The Study Of F- Waves In Normal Healthy Individuals

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Citation

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Abstract

BACKGROUND: F-waves are intriguing motor artifacts produced by anti dromic activation of motor neurons. Many studies have been published regarding normative data from several countries.
Aim: to study the characteristics of F wave including Minimum latency and its relation to limb length /height
Research design: Cross sectional, analytical
Material & Methods:
NCS for all limbs performed on 59 healthy participants. Different parameters of F wave including latency, chrono dispersion, persistence, amplitude were studied and compared with the literature..
Statistics: Descriptive statistics, Frequency tables, t-test used for the comparison of the characteristics of f-waves.
Results: all parameters well in agreement with literature, study demonstrates no significant side to side difference between minimum latencies of the same nerves. F minimum latency was highly correlated with height and limb length ($p<.01$), no significant correlation was found with age. The nomogram was established
Conclusions: reference values for our laboratory were established

INTRODUCTION

The clinical electro diagnosis involves the recording, display, measurement, and interpretation of action potentials arising from central nervous system (evoked potentials), peripheral nerves (nerve conduction studies) and muscles (electromyography). There are various principles that are followed whilst carrying out nerve conduction studies (NCS). A number of physiological and technical variables can influence the results of NCS viz. age, temperature, instrumentation errors, etc. These studies can be carried out on commercially available machines which have user friendly programs 1, 2, 3.

F-waves are intriguing motor artifacts produced by antidromic activation of motoneurons. They are irregular in appearance; low in amplitude; and inherently variable in latency, amplitude, and configuration. Meaningful analysis of F-waves requires allowance for these features of F-waves as well as an understanding of their physiology. Despite these complexities, F-waves are one of the basic studies in clinical neurophysiology and provide clinically useful information in patients with disorders of the peripheral and central nervous system 1,2, 3, 4, 10

Electrophysiological criteria for the F response have been published (Shahani and Young, 1976). Originally described by Magladery and McDougal (1950), this action potential response of a muscle is found readily in a wide distribution when its motor nerve is stimulated supramaximally. It is a response of low amplitude, usually less than 5% of the direct motor (M) response, with a latency directly related to the distance of the stimulating and recording sites from the spinal cord. Characteristically, the amplitude, latency, and configuration of the F response fluctuate with each stimulus. As an F response may be found in the absence of afferent input in both animals (Gassel and Wiesandanger, 1965; McLeod and Wray, 1966) and man (Mayer and Feldman, 1967; Miglietta, 1973), the response is thought to reflect antidromic activation of motoneurones. Single fibre studies (Trontelj, 1973) have confirmed the presence of this activation 4, 5, 6.

F-waves may be present following sub maximal stimulation, but F-waves are more prominent with supra maximal stimulations (i.e., 25% above that required for the maximum M-wave) since the amplitudes of the F-waves as well as the frequency of occurrence (persistence) increase as the stimulus intensity increases. Supra maximal stimulation also provides a physiologically definable and uniform environment in which F-waves will occur. Given the relatively small sizes of most F-waves, the associated supra maximal M waves generally need to be recorded at a lower gain 4,5.

The most common mode of assessing F-waves has been to collect a sample of 10 or more F-waves and then to measure the shortest latency F wave. Ten stimuli yielding anywhere from 7-10 F-waves probably suffice for most studies of persistence and latencies. However, 20 or more stimuli providing anywhere from 16-20 F-waves may be needed for accurate measurements To determine the number of individual repeater waves requires at least 100 stimuli 4,7, 8, the possibility that the increased amount of total F reps observed in the patients was merely due to loss of motor neurons or to their excitability changes as part of the aging process. Loss of motor neurons with age resulting in alterations of their corresponding motor unit size is a well-known process 8

L –Pulka et al used 20 stimuli to study Fwave, and according to their study age explained 71-87% of variability F min latency while height explained 80-95% of variability in all four nerves9.

F wave parameters commonly employed in the clinical practice are: Latency, chronodispersion , persistence, amplitude and repeater waves 1,2,3,4,10. The latency of F-waves consists of three serial components: the antidromic conduction time from the distal stimulation site to the spinal cord, the time required for motoneuron activation, and then orthodromic conduction to the site of recording 10,11

The clinical utility of F response has been substantiated in disorders of the peripheral nerve. It is emphasised that F-waves are particularly useful for the diagnosis of polyneuropathies at a very early stage and for the diagnosis of proximal nerve lesions. F-wave recording is indeed one of the rare methods in routine examination allowing at the same time the functional assessment of motor fibres on their proximal segment, and contributing to the evaluation of motoneuronal excitability 12, 17. Various studies have been done till date to establish normative data for laboratory setups, for various population. The present study attempted to establish normative / reference data for population residing near Karamsad, Anand district, Gujarat.

