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A study of Ulnar nerve conduction velocity in young healthy individuals in relation to isotonic exercise in the Department of Physiology, Gauhati Medical College

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ABSTRACT

Nerve conduction velocity [NCV] test is an important aspect of Nerve conduction study that aids in the diagnosis of various peripheral neuropathies and demyelinating conditions where in the conduction velocities reduces or become non existent.Nerve conduction study primarily includes the assessment of Compound muscle action potential and sensory nerve action potential [SNAP] from accessible parts of the body for peripheral nerves in upper and lower limbs including median,ulnar,radial,commonperoneal,tibial and sural nerves

Aims of the study-To study the ulnar nerve conduction velocity in young healthy individual in relation to isotonic exercise.

Materials and Methods

STUDY DESIGN

The cross sectional study was carried was carried out in 60 healthy individuals in Gauhati Medical College.

INCLUSION CRITERIA

The individuals who were aged between 18 to 25 years were selected.Only after a detail clinical history with the help of standard questioner.

EXCLUSION CRITERIA

The subjects having symptoms of peripheral sensory neural deficits and execessive muscle weakness were excluded . Also subjects with history of chronic alcohol abuse were excluded.

METHOD OF COLLECTION –Nerve conduction study [NCS] comprising of Motor Nerve conduction velocity [MNCV]and Sensory nerve conduction velocity was carried in both hands The NCV parameters that were recorded and studied for both MNCV and SNCV were latency,amplitude and conduction velocities respectively.

Parameters recorded are

1.Median motor nerve conduction velocities

2.Median sensory nerve conduction velocities

3.Ulnar Motor nerve conduction velocities

4.Ulnar sensory nerve conduction

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STASTICAL ANALYSIS

Comparative analysis is done by using ANOVA single factor and student unpaired t test

CONCLUSION

Although the study did not find any significant variation in the parameters of NCS in isotonic exercise but study showed gender variation in NCS parameters

KEY WORDS: Ulnar NCV Demyelination

INTRODUCTION

Nerve conduction velocity (NCV) test is an important aspect of Nerve conduction study (NCS) that aids in the diagnosis of various peripheral neuropathies especially demyelinating conditions wherein the conduction velocities reduces or becomes non-existent. They help in differentiating between demyelinating and axonal degenerative forms of the peripheral nerve diseases. Thus, it is the study of the speed at which an electrochemical impulse propagates down a peripheral neural pathway. The speed of nerve conduction is related to the diameter of the nerve, the degree of myelination and the internodal distance. It has been reported that the larger axon diameter, thicker myelin sheath and longer internodal distance shows a faster nerve conduction velocity[1] . Eichler in 1937 first reported the nerve action potential of Median and Ulner nerve stimulation32. [2]

Nerve conduction study primarily includes the assessment of compound muscle action potential (CMAP) and sensory nerve action potential (SNAP) from accessible parts of the body for peripheral nerves in upper and lower limbs including median, ulnar, radial, common peroneal, tibial and sural nerves. For motor nerve conduction the action potential so produced at the muscle (compound muscle action potential CMAP) is picked up and its onset, latency, duration and amplitude are studied.[3] For sensory nerve conduction - stimulation of sensory nerve will produce electrical activity i.e. the sensory nerve action potential (SNAP), and the study for onset latency, amplitude, duration of SNAP is done.[3]

Hand, wrist and elbow are crucial for everyday activities. Overuse and repeated pressure injuries in hand, wrist and elbow can happen as result of repetitive motions related to work, sports, hobbies, etc. These injuries may be manifested as entrapment syndrome of the median nerve and neuropathy of the ulnar nerve. There is evidence that it can be caused by exposure to biomechanical risk factors such as repetition, force and vibration (especially when combined together).[4] Median nerve entrapment neuropathy manifest mostly as Carpal tunnel syndrome (CTS) and ulnar nerve neuropathy can occur at elbow following repeated minor pressure over the bony condylar groove, at distal forearm

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and wrist following trauma or chronic repetitive ergonomic stress or repeated pressure by tools, handle of cane, crutches etc[5]. The Ulnar nerve also known as "Musician's nerve" because it controls fine movements of fingers [6].

With the advancement of industries, the working hours have increased, and it has led to an increase in stress on the muscles and nerves. Repetitive stressful movements involving peripheral nerves may lead to nerve entrapment, which is often associated with tingling and/ or numbness without pain found in many of computer users.[7]

Aims of the study-To study Ulnar motor nerve conduction and ulnar sensory nerve conduction velocity in young healthy individual in relation to isotonic exercise

Materials and Methods

STUDY DESIGN

The cross sectional study was carried was carried out in 60 healthy subjeets in Gauhati Medical College

INCLUSION CRITERIA

The sujects who were aged between 18 to 25 years were selected.Only healthy individual were included in the study after a detail clinical history with the help of standard questioner

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METHOD OF COLLECTION –Nerve conduction study [NCS] comprising of Motor Nerve conduction velocity [MNCV]and Sensory nerve conduction velocity were carried in both hands

EQUIPMENT AND APPARATUS

A computer system preinstalled with neurostim software

NeuroPerfect EMG2000machine

Surface disc electrodes

Ring Electrodes

Pre amplifier

Medi aid system stimulator

Conducting electrode jelly

Mosso's Ergography

SAMPLE SIZE

The study was carried out in 60 healthy subjects in Guwahati Medical College

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Ulnar NERVE CONDUCTION STUDY AND ISOTONIC EXERCISE

With the help of electrode /conducting jelly ,the recording was placed closed to motor of Abductor Policis Brevis and referance electrode 3cm distal at the metacarpophalangeal joint.The ground electrode is placed between stimulation and recording electrode .A supramaximal stimulation was given at first to wrist and then at below .

