7±5.4	2.1±0.1	66.6±6.3

M- Male, F – Female, n- number of subjects
DL- Distal Latency, PL- Proximal Latency, CV- Conduction Velocity

Table 5:Comparison of sensory nerve conduction parameters with other studies

				Median		Ulnar	
				DL(ms)	CV(m/s)	DL(ms)	CV(m/s)
Garg2013(8)	M, F	20-60	100	2±0.4	53.4±3.6	1.9±0.2	55.8±4.1
Awang -2006(10)	M, F	20-29			56.5±6.1		53.9±6.3
Karnain-2013(1)	M	17-35	50	2.4±0.1	58±2	2.3±0.2	58.8±1.6
	F	17-35	50	2.4±0.1	59.3±1.9	2.3±0.2	60.1±1.6
Pawar 2011(11)	M	18-66	144		58.4±7.3		57.9±6.3
	F	18-66	144		57.9±6.3		60.8±8
Shahabuddin 2013(2)	M	27-73	45	3±0.6	56.9±3.5	2.9±0.4	56.5±0.5
	F	33-73	45	3±0.5	56.2±3.4	2.9±0.3	56.5±0.7
Jayasinghe2010(7)	M, F	33±12	70		56±6		59.7±5.2
Present study	M	21.4 ± 1.2		2.8±0.2	69.7±4.6	2.4±0.3	64.8±5.5
Present study	F	21.7 ± 1		2.6±0.3	70.9±7.9	2.2±0.3	66.6±6.3

M- Male, F – Female, n- number of subjects

DL- Distal Latency, PL- Proximal Latency, CV- Conduction Velocity

Discussion

Proximal and distal latencies were influenced by gender but not conduction velocities except right ulnar motor and left ulnar sensory. Higher arm length in males may explain the higher latencies in males than females without significant different in velocity. Garg *et al*[8] found no influence of gender on distal latencies and nerve conduction velocities. Ulnar nerve in males is more vulnerable to external compression than females due to low fat content on the medial aspect of the elbow. This could be the reason for significant sex difference in ulnar nerve CV in our study. Significantly faster ulnar nerve CV was reported in previous study in Sri Lankans [6]. Karnain *et al* [1] also reported lower latency in females. However in contrast to our finding motor and sensory conduction velocities of both nerves differed significantly between both sexes. Faster sensory conduction than that of motor is consistent with the finding of Dawson in 1955 that the sensory afferent nerve fibres from the fingers had higher conduction velocity than that of the motor fibre to the small muscles of the hand (15). Conduction time derived from the action potentials were from the fastest motor and sensory fibres. Myelinated nerve fibres are faster than non myelinated fibres. One other factor determines the conduction velocity is diameter of the fibre. Our finding suggests that the diameter of the fastest sensory fibres to the fingers may be larger than the motor fibres to the muscles of the hand.

Statistically significant ($p<0.05$) positive correlation of height with median and ulnar motor latencies is consistent with the finding of Thakur *et al* [12].But in contrast to his finding we did not obtain a significant negative correlation between ulnar motor velocity and height. Awang *et al* [10] also could not obtain any relationship between these two variables. Our mean value for median motor DL is similar to the values reported by Karnain *et al* in both sexes. It is slightly lower than the values of Jayasinghe [7] Garg [8], Couhan [9] Pawar [11]. All the Conduction Velocities were faster in our subjects than previous reports [1, 2, 7, 8, 9, 10, 11]. Age difference of the subjects in the above study may contribute to these differences. Slower conduction with age has been reported by several authors [6, 10, 12]. This may have increased the latencies in the above studies as they have included older population. Ulnar nerve conduction parameters of patients who were investigated for Carpal Tunnel Syndrome was studied in our laboratory [14]. The age-range of the subjects was large as indicated in Table 4. Statistically significant negative correlations (-0.288, -0.306 in males and females respectively) were obtained between ulnar motor CV and age. Our present velocities are higher than those values. This may be due to the influence of age. Also the subjects in that study had symptoms of nerve lesions like pain, numbness, tinkling. Our sample size was comparatively higher than other studies for this particular age group [1, 2, 7, 8, 8, 9, 10, 11] and all the subjects did not have any signs or symptoms suspecting nerve lesions or any diseases which can cause neuropathies.