AIM AND OBJECTIVE OF THE STUDY

The aim was to study F waves in normal healthy subjects and establish reference values for our laboratory

The objective of the subject was to study the characteristics of F wave including:

i) Minimum latency and its relation to limb length
ii) F% M
iii) Chrono dispersion
iv) Persistence

MATERIALS AND METHODOLOGY

The study was conducted at ' K M Patel Institute of Physiotherapy, Shree Krishna Hospital, Karamsad, approved by the Human Research Ethics Committee of the institute.

RESEARCH DESIGN: cross sectional, analytical.

INCLUSION CRITERIA:
Healthy individuals, self declared, not on any medication, not a known case of any disorder, between age group of 18 to 60 years.

EXCLUSION CRITERIA:
- Diabetes
- Alcoholism
- Any trauma affecting muscles or nerves
- Renal or metabolic dysfunctions
- Peripheral vascular diseases
- Myopathy
- Neuropathy
- Motor neuron disorders
- Any genetic or other disorders affecting nerve and muscle.

The study included the data analysis of total 59 cases that satisfied the inclusion / exclusion criteria.

A RMS EMG EP Mark-II machine was used. Filters were set at 2 Hz to 10 kHz and sweep speed was 10 ms per division for motor study and for sensory study, filters were at 20 Hz to 3 kHz and sweep speed was 2 ms per division. Duration for both motor and sensory study was at 100 µs, F-sensitivity was at 500 µs. F wave parameters for lower limb were same except Sweep 10ms/Div

Nerve conduction studies (NCS) for bilateral Upper and Lower limbs were performed for a minimum of 59 healthy participants (including men and women) who satisfied the inclusion criteria. The procedure was described and informed consent obtained from each participant. NCS was performed in the room where the temperature was maintained at about 30 degree Celsius. NCS was performed by placing the participants in supine position with the respective limb to be tested at side with adequate support in the standard procedure given in standard books. Universal precautions were followed regarding the electrodes hygiene and patient safety inclusive of electrical safety measures. Participants were instructed about the sensory perception that they would have, and also to inform any discomfort / other abnormal sensation with the stimulation, if any. (If the participant reports any altered / abnormal / increased sensory

perception or intolerance to electrical stimulus the studies would be terminated). Recording of F waves was done and hard and soft copies of recording taken.

F wave were recorded from distal muscles viz. abductor pollucis brevis, abductor digiti minimi, extensor digitorum brevis, and abductor hallucis by stimulating the appropriate nerve (pictures). Recording electrodes placed on the belly tendon montage, wave recording done from a relaxed muscle. The stimulating cathode was proximal to the anodal electrode to avoid anodal block as it is said F-waves may be affected by a previous conditioning stimulus4. F-wave.Following F wave parameters will be used:

Supra maximal stimuli (25% above maximal) at a rate of 1 Hz were used. F-waves are more prominent with supra maximal stimulations (i.e., 25% above that required for the maximum M-wave) since the amplitudes of the F-waves as well as the frequency of occurrence (persistence) increase as the stimulus intensity increases. Supra maximal stimulation also provides a physiologically definable and uniform environment in which F-waves will occur.

RESULTS

F response was studied in the normal healthy people with age range 18-60 years, with 27 females and 32 males. All four nerves median, ulnar, peroneal, post tibial, in both the upper and lower limbs were studied.

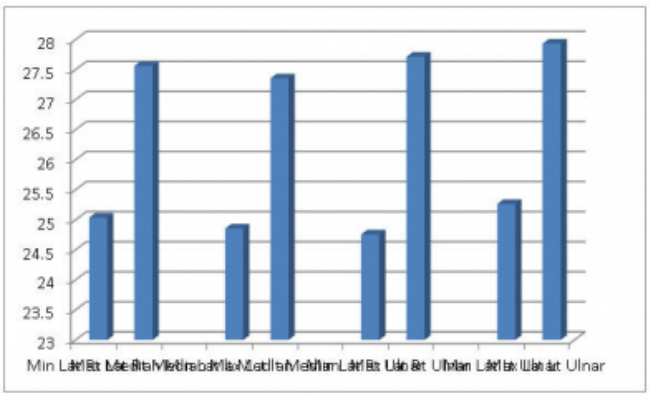
Table 1

F-response latency (Minimum and Maximum) for upper limb nerves (ms)

Minimum latency(mean +_ SD)				Maximum latency(mean +_ SD)			
Rt Median	Lt Median	Rt Ulnar	Lt Ulnar	Rt median	Lt median	Rt Ulnar	Lt ulnar
25.0360 ±2.31193	24.8566 ±2.45235	25.7590 ±3.90830	25.2641 ±2.37827	27.5636 ±2.41062	27.3554 ±2.64733	27.7151 ±2.52714	27.9320 ±2.68730

Figure 1

Bar graph showing chronodispersion of median and ulnar nerves



Max chronodispersion for Rt median is 3.4320±1.04967, for Lt median 3.3100±1.11726.

