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Original Article / Özgün Araştırma

Medial Femoral Cutaneous Nerve Conduction Study with Distal Stimulation and Recording Technique

Medial Femoral Kütanöz Sinir İletim Çalışmasında Distal Uyarım ve Kayıt Tekniği

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Abstract

Objective: To determine the normal values of the newly described distal stimulated medial femoral cutaneous (MFC) nerve conduction study in a healthy population using a wide range of ages and body mass index (BMI) values.

Materials and Methods: Distal stimulated MFC nerve conduction studies were performed bilaterally in 144 healthy volunteers with no peripheral nerve diseases affecting the lower extremities according to clinical and electrophysiological evaluations. The volunteers were divided into three groups according to their age: 18–39.9 years (age 1), 40–59.9 years (age 2), and 60 years and above (age 3). They were also grouped according to their BMI: 24.9 or less (BMI 1), 25–29.9 (BMI 2), and 30 or more (BMI 3).

Results: The mean MFC amplitude was 5.7 μV on both sides, the mean peak latency was 2.8 ms on both sides, and the mean conduction velocity was 61.5 m/s on the right and 61.9 m/s on the left. The MFC amplitudes obtained on the right and left sides were similar, and the mean amplitude difference between sides was 10.1 ± 9.1% (0–56.6). A negative correlation was identified between MFC amplitude and age and BMI.

Conclusion: This study revealed that the newly described distal stimulated MFC sensory nerve conduction study is repeatable and easily applicable.

Keywords: Medial femoral cutaneous nerve conduction, lumbosacral plexopathy, femoral neuropathy

Öz

Amaç: Yeni tanımlanan distal uyarımlı medial femoral kütanöz (MFK) sinir uyarım çalışmasının, daha geniş yaş ve vücut kitle indeksi (VKİ) aralığına sahip olan sağlıklı popülasyonda normal değerlerinin tanımlanması amaçlanmıştır.

Gereç ve Yöntem: Klinik ve elektrofizyolojik olarak alt ekstremiteleri etkileyecek periferik sinir hastalığı dışlanmış 144 sağlıklı gönüllüde distal uyarımlı MFK sinir çalışması iki yanlı olarak yapılmıştır. Denekler yaşlarına göre 18-39,9 (yaş 1), 40–59,9 (yaş 2) ile 60 ve üstü (yaş 3) olmak üzere 3 grupta sınıflandırıldı. VKİ'lerine göre de 24,9 ve altı (VKİ 1), 25–29,9 (VKİ 2) ile 30 ve üstü (VKİ 3) olarak gruplandırıldı.

Bulgular: MFK amplitüdü sağda ve solda ortalama 5,7 μV, tepe latansı sağda ve solda ortalama 2,8 ms ve ortalama iletim hızı sağda 61,5 m/sn, solda 61,9 m/sn olarak bulundu. Sağ ve sol tarafta elde edilen MFK amplitüdleri oldukça benzer olup taraflar arası amplitüd farkı ortalaması %10,1 ± 9,1 idi (0–56,6). MFK amplitüdü ile yaş ve VKİ arasında negatif bağıntı vardı.

Sonuç: Çalışmamız yeni tanımlanan distal uyarımlı MFK duyusal sinir iletim çalışmasının tekrarlanabilir ve kolay uygulanabilir olduğunu göstermiştir.

Anahtar Kelimeler: Medial femoral kütanöz sinir, lumbosakral pleksopati, femoral nöropati

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Introduction

The medial femoral cutaneous (MFC) nerve is a sensory branch originating from the anterior branch of the femoral nerve, consisting of the L2–L4 roots of the lumbosacral plexus (1). It departs from the femoral nerve approximately 4 cm distal to the inguinal ligament and innervates the anteromedial thigh (2). Inguinal catheterization procedures (3,4), total hip arthroplasty operations (5), intrapelvic masses (6), spontaneous and traumatic hematomas secondary to anticoagulation (4,7), and urological–gynecological operations in the lithotomy position (8) may cause femoral nerve damage.

