Article published online: 2023-06-13

Arm Length—Does It Influence Late Response in a Nerve Conduction Study?

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J Lab Physicians 2023;15:493–497.

Abstract

Introduction F wave response, a late response obtained from a motor nerve, can be influenced by various external factors like gender, temperature, height, weight, and limb length, and hence it causes variation in the measured parameters. Since very few studies have studied the impact of arm length on the F wave, this study was conducted to analyze the relation between the arm length on various parameters of F wave and hence to consider the importance of it during conduct of a nerve conduction study.

Methods The study was conducted among 40 healthy individuals and 40 diabetics with neuropathy. The arm length was measured in the upper limbs in both the groups and F wave was recorded following a conventional procedure using a standardized instrument.

Results This study showed that in the upper limbs of both the groups, there existed a positive correlation for certain parameters like minimum, maximum and mean latencies, persistence, FM latency and M latency, and a negative correlation for chronodispersion.

Conclusion F wave parameters should be adjusted for arm length to improve the sensitivity and diagnostic ability of neurological testing.

Keywords
- F wave
- arm length
- F minimum latency
- peripheral neuropathy

Introduction

In the present-day lifestyle, there are lot of neurological disorders that are emerging among all age groups. These neuronal damages pose a great impact on the quality of life. However, studies have shown that these disorders when detected early can be appropriately treated to provide a better outcome. With the advent of numerous technologies, electrophysiological studies like nerve conduction studies (NCS) would help in confirming a particular diagnosis of a nerve lesion, in addition to good history taking and physical examination. NCS can be used to identify neuropathy (focal, generalized, demyelinating, axonal), radiculopathy, diseases involving neuromuscular junction, motor neuron disease, or sensory neuronopathy.[1] However, the accuracy in NCS has to

received
July 4, 2022
accepted after revision
January 5, 2023
article published online
June 13, 2023

DOI https://doi.org/10.1055/s-0043-57229.
ISSN 0974-2727.

Thieme Medical and Scientific Publishers Pvt. Ltd., A-12, 2nd Floor, Sector 2, Noida-201301 UP, India

be kept in mind so that the diagnostic ability of NCS will not get compromised.

NCS is a simple, noninvasive method that can be used to assess the neuronal damage by applying mild electrical pulses over various points in the skin. These tests though slightly uncomfortable are relatively safe and well tolerated by the subjects when properly instructed. Studies have shown that various factors like age, gender, height, weight, temperature, myelination, and limb length can alter the parameters of NCS.[2–8] However, hardly few studies are available that could show the influence on the arm length on the NCS parameters.[2,3,9] This suggests that conscious consideration of these external factors along with a standardized technique followed during performance will help in preventing various sources of error and improve the diagnostic quality of NCS.

In the study we performed, we constructed an index—F wave index making use of the various parameters of a late response called F wave. F wave was a late response elicited following a motor response when a motor neuron is supramaximally stimulated. The stimulus travels to the spinal cord and again reaches the muscle thereby stimulating even the smallest nerve root. This compound action potential thus obtained can aid in the early identification of proximal nerve lesions.[1,10–13] To increase the diagnostic ability of the F wave in neuropathic subjects, we constructed an index making use of all parameters of F wave and the parameters were adjusted for arm length considering the fact that arm length could remain as a source of error. Also, there a barely any studies that have shown the influence of arm length on the F wave.[2,3,9] So, this study aimed to find the relation between arm length and the various parameters of median nerve F wave of healthy subjects and diabetics with peripheral neuropathy.

Methodology

After obtaining the institutional ethical clearance, the cross-sectional study was performed in a tertiary care hospital from January 2012 to January 2013. The study included males aged between 30 and 50 years. The age and gender matched study group included healthy individuals and subjects who were confirmed with the clinical diagnosis of diabetic peripheral neuropathy using Toronto clinical score. This score was used only to identify the individuals with diabetic peripheral neuropathy based on presence of certain clinical features like unpleasant, unusual, or abnormal sensation such as burning pain, electric shock-like sensations, tingling, pins and needles formication, prickly feeling, and cramp like sensation in the upper limb. The healthy study individuals were recruited from the relatives of the patients attending the various outpatient departments and were screened for the absence from various comorbidities. Those with a history of Guillain-Barré syndrome, carpal tunnel syndrome, neuromuscular disorder, hypothyroidism, myopathy, fracture of upper limb bones, and those who had implanted pacemakers were excluded from both the study groups. The study was conducted among diabetic peripheral neuropathy since it is the most common metabolic disorder with high prevalence in developing countries. Also, due to logistic feasibility, median nerve was chosen for the study. We preferred to conduct the study only in the median nerve. The sample size was calculated based on an earlier study15 (α—5%, β—10%, power—90%, standard deviation—2.79 and precision—2 millisecondsec).[14] So, there were 40 subjects in each group. Maintaining a standard temperature of 22°C in the laboratory, the F wave NCS was recorded from the median nerve of both upper limbs by applying a supramaximal stimulus. The F wave response was traced following a standard procedure in a belly tendon montage making use of a digitalized nerve conduction/electromyography/evoked potential machine (Aleron, Recorders Medicare systems, Chandigarh, India)[15,16] (►**Fig. 1**) Individuals who were clinically confirmed to have myopathy, neuromuscular injury/disorders, carpal tunnel syndrome, hypothyroidism, Guillain-Barré syndrome, upper limb bone fracture, and individuals with pacemakers were excluded from the study.

