

Evaluation of Motor NCS Parameters between Upper and Lower Limbs and Their Pattern of Maturation in Infants and Children

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Abstract: Peripheral nervous system (PNS) development plays a crucial role for normal motor performance of the child. Maturation of PNS starts before birth and continues till 5 to 6 years of age. Evolution of Peripheral motor nerves as detected by different Nerve Conduction Study (NCS) parameters are different for upper and lower limbs and also varies according to different motor nerves irrespective of extremity. Our aim was to evaluate how much the peripheral motor nerve NCS parameters differed from upper versus lower limbs and their pattern of maturation from birth to 6 years of age. For this a cross-sectional prospective study was undertaken on 63 normal infants and children in the department of Physiology of I.P.G.M. E & R in collaboration with paediatrics department of the same institute and Bangur Institute of Neurology, Kolkata. Compound Muscle Action Potential (CMAP) amplitude and Motor Nerve Conduction Velocity (MNCV) of Median, Ulnar, Tibial and Peroneal nerves were measured and results were analyzed by using SPSS version 20. It was seen that motor NCS parameters varied significantly between upper and lower limbs and also their pattern of maturation towards adult normal values from birth to 6 years of age varied for different motor nerves as depicted by means plot. Tibial was the first motor nerve and Peroneal was the last to attain normal adult values among the nerves. Thus motor NCS parameters not only varies from upper and lower limbs but also their progression towards adult normal values differed from one to another.

Key Words: PNS; NCS; CMAP; MNCV.

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I. Introduction

Infancy and Childhood are the two most important phases of life for anatomical maturation, future development of the peripheral nervous system and the motor performance of the child. Age dependent development of peripheral nervous system begins in utero, under developed at birth and gain maturity at the age of 5 to 6 years⁽¹⁾.

Electrophysiological values of peripheral motor nerves as assessed by nerve conduction studies (NCS) vary accordingly along with age and it differs from adult values. However there is very little information regarding maturation of peripheral motor nerves in infants and children as assessed by NCS. Moreover there was no such available data regarding comparison of evolution of motor nerves in upper and lower limbs in infants and children upto 6 years of age. Standard values of NCS parameters of peripheral motor nerves for both upper and lower limbs are essential for assessing normal development and to diagnose different infantile neuromuscular disorders⁽²⁾.

Hence an effort was made to evaluate the maturation of peripheral motor nerves in infants and children upto 6 years of age by NCS and also to differentiate the pattern of maturation of peripheral motor nerves between upper and lower limbs if any.

II.a. Materials and Methods

A cross-sectional prospective study was conducted in the department of Physiology of IPGME & R in collaboration with Bangur Institute of Neurosciences and department of Pediatrics of IPGME & R, Kolkata on 63 healthy, normal infants and children upto 6 years of age born at term, after getting informed consent from their mothers. NCS was performed on peripheral motor nerves Median and Ulnar in upper limbs and Tibial and Peroneal in lower limbs. Preterm babies, babies of mothers with antepartum and intrapartum complications, babies of mothers having Gestational diabetes, babies with birth asphyxia, sepsis, hyperbilirubinemia were excluded from the study. Results were computed and analyzed by using SPSS version 20. Unpaired t test, means plot were calculated.

II.b. Electrophysiological Methods

Nerve conduction study was performed on selected motor nerves using RMS EMG NCV EP Mark II 2011 computerized machine. No sedation was given to the children and skin temperature kept at 32-34°C. Surface disc recording active electrode was placed on the corresponding muscle and reference disc electrode was on the corresponding tendon after application of conductive jelly. The motor nerves were stimulated by bar pad electrode with pulses of 0.1 msec duration at two points, one proximally and another distally. Ground disc electrode was placed in between the stimulating and recording electrode. Mild abrasion with spirit cotton was used to keep impedance below 5kΩ. For both upper and lower limbs motor nerves Compound muscle action potential amplitude (CMAP) and Motor nerve conduction velocity (MNCV) was recorded.

III. Results and Analysis

Total 63 subjects were taken from (0-6) years of age and they were divided into six groups (Table1).

Table 1: Age and number wise distribution of subjects

Group	Age in months	No of subjects
Gr 1	(0-6)months	8
Gr 2	(6-12)months	9
Gr 3	(12-24)months	11
Gr 4	(24-36)months	11
Gr 5	(36-48)months	11
Gr 6	(48-72)months	13

NCS was performed on all subjects in upper and lower limbs and their values were expressed in mean and standard deviation according to different age groups.