Electroneurophysiological examinations evaluate the motor and sensory nerve conduction of the femoral nerve. Sensory conduction studies can be performed in the saphenous nerve, which is the sensory terminal branch of the femoral nerve (9). However, since the sensory action potential (SAP) is obtained with difficulty in this nerve in normal individuals, its absence cannot always be attributed to nerve pathology. In addition, saphenous nerve response may not be achieved in patients with polyneuropathy and/or ankle edema. In these situations, a proximal recorded sensory response may be helpful in differentiating between the femoral nerve, lumbosacral plexus, and root.

In 1995, Lee et al. (10) developed a technique for the evaluation of the MFC using inguinal stimulation in 32 healthy participants, recording a response 14 cm distal to the stimulation point (Figure 1a). However, it is difficult to stimulate the MFC and obtain a response using this technique, especially in patients with obesity. In 2021, Geney-Castro et al. (11) described a new method to obtain the MFC sensory response (Figure 1b).

In the present study, the reproducibility of this new technique was tested in another healthy population, and the normal values of the MFC sensory response obtained are presented herein.

Materials and Methods

Selection of Participants

The study involved 144 healthy volunteers aged between 18 and 75 years. The volunteers consisted of healthy relatives of the authors or patients referred to the electroneuromyography (EMG) laboratory with a pre-diagnosis of "carpal tunnel syndrome and other upper extremity entrapment neuropathies, cervical radiculopathy, or myopathy" and without clinical or electrophysiological findings indicating polyneuropathy under examination. The nerve conduction studies were performed after obtaining the participants' informed consent. The height and weight of all participants were recorded, and body mass index (BMI) values were calculated.

The study was approved by the Ethics Committee of University of Health Sciences Türkiye, Basaksehir Cam and Sakura City Hospital with the protocol number 2023-50. Signed informed consent forms were obtained from all healthy volunteers participating in the study.

Nerve Conduction Studies

The bilateral MFC sensory nerve conduction study was performed using the method described by Geney-Castro et al. (11) (Figure 1b). A four-channel EMG device (Natus UltraPro S100 EMG/NCS/EP Neurodiagnostic System, Galway, Ireland) was used to record the antidromic SAP of the MFC in all participants. The bar recording electrode was placed 10 cm proximal to the superior and medial edge of the patella along an imaginary line between this edge and the femoral pulse in the inguinal region. The nerve was stimulated 14 cm proximal to the recording point using a superficial stimulation electrode, with the cathode placed distally along the same line. A flat disc ground electrode was placed between the stimulation and recording sites. The lower frequency filter of the device was set to 20 Hz and the upper frequency filter to 2,000 Hz. Slight shifting of the recording electrode or stimulation point in the medial or lateral direction was required to achieve the highest amplitude, and an average stimulus intensity of 20 mA was needed. Tibial and peroneal motor and sural and superficial peroneal sensory nerve conduction studies were also performed to exclude the presence of subclinical polyneuropathy. Nerve conduction studies were performed in the same laboratory and with the same device. Care was taken to maintain the extremity temperatures at approximately 32–34 °C.

MFC sensory response baseline latency (b-lat), peak latency (p-lat), baseline-to-peak amplitude (amp), peak-to-peak amplitude (pp-amp), and conduction velocity data were analyzed. The percentage of the difference in amplitude between the right and left sides was calculated. Right-side and left-side data were pooled, and mean conduction velocity, pp-amp, and p-lat values were determined. The lower limit considered normal for conduction velocity was calculated by subtracting 3x standard deviation (SD) from the mean, and the upper limit considered normal for the latency parameter was calculated by adding 3xSD to the mean. Since the mean was low for amplitude and the SD was high, the smallest value recorded in the participants was accepted as the lower limit of normal.

The participants were divided into three groups according to their age: 18–39.9 (age 1), 40–59.9 (age 2), and 60 and over (age 3). They were further grouped according to their BMI: 24.9 and below (BMI 1), 25–29.9 (BMI 2), and 30 and above (BMI 3).