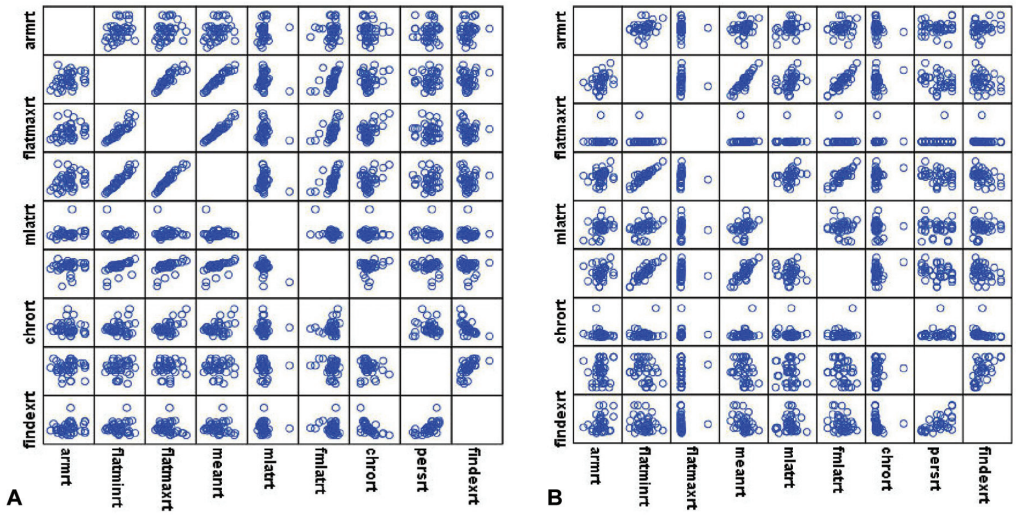

Fig. 1 Correlation between arm length and F wave parameters in the right arm of (**A**) controls and (**B**) diabetics.

Table 1 Demographic details of controls and patients with peripheral neuropathy

Parameters	Controls ($n = 40$)	Cases ($n = 40$)
	Mean ± SD	Mean ± SD
Age (y)	40.40 ± 6.58	42.70 ± 6.02
Height (cm)	165.75 ± 5.68	160.18 ± 24.13
Weight (kg)	62.92 ± 10.87	62.97 ± 10.40
BMI (kg/m^2)	23.66 ± 2.40	23.31 ± 3.45

Abbreviations: BMI, body mass index; SD, standard deviation.

Table 2 Mean and SD of the arm length of both upper limbs in both the groups

	Arm length right		Arm length right	
	Mean	SD	Mean	SD
Controls	73.63	3.01	73.19	3.09
Cases	72.9	2.03	72.73	2.23

Making use of an inch-tape, the arm length of the study individuals was measured in an abducted arm (20 degrees), beginning from the center of the spinous process of the seventh cervical bone to the tip of the ulnar styloid process.[17]

Statistical Analysis

The data were analyzed using Statistical Package of Social Sciences, version 21.0, (SPSS Inc, Chicago, Illinois, United States). Mean, standard deviation, median, and interquartile range of F wave parameters were tabulated. Pearson correlation was used to find the relation between the arm length of both the arms and the various parameters of F wave in both the groups.

Results

The demographic parameters of the study individuals are described in ►**Table 1.**

The mean and standard deviation for the arm length is tabulated in ►**Table 2**.

The correlation between the arm length and the F wave parameters are shown in ►**Tables 3** and **4**.

Discussion

NCS are major electrophysiological studies which that in the diagnosis of existence, distribution, and severity of neuronal damage. F waves form an integral part of NCS that will find its clinical utility in identifying the functioning of proximal motor nerve.

This study aimed at finding how arm length influenced various parameters of F wave like minimum latency (Fminlat), maximum latency (Fmaxlat), mean latency (Fmeanlat), chronodispersion (chrono), persistence (persis), FM latency (fmlat), and also its effect on M latency (mlat).

In the control group, the mean arm length in the right upper limb was 73.63 ± 3.01 cm and in the left arm was 73.19 ± 3.09 cm. In the diabetic group, the arm length in the right arm was 72.9 ± 2.03 cm and in the left arm it was 72.73 ± 2.23 cm (►**Table 2**).

The study showed that among controls, the right arm length had a significant positive correlation with the minimum latency of F wave, a weak positive correlation with maximum and mean latency of F wave, persistence, FM latency, and M latency but showed a negative correlation with the chronodispersion of F wave. Also in the left upper limb, there was a significant positive correlation with the minimum latency of F wave, a weak positive correlation with maximum and mean latency of F wave, persistence and FM latency but showed a negative correlation not only with the chronodispersion of F wave and also with M wave latency (►**Tables 3** and **4**).

