**Research Article**

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# F-Wave recorded from proximal and distal muscles innerved by the same nerve in the upper and lower extremities: could it be a new method?

## *Üst ve alt ekstremitede aynı sinir tarafından inerve olan proksimal ve distal kaslardan kaydedilen F dalgası: yeni bir yöntem olabilir mi?*

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**Abstract**

**Purpose:** The F- wave is a valuable measurement that provides information about both the proximal and distal parts of the nerve. Classical F-wave recording methods are performed from the distal muscles of the limb and so are affected from distal pathologies. Nerve conduction velocity of a nerve is affected by the diameter of the nerve. The diameter of a nerve gets thinner as it gives branches and travels distally. So it is expected that the nerve conduction velocity of a nerve is faster in proximal segment of the nerve than the distal part even they are the parts of the same nerve. The aim of this study is to compare the nerve conduction parameters of F waves recorded in proximal and distal muscles innervated by the same nerve which will provide additional information and may be valuable in detecting proximal pathologies accompanying background pathologies affecting the distal nerve.

**Materials and methods:** Twenty–six healthy volunteers who have normal routine nerve conduction studies are included in this study. The latencies of ulnar and peroneal F-waves of all participants were recorded from the proximal and distal muscles innervated by the same nerve.

**Results:** F-wave latencies recorded from proximal muscles were significantly later than the ones recorded from distal muscles.

**Conclusions:** Although the distances travelled by stimulation are shorter in F latencies recorded from proximal muscles, and the segment / branch of the nerve is expected to be thicker and faster, the latencies recorded from proximal muscles were longer than the ones recorded from distal muscles. This may be due to the distance of the recording electrodes effected by subcutaneous tissues in the proximal large mass muscles. One reason for this difference may be that the proximal relatively large mass muscles have higher desynchronization and temporal dispersions.

**Keywords:** F-wave, proximal F-response, distal peripheral neuropathy.

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**Öz**

**Amaç:** F dalgası sinirin hem proksimal hem de distal kısımları hakkında bilgi sağlayan değerli bir ölçümdür. Klasik F dalgası kayıt yöntemleri ekstremitenin distal kaslarından yapıldığı için distal patolojilerden etkilenir. Sinir iletim hızı, sinirin çapından etkilenir. Sinirin çapı dallanıp distale doğru ilerledikçe incelir. Yani bir sinirin sinir iletim hızının, aynı sinirin parçaları olsa bile sinirin proksimal segmentinde distal kısmına göre daha hızlı olması beklenir. Bu çalışmanın amacı aynı sinirin innerve ettiği proksimal ve distal kaslarda kaydedilen F dalgalarının sinir iletim parametrelerini karşılaştırmaktır. Bu sinir distalini etkileyen arka plan patolojilerine eşlik eden proksimal patolojilerin saptanmasında değerli olabilir ve ek bilgi sağlayacaktır.

**Gereç ve yöntem:** Bu çalışmaya rutin sinir iletim çalışmaları normal olan 26 sağlıklı gönüllü dahil edildi. Tüm katılımcıların ulnar ve peroneal F dalgalarının latansları, aynı sinir tarafından innerve edilen proksimal ve distal kaslardan kaydedildi.

**Bulgular:** Proksimal kaslardan kaydedilen F dalgası latansları, distal kaslardan kaydedilenlerden önemli ölçüde daha uzundu.

**Sonuç:** Proksimal kaslardan kaydedilen F latanslarında uyarının kat ettiği mesafeler daha kısa olmasına ve sinirin segment/dalının daha kalın ve hızlı olması beklenmesine rağmen proksimal kaslardan kaydedilen latanslar, distal kaslardan kaydedilenlerden daha uzundu. Bunun nedeni, proksimal büyük kütleli kaslarda cilt altı dokuların fazlalığı ve kasın kayıt elektrotlarına uzaklığı olabilir. Bu farklılığın bir nedeni de, proksimal nispeten büyük kütleli kasların daha fazla senkronizasyon ve zamansal dağılıma sahip olması olabilir.

