Original Article

Comparison of Conventional and Ultrasound-assisted Femoral Nerve Motor Conduction Study in Healthy Controls

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Abstract

Background: Ultrasound (US) can identify morphologic abnormalities and aid in the accurate localization of peripheral nerves. It can identify the femoral nerve and improve the stimulator placement in the femoral nerve motor conduction study. We aimed to compare the conventional and US-assisted femoral motor conduction techniques in a healthy population. **Methods:** One hundred and sixty-eight healthy controls (336 nerves) aged 18 years or more and both sexes were enrolled. Height, weight, body mass index (BMI), waist circumference (WC), and waist–hip ratio (WHR) were recorded. Stimulation of the femoral nerve was first done blindly (conventional) at the inguinal ligament and later at the site of the nerve identified using the US. Recording was done from the rectus femoris muscle. The mean and fifth percentiles of the compound muscle action potential (CMAP) obtained by both techniques were compared. **Results:** Mean (standard deviation) age of the cohort was 45.5 ± 14.01 years. US-assisted technique recorded larger CMAP than conventional in all age groups, gender, World Health Organization and Asia-Pacific BMI categories, WC, and WHR categories ($P < 0.01$). The fifth percentile of the CMAP amplitude was also higher in the US-assisted technique. **Conclusion:** Our results indicate that a US-assisted setup could improve conventional femoral nerve conduction studies.

Keywords: Compound muscle action potential, femoral nerve, nerve conduction studies, obesity, ultrasonography

Introduction

The femoral nerve motor conduction study is a useful electrophysiological test in evaluating femoral mononeuropathy, L2-L4 radiculopathies, and lumbar plexopathies.[1-4] Various conventional femoral nerve motor conduction techniques are described [Supplementary Table 1].[1,5-8] These conventional methods involve surface or invasive femoral nerve stimulation at or above the inguinal ligament and recording the time in milliseconds for the electrical impulse to cause muscle contraction measured as distal motor latency (DML) and contractility of one of the innervated muscles measured compound muscle action potential (CMAP). However, these conventional methods can yield erroneous results due to inaccurate placement of the stimulator, mainly because of the proximal location of the nerve, subcutaneous fat in obese subjects, and anatomical variations of the femoral nerve.[5-8]

Ultrasound (US) is increasingly being used to evaluate various neuromuscular disorders. It precisely provides the static and dynamic details of the nerves and surrounding structures.[9] Several studies have shown the potential of the US as a possible useful adjunctive tool to improve the yield of nerve conduction studies that may allow accurate localization and optimal stimulation and recording in selected cases. However, these were primarily aimed at superficial sensory nerves in the legs.[10,11] US-guided nerve conduction techniques have been described to allow more accurate and reliable electrophysiological evaluation of lateral femoral cutaneous, saphenous, sural, and superficial peroneal sensory nerves.[12-15] However, there is no study on using US guidance in femoral motor nerve conduction studies. We hypothesized that accurate localization of the stimulation site of the femoral nerve by US can overcome the limitations mentioned earlier during the conduction study.

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We, therefore, aimed to determine whether adding the US can improve nerve conduction studies of the femoral nerve using a comparative study with a conventional motor conduction technique in healthy controls.

Materials and Methods

This pilot exploratory study was conducted between September 2019 and August 2020 in the Department of Neurology, CARE Hospitals, Hyderabad, Telangana state, South India. The study was conducted following the principles of the Declaration of Helsinki and Good Clinical Practice. The Institutional Ethics Committee, CARE Hospitals approved the study protocol, and written informed consent was obtained from all the participating subjects before enrolment (ECR/94/Inst./AP/2013/RR-19).

Subjects

We included subjects if all the following criteria are met – (1) subjects between 18 and 80 years, (2) subjects of either sex, (3) subjects with no subjective or objective evidence of any neuromuscular or neurological disease, any trauma or surgery around the hip and thigh, lower limb contracture, and (4) those who gave informed consent. We excluded those who did not meet any one of the inclusion criteria. Anthropometric measurements, including the subjects' height, weight, and waist and hip circumference, were recorded. Body mass index (BMI) was calculated as weight (in kilograms) over squared height (in meters). Waist circumference (WC) was measured in the horizontal plane at the level of the superior border of the iliac crest, and the hip circumference was measured at the level of the widest part of the buttocks. The waist-to-hip ratio (WHR) was calculated. Subjects were grouped into BMI categories per the World Health Organization (WHO) and Asia-Pacific classification criteria.[16] WC categories per the WHO and International diabetic federation (IDF) classification criteria for males and females and WHR category per the WHO criteria.[17] The gender and anthropometric parameters were not matched across the age groups.