When the diabetic peripheral neuropathy individuals were tested, there was a significant positive correlation with the M latency, weak positive correlation with the minimum, maximum and mean F wave latencies and persistence of F wave and a negative correlation between the arm length and the chronodispersion of F wave in the right arm.

In the left arm of diabetic peripheral neuropathy individuals, there was a weak positive correlation with the minimum, maximum and mean F wave latencies, persistence and chronodispersion of F wave, and also with the M latency (►**Tables 3** and **4**) and (►**Figs. 1** and **2**).

Table 3 Correlation between arm length and F wave parameters in the right upper limb of both the groups

Arm length rt	Fminlatrt	Fmaxlatrt	Fmeanlatrt	Chronort	Persisrt	fmlatrt	mlatrt
Controls	0.328[a]	0.242	0.288	−0.094	0.034	0.102	0.211
Cases	0.305	0.007	0.236	−0.208	0.088	0.163	0.335[a]

[a]Statistically significant positive correlation.

Table 4 Correlation between arm length and F wave parameters in the left upper limb of both the groups

Arm length lt	Fminlatlt	Fmaxlatlt	Fmeanlatlt	Chronolt	Persislt	fmlatlt	mlatlt
Controls	0.321[a]	0.039	0.187	−0.292	0.055	0.15	−0.014
Cases	0.154	0.124	0.146	0.046	0.061	0.122	0.151

[a]Statistically significant positive correlation.

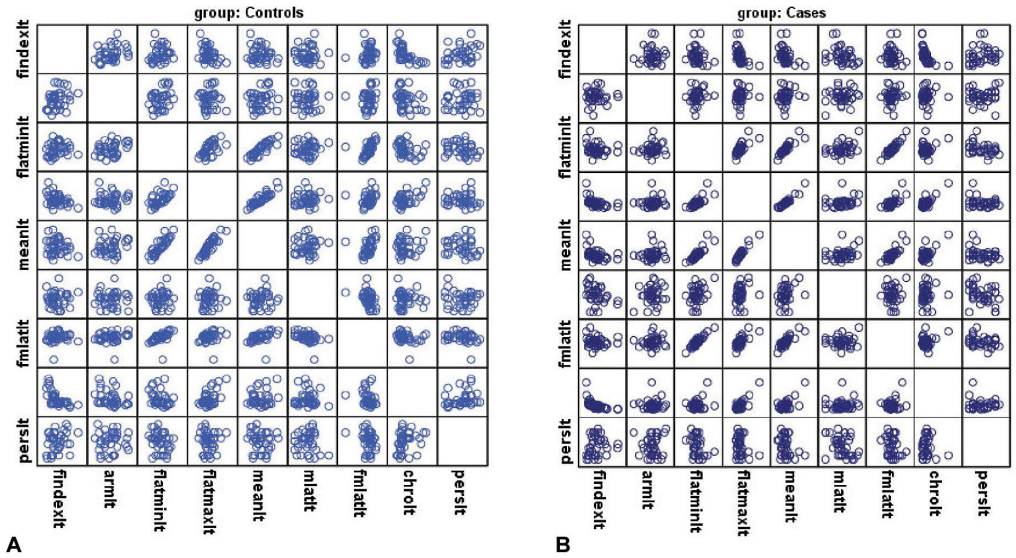

Fig. 2 Correlation between arm length and F wave parameters in the left arm of (**A**) controls and (**B**) diabetics.

Conclusion

This study was conducted with the purpose to explore the influence of arm length on the NCS with special concern to the F wave, a late response. There were contrasting findings in other studies with respect to the impact of arm length on the NCS. The present study showed that there existed a minimal to significant influence of arm length on the conventional used parameters of F wave. So, it would be better to consider the arm length while performing late response studies. F wave studies when done after correcting its various parameters for arm length and then conducted in a temperature-controlled environment with a standardized procedure will be of great utility in the clinical setting.

Limitations of the Study

The study was performed only among males and recording was done only in the median nerve. In future, studies involving both males and females can be performed. Also, the arm length can be related to the F wave parameters obtained from the other upper limb nerves. Similarly, lower limb length and its relation to F wave parameters in all the all the lower limb nerves might yield promising results. Also, in the present study, grading of peripheral neuropathy based on severity was not done.

Statement of Informed Consent

The study was performed after obtaining institutional ethical clearance and properly signed informed consent from the study individuals.

Also, the authors declare that the study was conducted honestly and the results were discussed and agreed by all the authors. The submission of this article was also accepted by all the authors.

Authors' Contributions

S.G.R. and J.A. contributed to conceptualization, methodology, formal analysis, investigation, and data curation. J.J. helped in methodology, formal analysis, investigation, data curation, and data analysis. M.M. contributed to data curation and data analysis.

Funding

None.

Conflict of Interest

None declared.

Acknowledgment

We, the authors, sincerely thank the subjects for their utmost cooperation and also the technician Mr. Mohan for his patient and dedicated support during the study procedure.

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