Table 2a: Comparison of motor NCS parameters between upper and lower limbs in (0-6)months of age

Group	Age Group	Motor Nerves	NCS Parameters CMAP (Mean ± SD)	P Value	NCS Parameters MNCV (Mean ± SD)	P Value	
Gr 1 (n=8)	(0-6)months	Median Tibial	4.525±0.5994	0.2760	32.268±2.7933	0.0537*	
		Tibial	4.9875±0.9862		28.794±3.7364		
		Median Peroneal	4.525±0.5994	0.0001*	32.268±2.7933	0.0711	
		Peroneal	1.675±0.4027		29.185±3.483		
		Ulnar Tibial	4.0125±0.7039		32.626±3.1083		0.0426*
		Tibial	4.9875±0.9862		28.794±3.7364		
Ulnar Peroneal	4.0125±0.7039	32.626±3.1083	0.0559*				
Peroneal	1.675±0.4027	29.185±3.483					

Table 2b: Comparison of motor NCS parameters between upper and lower limbs in (6-12) months of age

Group	Age Group	Motor Nerves	NCS Parameters CMAP (Mean ± SD)	P Value	NCS Parameters MNCV (Mean ± SD)	P Value	
Gr 2 (n=9)	(6-12)months	Median Tibial	5.8667±0.7331	0.1562	40.878±3.602	0.0002*	
		Tibial	6.3444±0.6247		32.7±3.7249		
		Median Peroneal	5.8667±0.7331	0.0001*	40.878±3.602	0.0002*	
		Peroneal	2.0667±0.3041		32.722±3.4314		
		Ulnar Tibial	5.4±0.5339		39.535±3.8235		0.0014*
		Tibial	6.3444±0.6247		32.7±3.7249		
Ulnar Peroneal	5.4±0.5339	39.535±3.8235	0.0011*				
Peroneal	2.0667±0.3041	32.722±3.4314					

Table 2c: Comparison of motor NCS parameters between upper and lower limbs in (12-24) months of age

Group	Age Group	Motor Nerves	NCS Parameters CMAP (Mean ± SD)	P Value	NCS Parameters MNCV (Mean ± SD)	P Value	
Gr 3 (n=11)	(12-24)months	Median Tibial	6.2455±0.5502	0.0040*	45.264±2.4606	0.0001*	
		Tibial	7±0.5385		34.745±2.1805		
		Median Peroneal	6.2455±0.5502	0.0001*	45.264±2.4606	0.0001*	
		Peroneal	1.9091±0.27		35.173±1.9734		
		Ulnar Tibial	6.0364±0.5988		38.4±2.4572		0.0015*
		Tibial	7±0.5385		34.745±2.1805		
Ulnar Peroneal	6.0364±0.5988	38.4±2.4572	0.0029*				
Peroneal	1.9091±0.27	35.173±1.9734					

Table 2d: Comparison of motor NCS parameters between upper and lower limbs in (24-36) months of age

Group	Age Group	Motor Nerves	NCS Parameters	P Value	NCS Parameters	P Value
			CMAP (Mean ± SD)		MNCV (Mean ± SD)	
Gr 4 (n=11)	(24-36)months	Median Tibial	6.7455±0.4009	0.0003*	47.636±2.2164	0.0001*
			7.6636±0.5714		37.591±2.0251	
		Median Peroneal	6.7455±0.4009	0.0001*	47.636±2.2164	0.0490*
			2.4545±0.3934		45.691±2.1342	
		Ulnar Tibial	6.9727±0.3849	0.0034*	40.996±2.3584	0.0017*
			7.6636±0.5714		37.591±2.0251	
Ulnar Peroneal	6.9727±0.3849	0.0001*	40.996±2.3584	0.0001*		
		2.4545±0.3934			45.691±2.1342	

Table 2e: Comparison of motor NCS parameters between upper and lower limbs in (36-48) months of age

Group	Age Group	Motor Nerves	NCS Parameters	P Value	NCS Parameters	P Value
			CMAP (Mean ± SD)		MNCV (Mean ± SD)	
Gr 5 (n=11)	(36-48)months	Median Tibial	7.6727±0.662	0.0040*	52.06±1.981	0.0001*
			8.5455±0.5956		41.536±1.4514	
		Median Peroneal	7.6727±0.662	0.0003*	52.06±1.981	0.0015*
			6.5545±0.5165		48.984±1.9315	
		Ulnar Tibial	7.9091±0.4826	0.0123*	44.084±2.1042	0.0035*
			8.5455±0.5956		41.536±1.4514	
Ulnar Peroneal	7.9091±0.4826	0.0001*	44.084±2.1042	0.0001*		
		6.5545±0.5165			48.984±1.9315	