The difference between two latent period in msec gives the time taken by the impulses to travel from the elbow to the wrist.The distance between two stimulation point at the wrist and the elbow was taken in mm and median motor nerve conduction velocity in m/sec was calculated .

For isotonic exercise the forearm was fixed properly on the ergograph by means of clamps.The middle finger was put into the loop to be pulled and a weight of 2kg was suspended ,the index finger were inserted into the metal tubes provided in the ergograph . A series of maximal contraction without moving the shoulder at regular interval for 10 minutes and then for 15 minutes was done.A resting time of 5 minutes between each procedure was undertaken .Thus the Ulnar nerve conduction was recorded at rest ,then after 10 minutes of isotonic exercise on the ergograph

Ulnar SENSORY NERVE CONDUCTION STUDY AND ISOTONIC EXERCISE

The Orthodromic conduction recording was done in this case.Here the recording electrode was placed 3cm proximal to the distal wrist crease 3cm proximal to the recording electrode.The ring electrode were placed in the second and third digit and it was used for stimulation of the nerve with the cathode placed at the proximal interphaleangeal .The grounding electrode was placed between stimulating electrode and grounding electrode.Supermaximal stimulation was ring electrode.The onset of latency in msec and the distance betweenstimulating electrode and the recording electrode.

RESULTS AND OBSERVATIONS

The present study titled, " A study of Median nerve conduction velocities in young healthy individuals in relation to isotonic exercise in the Department of Physiology, Gauhati Medical college" was conducted in the department of Physiology, Gauhati Medical College, Guwahati from July 2017 till June 2018.

A total of 60 individuals of age group 18 to 25 years from both genders were selected randomly after a proper clinical history and examination.

The results and observations and relevant data were analysed using the Microsoft Excel, 2007, Graph Pad version 7.0.1. Data have been represented in Mean and standard Deviation (SD) wherever applicable and p value calculated. The results and observations of the study groups

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have been expressed in the form of tables complemented by Pie diagrams, columns, Grapgs, Scatter diagrams etc as per requirement.

DEMOGRAPHIC PROFILES:

The participants were divided accordingly to their gender as shown in the Table 5.1a and Fig 5.1a:

Table 5.1a: showing gender distribution

Gender	Counts	Total
Male	34 (57%)	60
Female	26 (43%)	

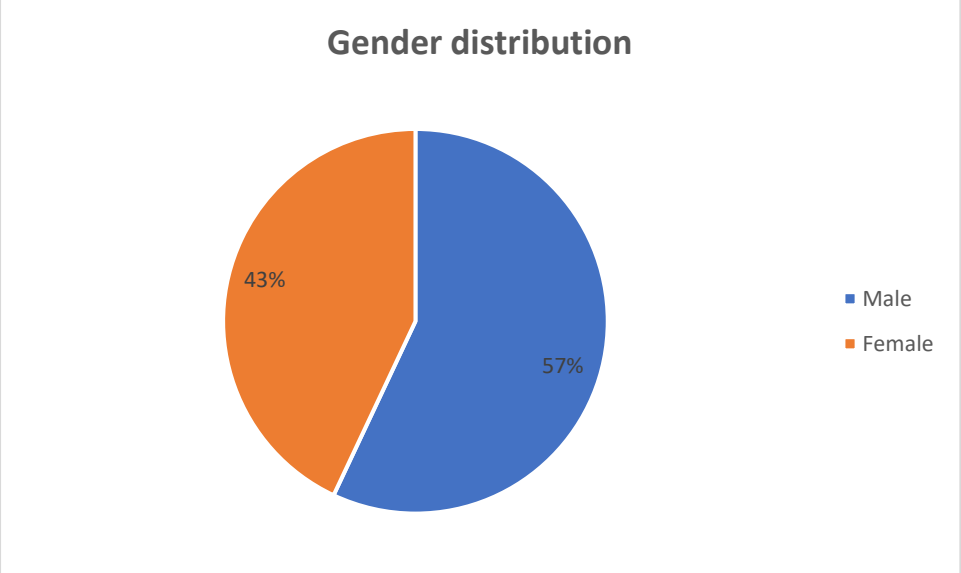

Fig 5.1a: showing percentage of gender distribution

Interpretation: Table 5.1a and Fig 5.1a shows that out of 60 participants 34 were male participants accounting for 57% and 26 were female participanis accounting for 43 %. They were found to fulfil the inclusion criteria necessary for the study.