Conclusion

Our values can be considered in interpretations of upper limb nerve conduction parameters of young adult group in our laboratory which will be useful in better interpretations without false positive or false negative results. But further studies including elder population would be worthy to correlate the nerve conduction parameters with age and to have better values for the population.

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References

1. Wadoo Ovais Karnain,Singh Surjit, Agrawal Bimal K, Kamra Monika & Gupta Sangeeta. Gender effect on upper limb nerve conduction study in healthy individuals of North India. J Pharm Biomed Sci 2013; 33:1589-93.
2. Shaikh Shahabuddin , Daimy Sayad Badar, , Khan Moizuddin, , Sami LB, Solepure AB. Noramtive values for Nerve Conduction Study among healthy subjects from Aurangabad, India. IJRTSAT 2013; 8: 56-61
3. Ralp M Buschbacher. Body mass index effect on common nerve conduction study measurements. Muscle Nerve 1998; 21: 1398-404.
4. Jagga M, Lehri A, Verma SK. Effect of aging and anthropometric measurements on nerve conduction properties – A Review. Journal of Exercise Science and Physiotheraphy 2011; 7: 1-10.
5. Ibraham I, Khan, WS, Goddard N, et al. Carpa Tunnel Syndrome: A Review of the Recent Literature. Open Orthop J 2012; 6: 69-76.
6. Mahinda Kommalage , Sampath Gunawardena . Influence of Age, Gender, and Sidedness on Ulnar Nerve Conduction. J ClinNeurophysiol 2013; 30: 98-101.
7. Jaysinghe SS, Pathirana KD, GunasingheKK. Normative values of motor and sensory nerve conduction studies. Galle Medical Journal 2010; 15: 43-4
8. Ruchika Garg, Nitin Bansal, Harpreet Kaur, Khusdeep Singh Arora. Nerve Conduction Studies in the Upper Limb in the Malwa Region-Normative Data. JCDR 2013; 7: 201-4.
9. Chouhan S. Motor nerve conduction studies of median nerve in young adult group. Int Biol Med Res 2012; 3: 1751-3.
10. Mohamed Saufi Awang, Jafri Malin Abdullah, Mohd Rusli Abdullah, John Tharakan, Atul Prasad, Zabidi Azhar Husin, Ahmad Munawir Hussin, Adnan Tahir and Salmi Abdul Razak. Nerve conduction study among healthy Malays. The influence of age, height and body mass index on median ulnar common peroneal and sural nerves. Malays J Med Sci 2006; 13: 19-23.
11. Sachin M Pawar, Avinash B Taksande , Ramji Singh . Normative data of upper limb nerve conduction in Central India. Indian J Physiol Pharmacol 2011; 55: 241-5.
12. Thakur D, Jha S, Pandey NK, Jha CB, Bajaj BK, Paudel BH. . Influence of height on the nerve conduction study parameters of peripheral nerves. JCDR 2011; 5: 260-3.
13. Thakur D, Paudel BH, Jha CB. Nerve Conduction study in healthy individuals a preliminary age based study. Kathmandu Univ Med J 2010; 8: 311-6.
14. Balasubramaniam M, Sivapalan K, Keshavaraj A. Ulnar nerve conduction parameters and the effect of age and gender on conduction velocity in carpal tunnel syndrome patients. Annual Scientific Sessions of the Physiological Society of Sri Lanka21-22 November 2014,p 20.
15. Dawson GD. The relative excitability and conduction velocity of sensory and motor nerve fibres in man. J Physiol 1956; 131: 436-51.

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