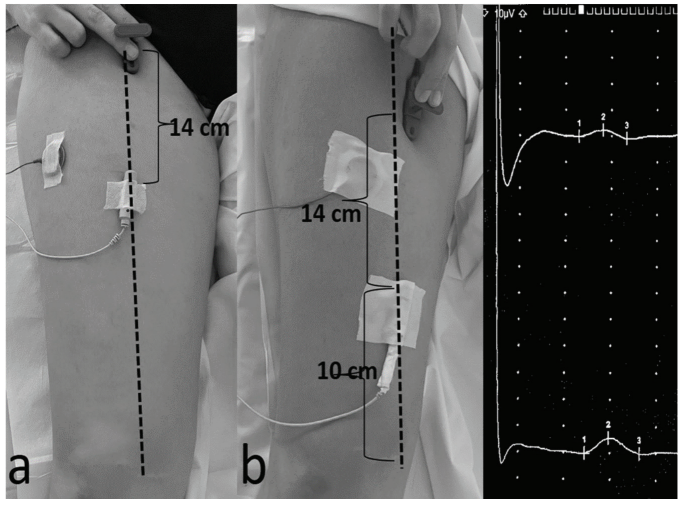

Figure 1. (a) Proximal (inguinal region) stimulated antidromic sensory nerve conduction study of the medial femoral cutaneous nerve described by Lee et al. (10) in 1995. (b) Distal antidromic sensory nerve conduction study of the medial femoral cutaneous nerve using the method described by Geney-Castro et al. (11) with the response obtained on the right

Statistical Analysis

The statistical analyses were performed using SPSS software (v.26; IBM SPSS, Armonk NY, USA). The categorical data were expressed as numbers (%) and the numerical data as mean ± SD (minimum, maximum). The Pearson chi-square test was used to compare the categorical data between groups. Numerical data with normal distribution were analyzed using parametric tests and those without normal distribution with non-parametric tests. In the groups formed according to age and BMI, the comparison of the parameters between the groups was performed using the Kruskal–Wallis test. Pairwise comparisons for the parameters with significant differences were evaluated using the Mann–Whitney U test following Bonferroni correction. The Spearman *rho* test was used for the correlation analysis. The significance level was set as $P < 0.05$.

Results

The mean age of the participants was 43.9 ± 13.2 (18–75) years, and 82 (56.9%) were women. The distribution of the participants by age is presented in Figure 2, and age, height, and BMI values by sex are summarized in Table 1. Of the participants, 38.2% (n = 55) were in the age 1 group, 47.9% (n = 70) were in the age 2 group, and 13.9% (n = 19) were in the age 3 group. The sex distribution by age group was similar (Pearson chi-square $P = 0.45$). The mean BMI was 25.5 kg/m^2 in the women and 26 kg/m^2 in the men (Table 1). There were 55 (36 women) participants in the BMI 1 group, 73 (37 women) in the BMI 2 group, and 16 (nine women) in the BMI 3 group. The older participants had the highest BMI (Pearson chi-square test $P < 0.001$) (Figure 3).

Table 1. Demographic data of the participants

	Male (n = 62)	Female (n = 82)
	Mean ± SD (min–max)	Mean ± SD (min–max)
Age (year)	44.5 ± 13.8 (18–75)	44 ± 12.5 (18–70)
Height (cm)	175 ± 5.8 (162–187)	160 ± 5.6 (150–177)
Weight (kg)	78.5 ± 10.7 (54–100)	65 ± 9.7 (43–93)
BMI (kg/m^2)	26 ± 3.2 (17–34)	25.5 ± 3.8 (17–36)

n: Number of participants, SD: Standard deviation, min: Minimum, Max: maximum, BMI: Body mass index