The mean of the age distribution in years of the participants for both genders were seen to be as shown in table 5.1b and Fig 5.1b:

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Table 5.1b: showing mean age distribution between genders:

Gender	Age in Mean ± SD (years)
Male	21.147±2.0617
Female	19.462±1.2077

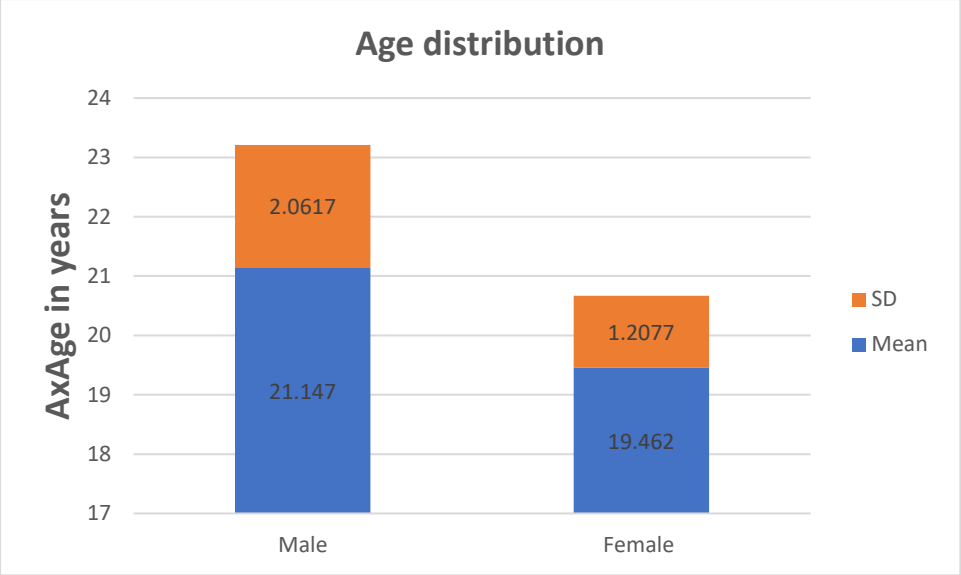

Fig 5.1b : Bar diagram showing mean age distribution for genders

Interpretation: Table 5.1b and Fig 5.1b shows that the mean age of male participants were 21.147± 2.0617 years and that of female participants was 19.462 ± 1.2077 years. Young healthy college going individuals were preferably sought from the age group of 18 – 25 years. The hand dominance pattern of the individuals irrespective of the age and gender are shown in table 5.1c and figure 5.1c.

MEDIAN MNCV IN RELATION TO ISOTONIC EXERCISE /CONTRACTIONS

Table 5.2a : Distal latency (DL) in relation to Isotonic Exercise/Contraction

	Right Ulnar MNCV (ms)			Left Ulnar MNCV (ms)		
	At rest	10 min	15 min	At rest	10 min	15 min
Mean	3.83	3.814	3.806	3.841	3.828	3.827
SD	0.512	0.496	0.493	0.485	0.482	0.494
p value	0.9638			0.986		

N.B. p-value was calculated using ANOVA single factor. SD : Standard Deviation

*p< 0.05 is considered as significant.

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Interpretation : Table 5.2a shows the distal latency in Mean ± SD at rest, after 10 minutes of isotonic exercise and after 15 minutes of isotonic exercise respectively . between each reading a resting time of 5 minutes was undertaken. For right Median MNCV, at rest DL was found to be 3.83 ±0.512, after 10 minutes it was 3.814±0.496 and then after 15 minutes DL was found to be 3.806 ± 0.493 respectively. For left Median MNVC, at rest the DL was found to be 3.841 ± 0.485 , after 10 minutes it was 3.828 ± 0.482 and then after 15 minutes DL was found to be 3.827 ± 0.494 respectively.

The p value was found to be > o.05 in both the cases and hence it was found to be not significant.

Table 5.2b : Amplitude in relation to Isotonic Exercise/Contraction

	Right Ulnar MNCV (μV)			Left UlnarMNCV (μV)		
	At rest	10 min	15 min	At rest	10 min	15 min
Mean	6.902	6.88	6.89	6.909	6.9155	6.909
SD	0.529	0.531	0.532	0,5022	0.5062	0.5277
p value	0.9845			0.9977		

N.B. p-value was calculated using ANOVA single factor. SD : Standard Deviation

*p< 0.05 is considered as significant.

Interpretation : Table 5.2bshows the amplitude in Mean ± SD at rest, after 10 minutes of isotonic exercise and after 15 minutes of isotonic exercise respectively . between each reading a resting time of 5 minutes was undertaken. For right Median MNCV, at rest the amplitude was found to be 6.902±0.529, after 10 minutes it was 6.88±0.531 and then after 15 minutes amplitude was found to be 6.89 ± 0.532 respectively. For left Median MNVC, at rest the amplitude was found to be 6.909 ± 0.0.5022 , after 10 minutes it was 6.9155 ± 0.5062 and then after 15 minutes amplitude was found to be 6.909 ± 0.5277 respectively.