**Anahtar kelimeler:** F-dalgası, proksimal F-yanıtı, distal peripheral nöropati.

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## Introduction

Peripheral nerves become thinner as they go from proximal to distal, giving their fibers to peripheral muscles [1-3]. The nerve fibers to different muscles travel together in the peripheral nerve but are separate bundles [1-3]. Generally, each peripheral nerve provides a sensation of a specific skin area, muscular innervation of a few muscles and sensory innervation of the deep structures [3, 4]. Thus, motor fibers from the same nerve root provide motor innervation of muscles with different peripheral nerves. Also, sensory fibers from the same nerve root provide sensory innervation of the skin in other peripheral nerve distribution areas [4]. The reason for the higher nerve conduction velocity in the proximal segments compared to the distal segments may be the thinning of the nerve fiber diameter from proximal to distal, the shortening of the internodal segments in the nerve fibers in the distal segments, and the lower extremity temperature in the distal compared to the proximal segments [5]. If a peripheral nerve is stimulated at the same site and electrophysiological recordings are made from two different muscles located proximally and distally, it is possible to comment on the conduction parameters of nerve fibers with the same course and in the same peripheral nerve but of different diameters [5, 6].

The F-response shows the conduction of antidromic motor impulses involving both distal and proximal segments of motor nerves and motor roots [1]. While the distal part of the motor unit can be examined with known classical motor conduction methods, the proximal part of the motor unit can only be examined with the F-response [1, 7]. It was considered advantageous to examine the F-response in proximal nerve and root involvement [7].

In the light of all this information, the aim of this study is to evaluate the F-response in proximally located muscles with relatively larger mass and distally located muscles with relatively smaller mass stimulated by the same nerve. By comparing the upper and lower extremity, distal and proximal values, it is aimed to discuss the use of these values in patients with concomitant peripheral motor lesions.

## Material and methods

This study included 26 healthy volunteers with regular routine nerve conduction studies and between 18 and 80. Individuals were evaluated in the EMG laboratory of Prof. Dr. A. İlhan Özdemir Training and Research Hospital. In addition to routine nerve conduction studies, F-wave is studied from the ulnar nerve in the right upper extremity and the peroneal nerve in the right lower extremity. The ulnar and peroneal nerves were stimulated supramaximally. At least 10 F response recordings were recorded from each participant, those with a persistence above 50% and chronodispersion below 4 milliseconds (ms) for the upper limb and 6 ms for the lower limb were included in the study. In the upper extremity, the ulnar nerve was stimulated antidromically medial to the wrist. F-wave was recorded from the abductor digiti minimi (ADM) and flexor carpi ulnaris (FCU) muscles. In the lower extremity, the peroneal nerve was stimulated antidromically from the anterior ankle and the F-wave was recorded from the extensor digitorum brevis (EDB) and tibialis anterior (TA) muscles. Room temperature was kept between 25-28 °C in the study. The latencies of ulnar and peroneal F-wave of all participants were recorded from the indicated proximal and distal muscles and compared with ulnar and peroneal nerve conduction velocity and amplitude. The minimum F-wave latency is accepted to be below 32 ms for the ulnar nerve in the upper extremities and below 56 ms for the peroneal nerve in the lower extremities.

Individuals aged 18-80 years, with regular routine nerve conduction studies, without a chronic disease, and who agreed to participate were included. Patients under the age of 18 and over 80, with abnormal nerve conduction studies, with a chronic illness, who refused to participate or wanted to quit at any time were excluded from the study.

Informed consent was obtained from all subjects. The study was approved by Ordu University Clinical Research Ethics Committee. The data were analyzed with SPSS package program and p value less than 0.05 was considered statistically significant.

## Results

The study included 26 subjects, including 15 women and 11 men. The mean age was 49.4 (±14.4) years. The mean age of women was 49.1 years and 49.9 years for men. In all participants, the mean ulnar F-response latency (FUD) recorded distally was 18.3 (±1.67) ms and the mean ulnar F-response latency (FUP) recorded proximally was 19.1 (±1.94) ms. These values were FUD 17.8 ms and FUP 18.7 ms in women and FUD 19.1 ms and FUP 19.8 ms in men. In all participants, the mean peroneal F-response (FPD) recorded distally was 31.9 (±3.45) and the mean peroneal F-response (FPP) recorded proximally was 32.5 (±2.88). These values were FPD 31.9 ms and FPP 32.1 ms in women and FPD 32 ms and FPR 33 ms in men. The velocities and amplitudes of the ulnar and peroneal motor nerves were recorded only from the distal muscles. The mean ulnar motor nerve velocity (UMV) was 54.9 (±2.7) and the mean ulnar motor nerve CMAP amplitude (UMA) was 8.3 (±1.2). The mean peroneal motor nerve conduction velocity (PMV) was 47.9 (±5.28) and the mean peroneal motor nerve CMAP amplitude (PMA) was 4.2 (±1.89).