Max chronodispersion for Rt ulnar is 3.4196±.95100, for Lt ulnar 3.4019±.80622.

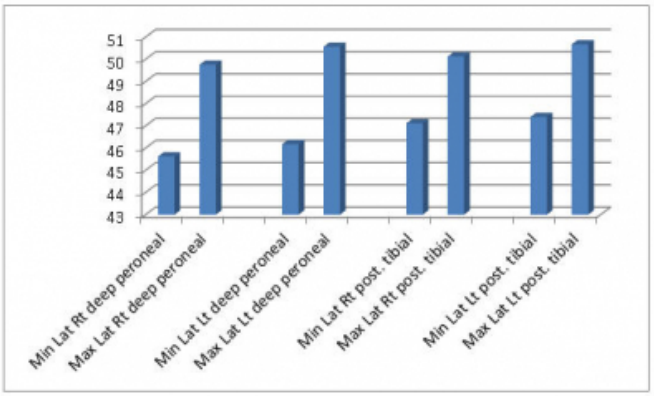
Table 2

F-response latency for lower limb nerves (ms)

Minimum latency(mean +_ SD)				Maximum latency(mean +_ SD)			
Rt deep peroneal	Lt deep peroneal	Rt post. tibial	Lt post. tibial	Rt deep peroneal	Lt deep peroneal	Rt post. tibial	Lt post. Tibial
45.6207 ± 3.89410	46.1737 ± 3.68271	47.1093 ± 4.48428	47.398 ± 4.50106	49.7515 ± 4.99596	50.5629 ±4.81308	50.1174 ± 4.57077	50.6676 ± 4.72649

Figure 2

Bar graph showing chronodispersion of deep peroneal and post tibial nerves



Max chronodispersion for Rt deep peroneal is5.3585±2.35913, for Lt deep peroneal is 5.9132±2.27468.

Max chronodispersion for Rt post tibial4.0595±1.22675 and is 4.4389±1.39985, for Lt post tibial.

Table 3

F min latency Pearson coefficient with age, height and limb length

F min latency (Mv)	Age	Height	Upper limb length (Cm)
Rt Median	.318*	.462**	.426**
Lt Median	.324*	.452**	.401**
Rt Ulnar	.195	.418**	.432**
Lt Ulnar	.240	.549**	.423**
Rt Peroneal	.072	.356*	.507**
Lt Peroneal	.093	.395*	.629**
Rt Post tibial	.189	.394**	.541**
Lt Post tibial	.294	.341*	.573**

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

Table 4

Showing F%M amplitude reading for upper and lower limb nerves

Nerve	Mean± SD
Rt Median	4.49±2.40
Lt Median	4.76±3.53
Rt Ulnar	3.17± 1.45
Lt Ulnar	3.18±1.46
Rt Common Peroneal	4.49± 3.37
Lt Common Peroneal	3.57± 1.43
Rt Post. Tibial	3.69±2.34
Lt Post. Tibial	3.33±1.45

The present study demonstrates no significant side to side difference between the minimum latencies of the same nerves.

The F min latency for all nerves is highly correlated with height and upper limb length($p<.01$) and to a lesser extent with age($p<.05$).

Figure 3

Nomogram: Regression Line: F_Min_Lat_R = 6.208 + 0.119 (Ht) i.e. as one cms ht increases, there is increase of 0.119 in F_Min_Lat_R.