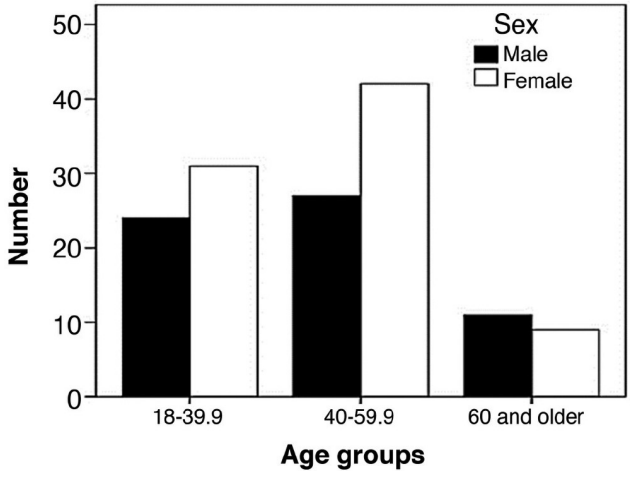

Figure 2. Distribution of the participants by age and sex

MFC sensory responses were obtained in all participants. However, due to the short stature of two participants, the distance between the recording and stimulation electrodes was set to 120 cm. There were no significant differences in terms of pp-amp (right 5.7; left 5.7 µV), p-lat (right 2.8; left 2.8 ms), or conduction velocity (right 61.5; left 61.9 m/s) between the right and left sides (Table 2). The mean amplitude difference between the two sides was 10.1 ± 9.1% (0–56.6). The upper limit of normal for latency was determined to be 3.8 ms, the lower limit of normal for pp-amp was 1.2 µV, and the lower limit of normal for conduction velocity was 61.3 m/s.

A significant difference ($P = 0.001$) in terms of MFC sensory response amplitudes was identified between the age groups; it

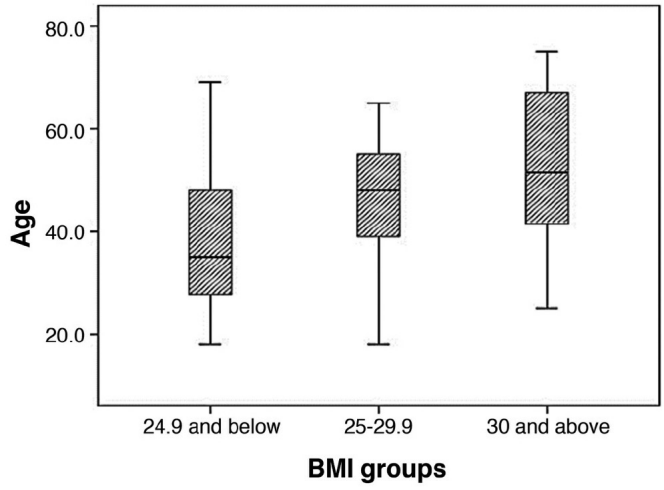

Figure 3. Distribution of participants by body mass index and age

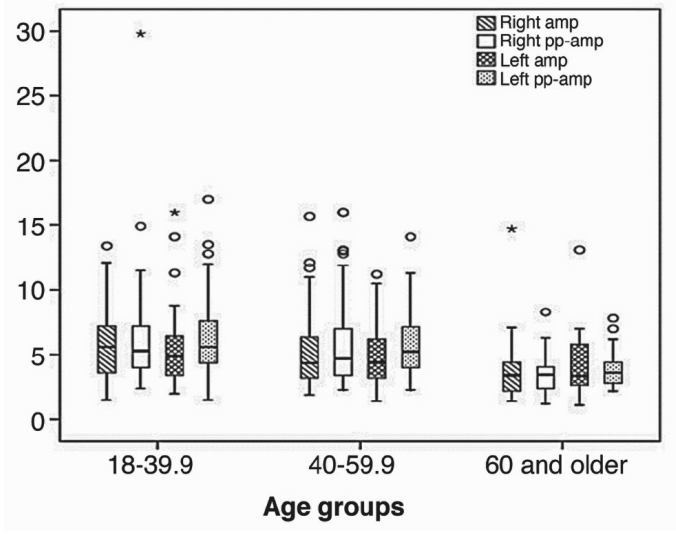

Figure 4. Change in medial femoral cutaneous sensory response amplitude according to age group