The p value was found to be > o.05 in both the cases and hence it was found to be not significant.

Table 5.2c : NCV in relation to Isotonic Exercise/Contraction

	Right Ulnar MNCV (m/s)			Left Ulnar MNCV (m/s)		
	At rest	10 min	15 min	At rest	10 min	15 min
Mean	55.014	55.201	55.298	54.778	55.003	55.239
SD	4.178	4.128	4.219	3.951	3.918	4.037

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p value	0.9309	0.81673

N.B. p-value was calculated using ANOVA single factor. SD : Standard Deviation

*p< 0.05 is considered as significant.

Interpretation : Table 5.2c shows the NCV in Mean ± SD at rest, after 10 minutes of isotonic exercise and after 15 minutes of isotonic exercise respectively . between each reading a resting time of 5 minutes was undertaken. For right Median MNCV at rest NCV was found to be 55.014± 4.178, after 10 minutes it was 55.201± 4.128 and then after 15 minutes NCV was found to be 55.298 ± 4.219 respectively. For left Median MNVC, at rest the NCV was found to be 54.778± 3.951, after 10 minutes it was 55.003 ± 3.918 and then after 15 minutes NCV was found to be 55.239 ± 4.037 respectively.

The p value was found to be > o.05 in both the cases and hence it was found to be not significant.

Table 5.3a : Median MNCV in Mean ± SD between male and female:

	Distal latency (ms)	Amplitude (µV)	NCV (m/s)
Male (n= 34)	4.1747 ±0.3297	6.5718 ±0.33875	53.03875±2.8499
Female (n= 26)	3.3979± 0.3189	7.3338± 0.3494	57.602± 4.2648
Df	53	54	39
p value	0.001	0.001	0.001

NB: p value was calculated using unpaired t-test. * p<0.05 is considered as significant.

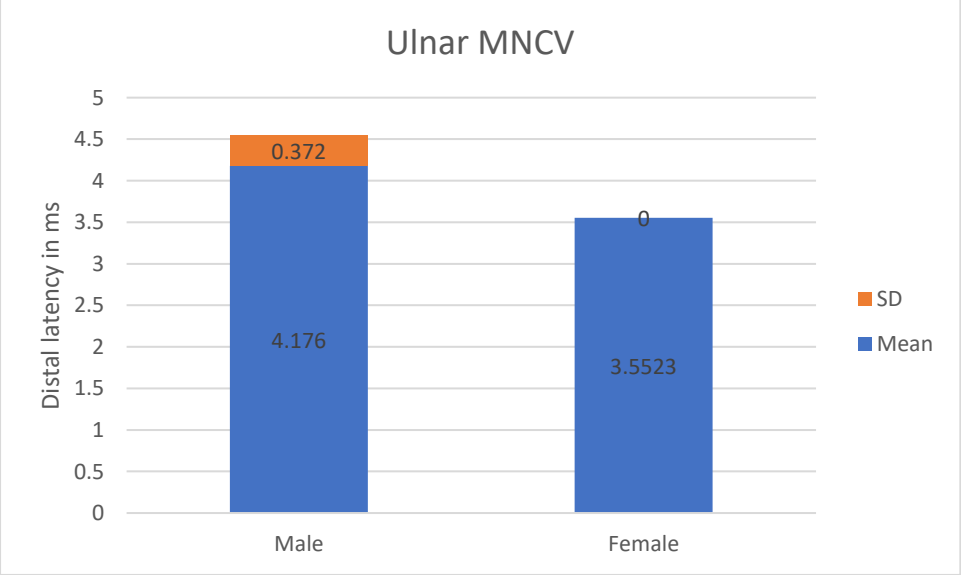

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Fig 5.3a : Bar diagram showing distal latency in mean ±SD in males and females.