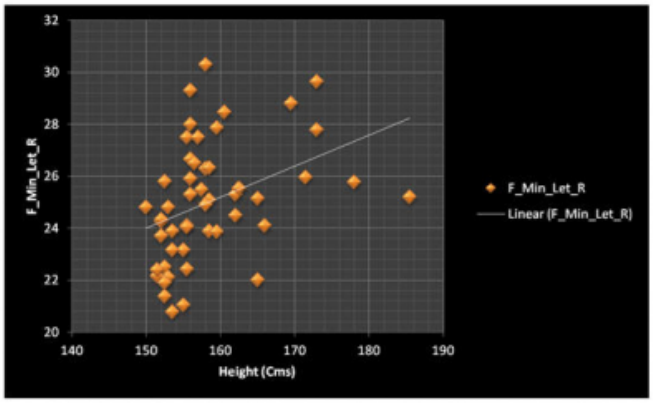
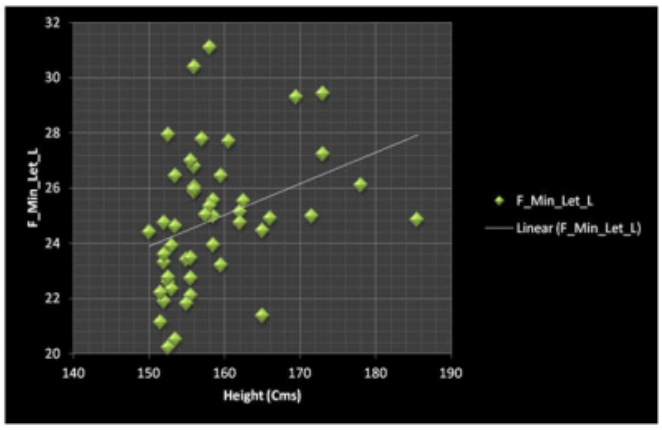


Figure 4

Nomogram:Regression Line: F_Min_Lat_L = 6.868 + 0.113 (Ht) i.e. as one cms ht increases, there is increase of 0.113 in F_Min_Lat_L.



DISCUSSION

Electro diagnosis (EDX) is a functional procedure that tests neuromuscular junctions, muscles, peripheral nerves, plexus, root or central pathways. The choice and need for a particular diagnostic procedure should be based on indications from an adequate history and examination. EDX is an extension of neurological examination and as integral a tool as the tuning fork and reflex hammer.12F waves allow testing of proximal segments of nerves that would otherwise be inaccessible to routine nerve conduction studies. F waves test long lengths of nerves whereas motor studies test shorter segments. Therefore F wave abnormalities can be a sensitive indicator of peripheral nerve pathology, particularly if sited proximally12, 13, 14, 17

The present study aimed to establish laboratory norms and compare to those available in the literature.

Opinions vary from 10 to > 100, with regard to the number of F-responses required to obtain a correct minimum persistence and latencies value4, 7, 13, 15, 16, 17.

F MINIMAL LATENCY: The upper limit in the normal adult for F minimal latency is 31-37 ms for hand 4,11, 14, 17. In the lower limbs the reported values are 60 ms 4, 11. The average minimal F- wave latencies tend to be 25-32 msec. in the upper extremities and 45-56 msec in the lower extremities, height dependent (Preston and Shapiro, 2005)11.

F minimum latency upper limit in the present study was 27.9320 +2.68730 (ulnar) in the upper limbs, median nerve 25.0360 +2.31193, unlike Ghosh the ulnar nerve F min latency was prolonged compared to median, well in agreement with the literature 24 & in lower limbs F min

latency was 50.6676+_4.72649 which is also well compatible with the literature. 4, 11, 12, 14, 17, 18,19 20,21, 22, 23,24,25.

The present study demonstrates no significant side to side difference between the minimum latencies of the same nerves well in agreement with the literature 12, 16, 21, 22. Right to left asymmetry of minimum F latency exceeding 2 ms in hand is considered abnormal16. Few studies report side to side difference 7, 22. Buschbacher, Ralph19M. found the mean side-to side difference in F min median as 0.2 +/- 1.2 ms, for peroneal was Fmin was 0.7 +/- 2.4 ms, one study reported this only in the minimum latency values of the median nerve, the right side being on average 0.3 ms longer ($p < 0.001$)15.

Cornwall MW et al stated that because no difference greater than 1°C was found between extremities on any of their subject, temperature was not considered to be a critical factor in the study17.