Table 2f: Comparison of motor NCS parameters between upper and lower limbs in (48-72) months of age

Group	Age Group	Motor Nerves	NCS Parameters	P Value	NCS Parameters	P Value
			CMAP (Mean ± SD)		MNCV (Mean ± SD)	
Gr 6 (n=13)	(48-72)months	Median Tibial	9.7583±1.6752	0.0594*	56.375±4.5478	0.0001*
			11.125±1.842		47.725±4.1132	
		Median Peroneal	9.7583±1.6752	0.0001*	56.375±4.5478	0.0014*
			6.996±0.8666		49.998±4.4651	
		Ulnar Tibial	9.1917±1.6489	0.0095*	57.567±4.5316	0.0001*
			11.125±1.842		47.725±4.1132	
Ulnar Peroneal	9.1917±1.6489	0.0003*	57.567±4.5316	0.0003*		
		6.996±0.8666			49.998±4.4651	

Now mean values of MNCV and CMAP of Median,Ulnar, Tibialand Peroneal nerves were expressed in means plot (Fig 1A – Fig 6B)

Figure 1A: Means Plot of Median MNCV in different age groups

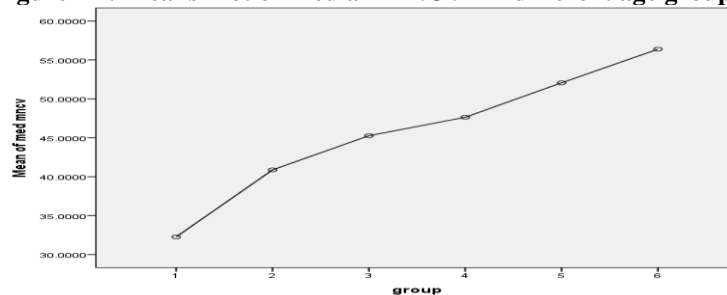


Figure 1B: MeansPlot of Median CMAP in different age groups

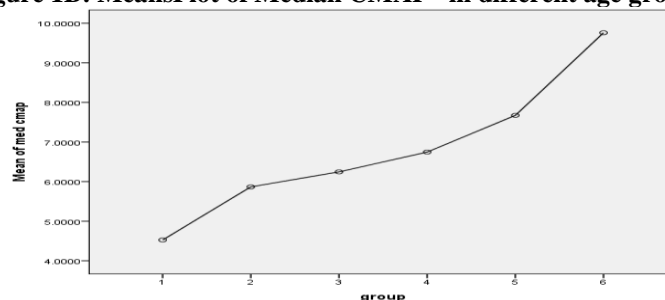


Figure 2A: Means Plot of Ulnar MNCV in different age groups

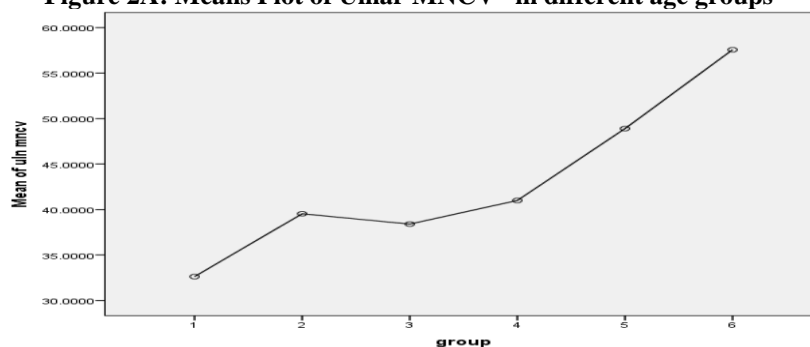
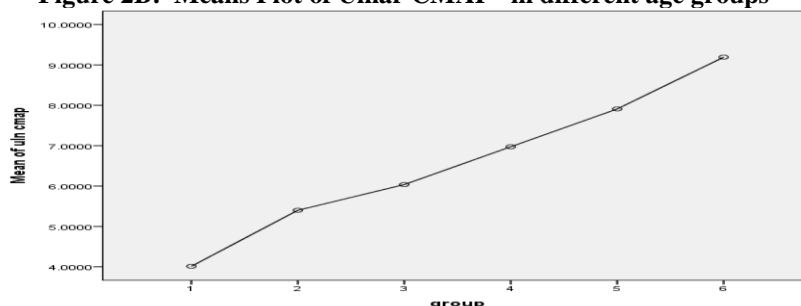