There was no significant difference between the age and gender of the participants. No significant difference was found when the age and gender of the participants were compared with FUD, FUP, FPD, FPP values ($p$>0.05). Participiants' FUD and FUP were compared, and the difference was statistically significant ($p$=0.03). Participiants' FPD and FPP values were compared, and the difference was statistically significant ($p$=0.00). When other F response values were compared with each other and with UMA, UMH, PMA, PMH values, no statistically significant difference was found (Table 1).

**Table 1.** Electrophysiological findings of the individuals

| | Female (n=15) | Male (n=11) | All (n=26) |
|---|---|---|---|
| **Age** | 49.1 | 49.9 | 49.4 |
| **FUD (ms)** | 17.8 | 19.1 | 18.3 |
| **FUP (ms)** | 18.7 | 19.8 | 19.1 |
| **FPD (ms)** | 31.9 | 32.0 | 31.9 |
| **FPP (ms)** | 32.1 | 33.0 | 32.5 |
| **UMV (m/s)** | 55.7 | 53.9 | 54.9 |
| **UMA (mA)** | 8.2 | 8.4 | 8.3 |
| **PMV (m/s)** | 49.5 | 45.8 | 47.9 |
| **PMA (mA)** | 3.7 | 4.8 | 4.2 |

CMAP:compound muscle action potential, ms:milliseconds, mV:millivolt, mA:milliampere, m/s:meter/seconds, ADM:abductor digiti minimi, FCU:flexor carpi ulnaris, EDB:extensor digitorum brevis TA:tibialis anterior, FUD:distal stimulated ulnar F-response latency, FUP:proximal stimulated ulnar F-response latency, FPD:distal stimulated peroneal F-response latency, FPP:proximal stimulated peroneal F-response latency, UMV:ulnar motor nerve velocity, UMA:ulnar motor nerve CMAP amplitude, PMV:peroneal motor nerve conduction velocity, PMA:peroneal motor nerve BKAP amplitude

## Discussion

The F-response is recorded by supramaximal antidromic stimulation of a motor nerve [1]. It is assumed that electrical stimulation of peripheral motor fibers results in antidromic activation of the motor neuron [1, 7, 8]. The most important benefit of the F-response is probably from some of its physiological features. The F-response shows antidromic motor impulses involving both distal and proximal segments of motor nerves and motor roots [8, 9]. While the distal parts of the motor unit can be examined with routine nerve conduction studies, the proximal part can only be examined with the F-wave. Examining F-wave in proximal nerve and root involvement was considered advantageous [10, 11]. In this study, participants minimal

F-latency was compared by recording from two different muscles located proximally and distally innervated by the same nerve. Four different F-wave minimal latencies (FUD, FUP, FPD, FPP) were recorded from each participant, and these four different F-wave latencies were found to be within normal limits.

When the minimum latencies of the F- wave recorded from the distal and proximal muscles in the lower and upper extremities were compared, it was found that the minimum latencies of the F-wave recorded from the proximal muscles (FUP and FPP) were longer than the minimum F-wave latencies recorded from the distal muscles (FUD and FPD). In previous studies comparing nerve conduction velocities, conduction velocity was found to be higher in proximal muscles with greater mass then the distal small muscles even they are innervated by the same nerve [6, 12, 13]. Considering the physiology of the F-wave, it is conceivable that the F-wave latency recorded from the proximal muscle should be shorter. In this study, the result was the opposite. This may be due to the distance of the recording electrodes from the muscle due to the excess of subcutaneous tissues in the proximal large mass muscles. One reason for this difference may be that the proximal relatively large mass muscles have higher desynchronization and temporal dispersions, which contain muscle fibers of different nerve conduction diameters [12, 14, 15].

Previous F-wave studies found that F-wave minimum latency increased with age by 0.03 ms/year in the upper extremity and 0.1 ms/year in the lower extremity. At the same time gender did not affect F-wave minimum latency [16]. In this study, a modest increase in the minimum F-wave latency is recorded with increase of the age.

It was observed that the mean F-wave minimum latencies of female participants were shorter than those of male participants. However, these differences were not statistically significant. The findings are consistent with the literature [16, 17].

The data obtained in this study are valuable because of the lack of studies in the literature examining F-wave recorded from proximal muscles and because of the exclusion of concomitant pathologies affecting the distal nerve. F-wave measurement by recording from proximal muscles can be used in clinical practice. However, larger studies with proximal stimulation and recording from proximal muscles are needed.

**Conflict of interest:** No conflict of interest was declared by the authors.

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