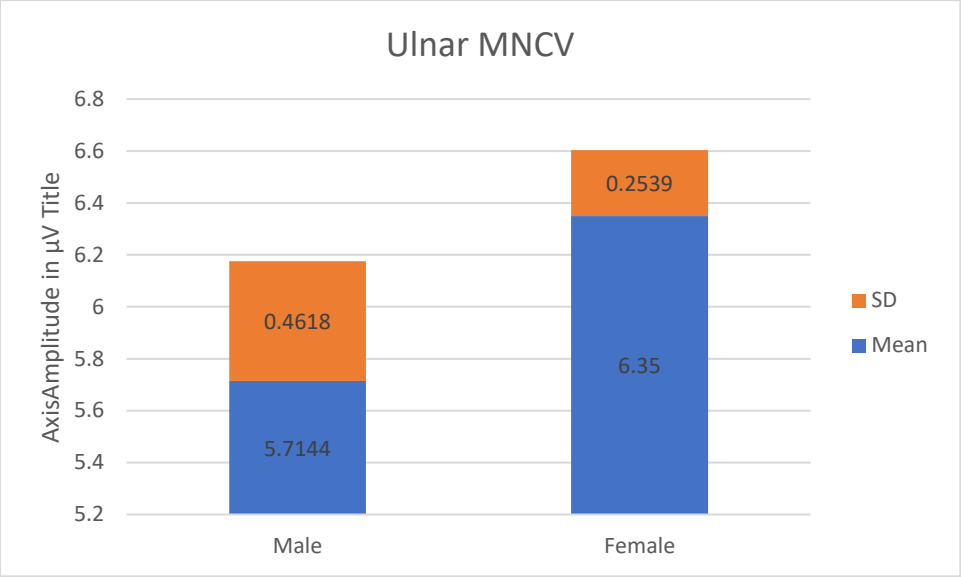

Fig 5.3b: Bar diagram showing amplitude in mean ±SD in males and females.

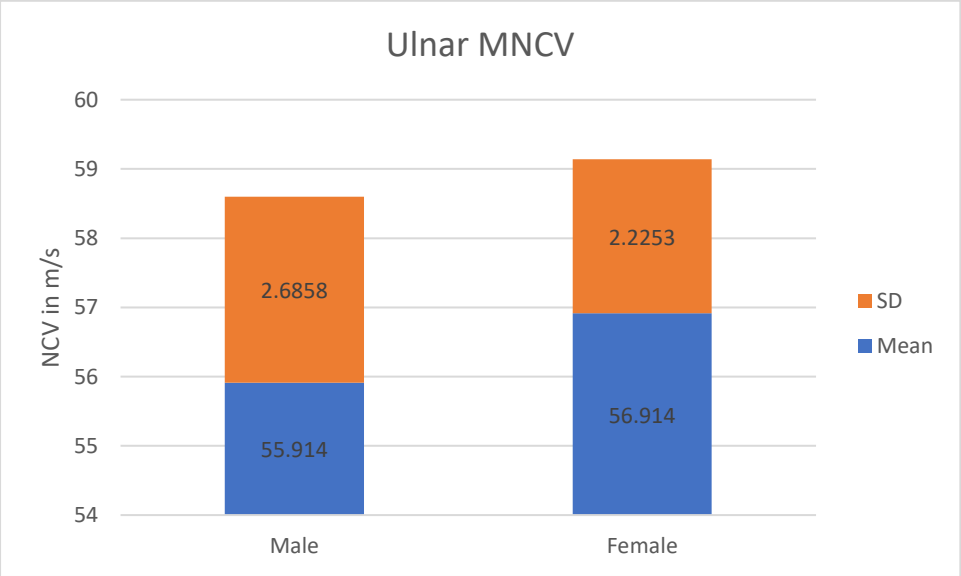

Fig 5.3c: Bar diagram showing conduction velocity in mean ±SD in males and females.

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Interpretation : Table 5.3a, Fig 5.3a, 5.3band 5.3c showst he Median MNCV in mean ±SD for distal latency in ms, amplitude in µV and NCV in m/s. For males, the distal latency was found to be 4.176± 0.372, the amplitude was 5.7144±0.0.4618 and NCV was found to be 55.914±2.6858respectively. For Females, the distal latency was found to be 3.5523± 0.248, the amplitude was 6.35±0.2539 and NCV was found to be 56.914±2.2253 respectively. The df (degree of freedom) was found to be 55 for latency, 51 for amplitude and 56 for the NCV respectively.

The p value for ulnar NCV was found to be < 0.05 and hence considered significant, the distal latency in case of males was found to be significantly higher than the females whereas amplitude and NCV parameters were significantly higher in females than in males.

MEDIAN SNVC IN RELATION TO ISOTONIC EXERCISE/CONTRACTIONS

Table 5.4a : Distal latency (DL) in relation to Isotonic Exercise/Contraction

	Right Ulnar in SNCV (ms)			Left Ulnar SNCV (ms)		
	At rest	10 min	15 min	At rest	10 min	15 min
Mean	2.3657	2.3533	2.3475	2.3475	2.3373	2.3533
SD	0.3886	0.3846	0.3869	0.3869	0.3864	0.3846
p value	0.966			0.9725		

N.B. p-value was calculated using ANOVA single factor. SD : Standard Deviation

*p< 0.05 is considered as significant.

Interpretation : Table 5.4a shows the distal latency in Mean ± SD at rest, after 10 minutes of isotonic exercise and after 15 minutes of isotonic exercise respectively . between each reading a resting time of 5 minutes was undertaken. For right Ulnar SNCV, at rest DL was found to be 2.3657 ±0.3886, after 10 minutes it was 2.3533±0.3846 and then after 15 minutes DL was found to be 2.3475 ± 0.3869 respectively. For left Ulnar MNVC, at rest the DL was found to be 2.3475 ± 0.3869 , after 10 minutes it was 2.3373 ± 0.3864 and then after 15 minutes DL was found to be 2.3533 ± 0.3846 respectively.

The p value was found to be > o.05 in both the cases and hence it was found to be not significant.