Amp: Baseline-to-peak amplitude, pp-amp: Peak-to-peak amplitude

Table 2. Medial femoral cutaneous sensory response parameters			
		Right	**Left**
		Mean ± SD (min–max)	**Mean ± SD (min–max)**
Amplitude (μV)	amp	5.2 ± 2.8 (1.4–15.7)	5.0 ± 2.6 (1.1–16)
	pp-amp	5.7 ± 3.6 (1.2–29.8)	5.7 ± 2.7 (1.5–17)
Latency (ms)	b-lat	2.2 ± 0.2 (1.2–3.3)	2.2 ± 0.3 (1.2–3.1)
	p-lat	2.8 ± 0.2 (1.7–4)	2.8 ± 0.3 (1.6–3.8)
Conduction velocity (m/s)		61.5 ± 6.3 (43–87)	61.9 ± 7.4 (43–80)

SD: Standard deviation, min: Minimum, max: Maximum, amp: Baseline-to-peak amplitude, pp-amp: Peak-to-peak amplitude, b-lat: Baseline latency, p-lat: Peak latency

Table 3. Significant correlations in medial femoral cutaneous sensory response		
Parameters	**Correlation**	**Spearman rho/P**
Latency	Amplitude	-0.272/<0.001
	Conduction velocity	-0.875/<0.001
Amplitude	Age	-0.159/<0.007
	BMI	-0.240/<0.001
	Weight	-0.139/0.019
	Latency	-0.272/<0.001
	Conduction velocity	0.295/<0.001
Conduction velocity	Age	-0.141/0.017
	BMI	-0.127/0.031
	Latency	-0.875/<0.001
	Amplitude	0.295/<0.001

BMI: Body mass index

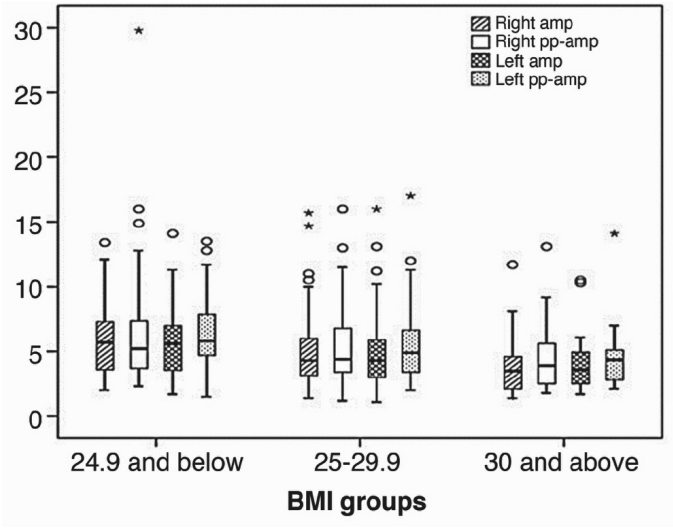

Figure 5. Change in medial femoral cutaneous sensory response amplitude according to body mass index group

Amp: Baseline-to-peak amplitude, pp-amp: Peak-to-peak amplitude

was lower in the >60 age group than in the other groups (P = 0.001 for age 3 and age 1 groups; P = 0.009 for age 3 and age 2 groups) (Figure 4). The MFC sensory response conduction velocity was also significantly different among the age groups (P = 0.016), with the conduction velocity slower in the >60 age group than in the other groups (P = 0.022 for age 3 and age 1 groups; P = 0.020 for age 3 and age 2 groups). Significant correlations were found between the MFC sensory response amplitude, latency, and conduction velocity values (Table 3). A high MFC sensory response amplitude was associated with short latency and fast conduction. In addition, there was a negative correlation between MFC sensory response amplitude and age, body weight, and BMI. A significant difference was observed between the BMI groups only in terms of MFC sensory response amplitude (P = 0.001); the amplitude decreased as the BMI increased (Figure 5) (P = 0.002 for BMI 3 and BMI 1 groups; P = 0.045 for BMI 2 and BMI 1 groups).

Discussion

In this study, the reproducibility of the new method, as defined by Geney-Castro et al. (11), in which the MFC sensory response was obtained from the more distal thigh, was tested in a large population using a wider range of ages and BMI values than in other studies, and the correlations of the MFC sensory response were investigated.