Figure 2B: Means Plot of Ulnar CMAP in different age groups



There was an increase in values of Median MNCV and CMAP amplitude from birth to 6 years of age with steep increase seen between Group 1 and 2. Gradual increase was seen in Group 2 to Group 5, again there was a sharp increase of both value in Group 5 to Group 6 especially in case of Median CMAP. From the (Figure 2A and 2B) it was seen that Ulnar MNCV sharply increased from Group 1 to Group 2, but thereafter the values were almost horizontal in Group 2 to Group 4 and again there was a rapid increase from Group 4 to Group 6. But when Ulnar CMAP was considered it showed gradual increase from Group 1 to Group 6.

Figure 3A: Means Plot of Tibial MNCV in different age groups

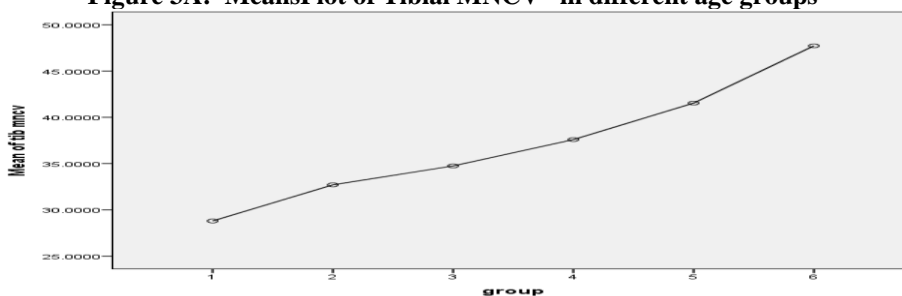


Figure 3B: Means Plot of Tibial CMAP in different age groups

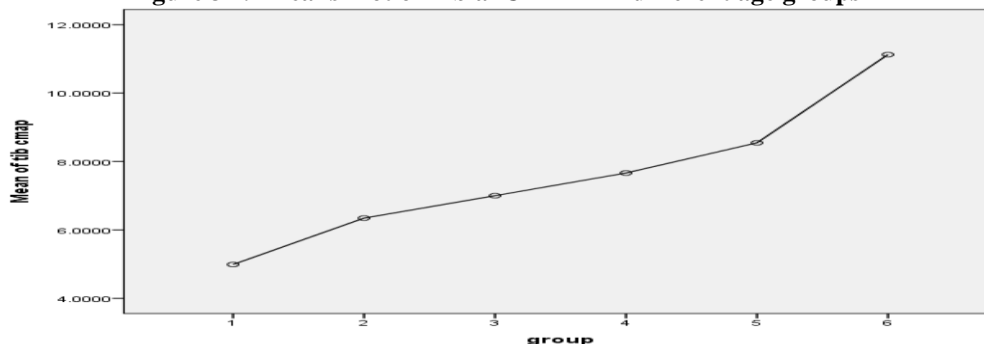


Figure 4A: MeansPlot of Peroneal MNCV in different age groups

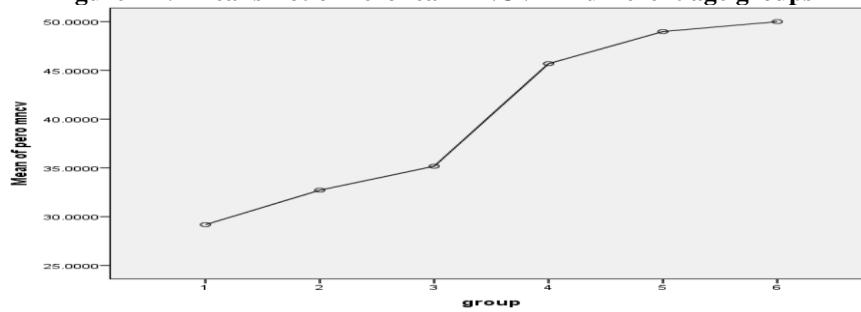
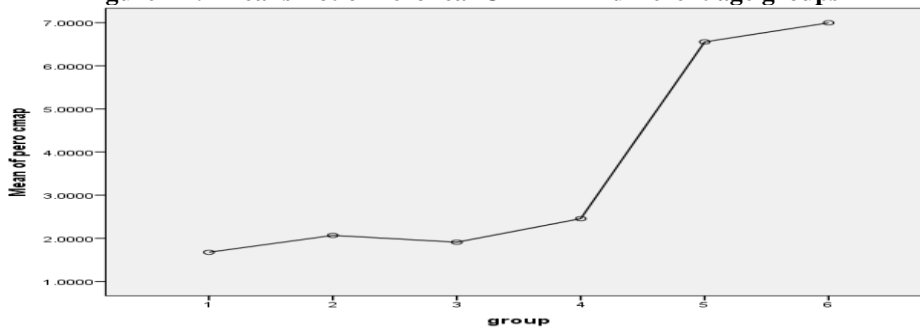