Table 5.4b : Amplitude in relation to Isotonic Exercise/Contraction

	Right Ulnar SNCV (µV)			Left Ulnar SNCV (µV)		
	At rest	10 min	15 min	At rest	10 min	15 min

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Mean	4.126	4.1324	4.1362	4.1322	4.138	4.1325
SD	0.4971	0.4925	0.5265	0.4969	0.4908	0.4925
p value	0.908			0.997		

N.B. p-value was calculated using ANOVA single factor. SD : Standard Deviation

*p< 0.05 is considered as significant.

Interpretation : Table 5.4 b shows the amplitude in Mean ± SD at rest, after 10 minutes of isotonic exercise and after 15 minutes of isotonic exercise respectively . between each reading a resting time of 5 minutes was undertaken. For right Ulnar SNCV, at rest the amplitude was found to be 4.126±0.4971, after 10 minutes it was 4.1324±0.4925 and then after 15 minutes amplitude was found to be 4.1362 ± 0.5265 respectively. For left Ulnar MNVC, at rest the amplitude was found to be 4.1322 ± 0.0.4969 , after 10 minutes it was 4.138± 0.4908 and then after 15 minutes amplitude was found to be 4.1325 ± 0.4925 respectively.

The p value was found to be > o.05 in both the cases and hence it was found to be not significant.

Table 5.4c : NCV in relation to Isotonic Exercise/Contraction

	Right Ulnar SNCV (m/s)			Left Ulnar SNCV (m/s)		
	At rest	10 min	15 min	At rest	10 min	15 min
Mean	50.871	51.196	51.283	51.283	51.658	51.196
SD	3.4319	3.5341	3.4985	3.4985	3.74	3.5341
p value	0.7851			0.7395		

N.B. p-value was calculated using ANOVA single factor. SD : Standard Deviation

*p< 0.05 is considered as significant.

Interpretation : Table 5.4 c shows the NCV in Mean ± SD at rest, after 10 minutes of isotonic exercise and after 15 minutes of isotonic exercise respectively . between each reading a resting time of 5 minutes was undertaken. For right Ulnar SNCV, at rest the NCV was found to be 50.871± 3.4319, after 10 minutes it was 51.196±3.5341 and then after 15 minutes NCV was found to be 51.283 ± 3.4985 respectively. For left Ulnar SNVC, at rest the NCV was found to be 51.283± 3.4985 , after 10 minutes it was 51.658 ± 3.74 and then after 15 minutes NCVwas found to be 51.196 ± 3.5341 respectively.

The p value was found to be > o.05 in both the cases and hence it was found to be not significant.

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Table 5.5a : Ulnar SNCV in Mean ± SD between male and female:

	Distal latency (ms)	Amplitude (µV)	NCV (m/s)
Male (n= 34)	2.5906± 0.3377	3.827±0.377	50.411±4.0526
Female (n= 26)	2.0715± 0.217	4.517± 0.337	51.473± 2.335
Df	55	54	53
p value	0.001	0.001	0.0413

NB: p value was calculated using unpaired t-test. * p<0.05 is considered as significant.

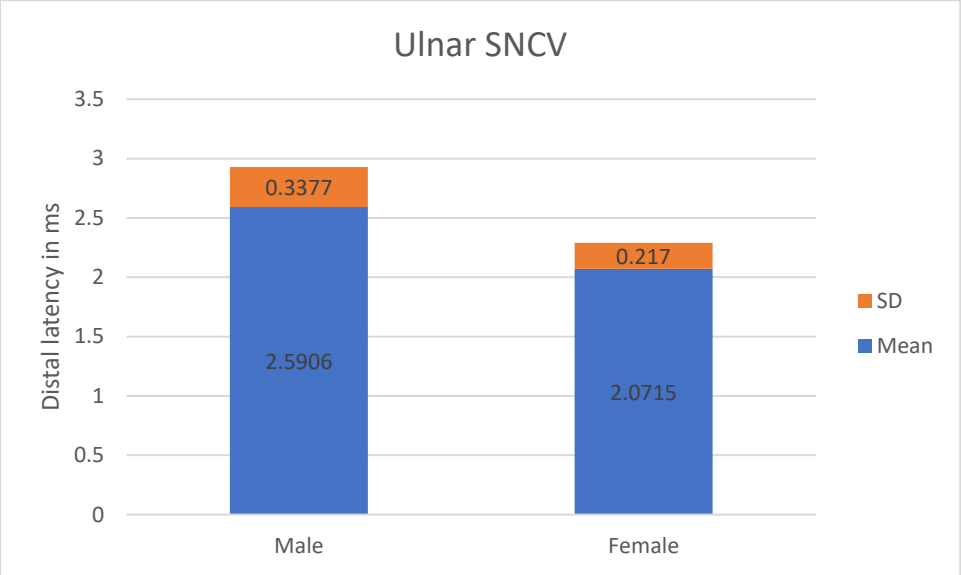

Fig 5.5a : Bar diagram showing distal latency in mean ±SD in males and females.