In the first method described by Lee et al. (10) in 1995, stimulation was made just lateral to the femoral artery in the groin, and MFC sensory responses were obtained from 14 cm distal to the stimulation point in a relatively young and small population (age range: 21–56 years; 32 healthy volunteers) with a lower amplitude (generally <5 μV). The stimulation intensity was mostly maintained below 10 mA since the vastus medialis muscle potential affected the response (10). In the new technique performed with more distal stimulation and recording, the stimulation intensity could be increased to 30–35 mA without interfering with the muscle potential. Using the new technique, MFC sensory responses were recorded in 19 individuals over the age of 60 and 16 individuals with a BMI of 30 and above. An MFC amplitude of 5 μV and above was obtained on 143 sides. This new technique does not require stimulation from the inguinal region and is an easily applicable method. In addition, our participants did not describe any discomfort during the examination.

Conclusion

This study revealed that the newly defined distal stimulated MFC sensory nerve conduction study is reproducible and easy to apply. We believe that this method can be used in isolated MFC

nerve lesions, femoral neuropathy, or lumbar plexopathy, even in the presence of advanced age and obesity.

Ethics

Ethics Committee Approval: Ethics Committee of University of Health Sciences Türkiye, Basaksehir Cam and Sakura City Hospital with the protocol number 2023-50.

Informed Consent: Signed informed consent forms were obtained from all healthy volunteers participating in the study.

Peer-review: Externally and internally peer-reviewed.

Authorship Contributions

Concept: Ş.D., Z.M., A.E.Ö., Design: Ş.D., Z.M., A.E.Ö., Data Collection or Processing: Ş.D., Z.M., A.E.Ö., Analysis or Interpretation: Ş.D., Z.M., A.E.Ö., Literature Search: Ş.D., Z.M., A.E.Ö., Writing: Ş.D., Z.M., A.E.Ö.

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

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References

1. William PL, Warwick W. Gray's Anatomy. 29th ed. Philadelphia: WB Saunders, 1980:1108-1111.
2. Rea P. Lower Limb Nerve Supply. In: Rea P (ed). Essential clinically applied anatomy of the peripheral nervous system in the limbs. Academic Press; 2015. p. 101-177.
3. Preston DC, Shapiro BE. Electromyography and neuromuscular disorders: clinical–electrophysiologic correlations. 3rd ed. Elsevier Inc, 2013. p.357-364.
4. Butterfield WC, Neviaser RJ, Roberts MP. Femoral neuropathy and anticoagulants. Ann Surg 1972;176:58-61.
5. Farrell CM, Springer BD, Haidukewych GJ, Morrey BF. Motor nerve palsy following primary total hip arthroplasty. J Bone Joint Surg Am 2005;87:2619-2625.
6. Colak M, Canbaz H, Ayan I, Karabacak T, Kuyurtar F. Intrapelvic mass causing femoral compression neuropathy in a patient with Gaucher disease: a case report. Eklem Hastalik Cerrahisi 2009;20:169-173.
7. Parmer SS, Carpenter JP, Fairman RM, Velazquez OC, Mitchell ME. Femoral neuropathy following retroperitoneal hemorrhage: case series and review of the literature. Ann Vasc Surg 2006;20:536-540.
8. al Hakim M, Katirji B. Femoral mononeuropathy induced by the lithotomy position: a report of 5 cases with a review of literature. Muscle Nerve 1993;16:891-895.
9. Preston DC, Shapiro BE. Electromyography and neuromuscular disorders: clinical-electrophysiologic correlations (expertconsult-online). New York: Elsevier Health Sciences, 2012.
10. Lee HJ, Bach JR, DeLisa JA. Medial femoral cutaneous nerve conduction. Am J Phys Med Rehabil 1995;74:305-307.
11. Geney-Castro DE, Vanegas-Muñóz J, Plata-Contreras J, Salinas-Duran F. Medial femoral cutaneous nerve conduction study with distal recording: a novel technique. Muscle Nerve 2020;61:383-386.