Figure 4B: MeansPlot of Peroneal CMAP in different age groups



There was a gradual increase of MNCV of Tibial nerve from Group1 to Group6, but in case of Tibial CMAP, a sharp increase was seen from Group5 to Group6. For Peroneal MNCV a rapid increase of value was seen from Group 3 to Group 4 but in case of Peroneal CMAP, a very steep increase was seen from Group 4 to Group 5.

From all of these above tables and graph, it had been seen that Compound Muscle Action Potential (CMAP) amplitude and Motor Nerve Conduction Velocity (MNCV) varied significantly for upper and lower limb peripheral motor nerves in all age group from 0 to 6 years of age except for (0-6)months of age for CMAP of Median and Tibial and MNCV of Median and Peroneal nerves. Another exception was seen in (6-12) months of age for CMAP of Median and Tibial nerves. CMAP amplitude and MNCV of respective motor nerves also differed from Group 1 to Group 6.

IV. Discussion and Conclusion

A cross-sectional prospective study was performed on 63 healthy infants and children upto 6 years of age born at term from a relatively uneventful pregnancy. Motor nerve conduction study was performed on Median and Ulnar nerves in upper limbs and Tibial and Peroneal nerves in lower limbs in all age groups. The mean values of different NCS parameters were compared between upper and lower limbs and also in different age groups and their progression pattern towards adult values.

The changes in the peripheral nervous system are most obvious in the first few years of life. It depends on the maturational factors of the peripheral nerves. Maturation factors are important contributors for the evaluation of normal neuromuscular developments in infants and children⁽³⁾. From our study it was seen that in Group 1, mean values of CMAP amplitude and MNCV of respective motor nerves were about half of the normal adult values and the most rapid increase was found during the first year of life. These concur with the previous study done by Cai and Zhang in 1997; Parano et al, 1993; Vecchierini Blineau and Guiheneuc in the year of 1984; Audry Chaboud et al in 1984, Cruz Martinez et al., 1977; Wagner and Buchthal 1972; Gamstorp and Shelburne, 1965; Baer and Johnson, 1965^(4,5,6). Actually peripheral nerve myelination begins usually at 15th week of gestation and continues upto 5 to 6 years of birth. As axonal diameter and myelin thickness are less in children than adults, the ratio of the diameter of an axon without myelin to that of a fully myelinated fiber (G-ratio) is above normal, it is a finding of hypo myelination – particularly seen in first few years of life⁽⁷⁾ which is mainly responsible for low MNCV value and CMAP amplitude at birth upto 5 to 6 years. Throughout this period there is progressive increase in the thickness of the myelin sheath in relation to the axon diameter. Remodeling of the nodes of Ranvier also occurs in first few years of life with internodal distances reaching at its peak at 5 – 6 years, resulting in an adult normal conduction velocity. Gradual increase in the number of large fibers results an increase in the axonal diameter and a gradually completed myelination of nerve fibers leads to progressive increase in nerve conduction velocity seen during infancy and early childhood.

In our study when we compared the NCS parameters for upper and lower limbs motor nerves in infants and children and their pattern of progression towards adult values, we found that among all the motor nerves, Tibial CMAP and MNCV reached towards adult value earliest at 2 years of age followed by Median and Ulnar which were reached by 3 to 4 years of age followed by Peroneal nerve, where normal adult values were reached at the age of 5 to 6 years. Similar picture was also found by other studies done by Miller and Kuntz in 1986⁽⁸⁾, and Guchhait B. et al in 2014⁽⁹⁾.

So, we can conclude that maturation of peripheral motor nerves from birth to 6 years of age not only differs between upper and lower limbs, but the progression pattern of maturation for different peripheral motor nerves parameters as revealed by NCS also varied significantly throughout this time period. Tibial nerve was the first motor nerve to reach normal adult values followed by Median and Ulnar. Peroneal was the last motor nerve among these four to attain normal adult values.

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