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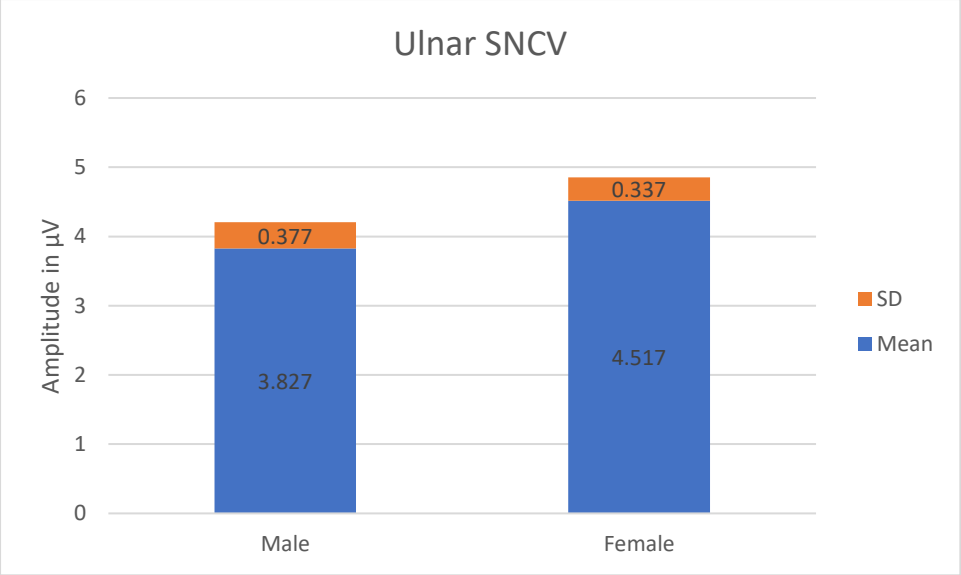

Fig 5.5b: Bar diagram showing amplitude in mean ±SD in males and females.

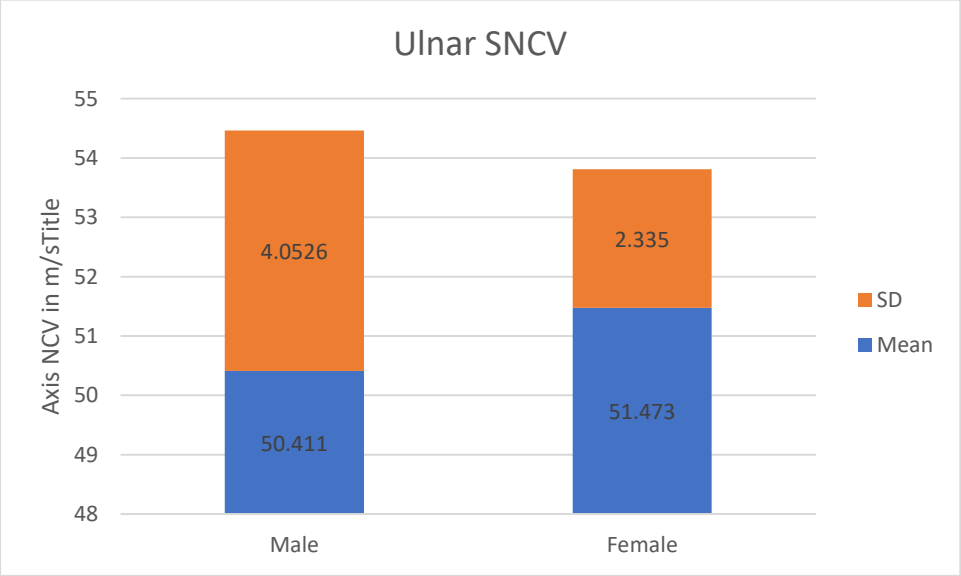

Fig 5.5c : Bar diagram NCV in mean ±SD in males and females.

Interpretation : Table 5.5a, Fig 5.5a, 5.5b and 5.5c shows the Ulnar SNCV in mean ±SD for distal latency in ms, amplitude in µV and NCV in m/s. For males, the distal latency was found to be 2.5906± 0.3377, the amplitude was 3.827±0.0.377 and NCV was found to be 50.411± 4.0526 respectively. For Females, the distal latency was found to be 2.0715± 0.217, the amplitude

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was 3.827±0.0.377 and NCV was found to be 51.473±42.335 respectively. The df (degree of freedom) was found to be 55for latency, 54 for amplitude and 53 for NCV respectively.

The p value for NCV was found to be<0.05 for distal latency, amplitude and NCV for Ulnar NCV therefore was considered as significant.

Whereas p value for distal latency and amplitude was found to be < 0.05 and hence considered significant. The distal latency in case of males was found to be significantly higher than the females. However amplitude and NCV were significantly higher in females than in males.