The upper limit of F amplitude is 5% of M wave 2, 3, 4, 5, 6, 7,10 we found the same upper limit except in the median nerve which is 4.76±3.53, which different from S. Ghosh, who reports 2.08±1.07 for abductor pollicis brevis and 3.06±5.22 for abductor digiti minimi. M-response, with median F%M values ranged from 0-8% to 4% 7. The size of F wave is likely to be dependent on the resting level of excitability 26.
In a study of F-wave parameters of normal ulnar and median nerves by S Ghosh 16, the F-wave persistence varied minimum 8 and maximum 10. Another study showed that the persistence of F wave in the range of 8 to 9 respectively. In a study conducted by Buschbacher et al 18 Fpersist of peroneal nerve in normals were between 5 and 6 and according to them a low Fpersist does not seem particularly clinically useful for the peroneal nerve, although a high Fpersist seems to be a sign of normality. E Chroni, C P Panayiotopoulos reported in their study persistence ranging from 70 to 99% for the ulnar nerve and from 24 to 88% for the peroneal nerve27.
In the present study F wave persistence for median nerve is between 9.15 and 9.18 and for ulnar nerve is between 9.063 and 9.126. In the lower limb for deep peroneal it is between 7.341 and 8.313 and for post. tibial which is recorded from abductor hallucis it is 10. The present study found no relationship or variation of persistence with age especially so in post tibial.
Persistence of F waves depends upon the physiological organization of muscle. The persistence is a measure of anti dromic excitability of a particular motor neuron pool. F wave persistence may be decreased in axonal injury. Absence of F wave with normal M wave is highly suggestive of peripheral nerve demyelination. If the neuropathy is in its early stage, the delayed F wave may be the first indication for the diagnosis 11, 12.

Chronodispersion of F waves refers to the difference between minimal and maximal latencies in a series of F waves and it is a measure of the range of conduction of F waves.1,2,3.4,16
The highest reported normal values for F wave chronodispersion (mean ± SD) for the median nerve (abductor pollicis brevis) is 3.6 ± 1.2 ms [7] (Peioglou-Harmoussi et al), for the ulnar nerve (abductor digiti minimi) 3.3 ± 1.1 ms (papayiotopoulos,1979) and for extensor digitorum brevis is 6.4±0.8ms(peioglou harmoussi et al 1985) The difference between minimum and maximum values varied between 1.3 and 8.4 in the four nerves studied (peioglou harmoussi et al 1985) There were no significant differences between the values for the right and left sides. There was also no correlation between F-chronodispersion and age, height or sex of the subject.

In our laboratory 4 times stimulation of 10 traces of F waves each are analyzed.
In the present study highest reported normal values for F wave chronodispersion (mean ± SD) for abductor pollicis brevis is 3.4±1.1,for abductor digiti minimi 3.4 ±.1 , for extensor digitorum brevis is 5.3585 ±2.4 and for abductor hallucis is 4.4389±1.4. The present study showed the chrono dispersion in the median much lower and well in the agreement with the literature than Ghosh who reports CD of 5±2.8ms .

F chronodispersion describes the latency characteristics of the compound F wave populationand is defined as 'the scatter or dispersion of the relative latencies of statistically significant numbers of consecutively recorded F waves'. It has been shown to be more sensitive than conventional neurophysiological methods in detecting mild neuropathies where affected fibres do not influence the CMAP or the FL, measurements but appear delayed (prolonged F chrono dispersion range) in relation to the main bulk of unaffected nerve fibres27.
Chronodispersion *as reported by Morris A Fisher4
APB 6.2 msec, ADM 5.5 msec, Soleus 7 msec, EDB 9.5 msec, AH 9.3 msec
*upper limit of normal

A Mallik, A I Weir state that because of the long pathway, normal values have to be related to limb length, pathway measurement or body height13. Soudmand R et al 11 reported positive correlation between height and median, peroneal F-wave minimum latency (r = 0.74 and 0.69 respectively ; P < 0.001). As subject's height increases, length of nerve increases, latency of conduction also increases. Gender, age and height had major role in F-wave latency determination. These factors must be taken into consideration in clinical evaluation of patients17

A number of studies have confirmed 7, 9, 10, 13, 21,28have confirmed the direct relationship between minimum F-response latency and limb length and height and also between maximum F-latency and height, while a much weaker correlation was found with age.
Gender difference in nerve conduction parameters could also be due to difference in height21,
Race and body mass index (weight divided by height squared) were not associated with any differences in results19, 21, 22

The present study has confirmed the direct relationship between minimum F-response latency and height as reported by others. The F min latency for all nerves is highly correlated with height and upper limb length ($p<.01$) and to a lesser extent with age ($p<.05$).
The nomogram was established as below
Regression Line : F_Min_Lat_R = 6.208 + 0.119 (Ht) i.e. as one cms ht increases, there is increase of 0.119 in F_Min_Lat_R.
Regression Line : F_Min_Lat_L = 6.868 + 0.113 (Ht) i.e. as one cms ht increases, there is increase of 0.113 in F_Min_Lat_L.

CONCLUSION

The present study established reference values for the laboratory. In the present study it is found that the F minimum latency is highly correlated with height and limb length which is in accordance with the other studies. The nomogram was established.
F wave minimum latency, Chronodispersion, F%M Amplitude, Persistence were all found to be compatible with the literature.

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