DISCUSSION

The present study entitled "A STUDY OF Ulnar NERVECONDUCTION VELOCITIES IN YOUNG HEALTHY INDIVIDUALS IN RELATIONTO ISOTONIC EXERCISE IN THE DEPARTMENTOFPHYSIOLOGY, GAUHATI MEDICAL COLLEGE" was undertaken to measure, compare and provide an overview of how NCV parameters of upper limb responds to isotonic exercise/ contractions and to see any changes (whether increasing or decreasing) that may take place following isotonic exercises/ contractions. The study was carried out on 60 young healthy individuals who met the inclusion criteria in the Department of Physiology, Gauhati Medical College, Guwahati. The ulnar nerves of upper limb was considered for the study as they are involved in the coarse and the fine movements.[8]

The purpose of the study was to see any changes that takes place in NCV parameters following isotonicexercises/ contractions and to provide an overview of how the NCV parameters responds to isotonic exercise/ contractions. The Nerve Conduction study was done, and three consecutive readings were taken i.e. 1st reading at rest, followed by 2nd reading after 10 minutes of isotonic exercise on ergograph and the 3rd reading following 15 minutes of ergographic exercise. A 5 minutes rest time was allotted in between each reading to allow adequate rest to the muscles. Also, to see the variations in NCV parameters of males and females. The NCV parameters that were studied comprised of Ulnar MNCV and SNCV. The parameters recorded under MNCV Was CMAP (compound muscle action potential) for distal latencies, amplitudes and NCV, the parameters recorded under SNCV were SNAP (sensory nerve action potential) distal latencies, and potential) NCV [1]

In the present study there was no significant variation (either increasing or decreasing) seen in the NCS (Nerve conduction Study) parameters for distal latencies, amplitudes and NCV for both Median and

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Ulnar MNCV and SNCV following isotonic exercise/ contractions for 10 minutes and 15 minutes. This was evident by p value of >0.05.

A study done by Ozbek et al in 2006 with the purpose of determining that whether asymptomatic volleyball players presented with a distinct variation of nerve conduction of the ulnar nerve at the elbow in contrast to non-active controls found that the nerve conduction velocity at the above to below elbow segment of the motor nerve were slower in the volleyball players but no statistical differences in latencies and conduction velocity was found of the ulnar nerve on the forearm, both in the volleyball players and the controls. They suggested that the possible reason for slowing of ulnar nerve conduction at the elbow may have been due to subclinical entrapment neuropathy because of strenuous elbow movements[9].

However, it is also reported that pressure injuries in hand, wrist and elbow can happen as a result of overuse and repeated pressure over the points where nerves pass by; these injuries can manifest as entrapment syndromes and hence cause lowering of nerve conduction.[4] Also, the ulnar nerve in the distal forearm, wrist and hand has been reported to be damage by repetitive ergonomic stress, repeated pressure by tools, handles of canes, crutches etc. [1,5,7,8]

Yet in another study done by Ganeriwal et al on computer users, they found a significant decrease in the nerve conduction parameters of both median and ulnar nerves as compared to non-computer user. They suggested that the reduction in the conduction velocity resulted from repeated friction and tension leading to inflammatory changes which in turn hampers the normal functions of the nerve and axoplasmic transport.[4] Further it was hypothesised that the decreased in the nervous function may be aggravated by impaired local vascular perfusion.[7,10] A similar result was obtained by Murata et al wherein the computer operators at least worked for more than 6 hours on computers.[11] But Sanden et al found no such significant variation in the median nerve conduction velocity.[12]

In the present study the variations of NCV parameters to gender were also compared and studied. We found significant variations in the ulnar NCV parameters. In Ulnar NCV parameters we found the distal latencies to be longer in males, amplitude higher mean for females and the conduction velocity significantly faster in females than males.

A similar result was documented by Misra and Kalita where they reported that females have shorter latency and higher nerve conduction velocity compared to males.[1] Misra and Kalita also report that

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SNAP amplitude in females were higher compared to males and this had been attributed to lower digital circumference in females resulting in lower subcutaneous tissue-to-nerve tissue ratio.[1] Stenson et al., in 1992 found no association between sex and median or ulnar nerve conduction measures that could be attributed to the co-relation between sex. [13] Samol et al., in 2016 reported that latencies of both the Median and Ulnar nerves for motor and sensory were observed to be longer in males than females but the motor distal latency difference was statistically insignificant. [14] A similar result was obtained by Gakhar et al in 2013, wherein they found that the latencies of both median and ulnar nerves for motor and sensory were longer in males than females. The amplitude was higher in females and the conduction velocity faster in female than males.[15]

Conclusion

The present study was undertaken to provide an overview of how peripheral nerves responds to isotonic exercises/contractions and to see any variations in the NCS parameters in relation to gender of the individuals.

The study did not find any significant variations in the parameters of NCS in relation to isotonic exercises/contractions. However, the study did manage to find a significant variation in the distal latencies which tended to be longer in males as compared to females.

The study had various limitations as it was across-sectional study implementing a cross-sectional analysis to find out the response of Median nerve to short duration of isotonic exercises/contractions. Also various confounding factors such as duration of exposure to isotonic exercises/contractions, age height, BMI, temperature etc needs to be included and adjusted for the statistical accuracy in the study to find out the changes in the variables independent of these factors.

Moreover the sample size (n=60) was small which further limited the results of the study appropriately.

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