Conventional nerve conduction studies

Motor nerve conduction studies were performed bilaterally using an electrodiagnostic machine (Nicolet Synergy, Natus Medical Inc., USA) by a single senior technologist (third author) with 15 years of experience performing nerve conduction studies. He was blinded to the US findings. We performed the femoral nerve motor conduction method described by Preston and Shapiro in the present study.[1] Skin temperature (measured over the dorsum of the hand) during the procedure was maintained between 28°C and 32°C using warmers or heat blowers. Machine settings were calibrated as - a sensitivity of 5 mV per division, sweep speed of 5 ms per division, and bandwidth of 3–10,000 Hz. The stimulation was done keeping parameters similar in both methods. The femoral nerve was stimulated using surface electrodes at the inguinal ligament lateral to the femoral artery. The stimulator was moved parallel to the presumed nerve site to ascertain the optimal stimulation site. The active recording surface electrode (G1) was placed over the anterior thigh, halfway between the inguinal crease and knee, and the reference

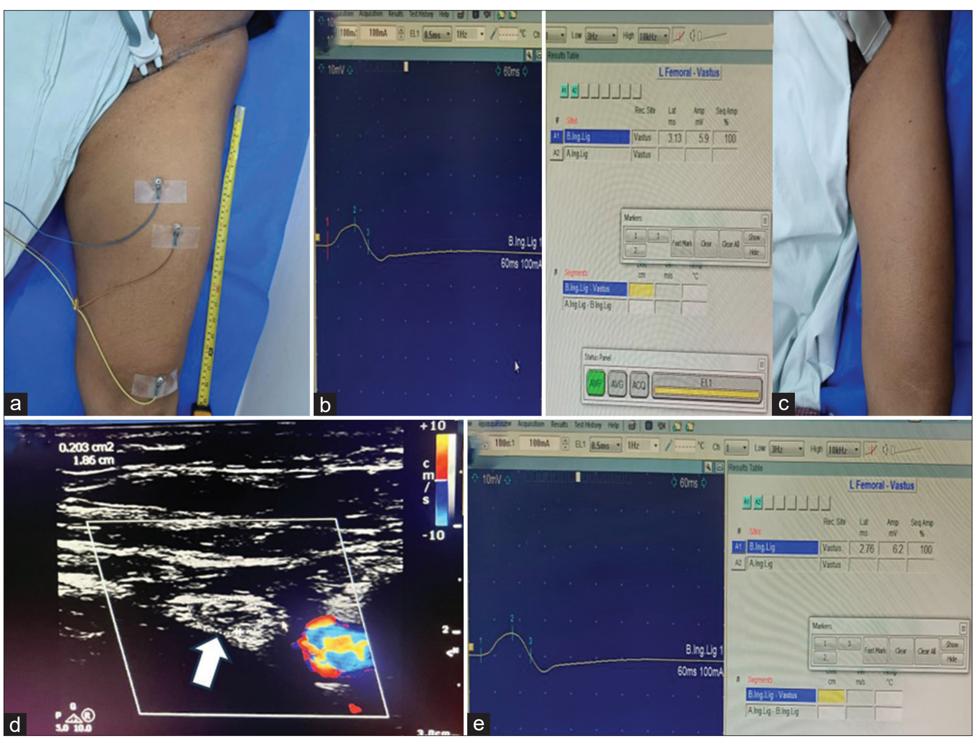

Figure 1: Clinical photograph (a) showing stimulation and recording electrode placement and compound muscle action potential (CMAP) recording (b) by conventional method; Clinical photograph (c) and corresponding ultrasound (US) image (d) showing transducer placement and femoral nerve (marked in dots and shown in bold white arrow) respectively; CMAP recording with US assistance (e)

electrode (G2) over the bony prominence at the knee. The electric current was delivered incrementally until CMAP amplitude reached a plateau. The current intensity was increased by 25% more than this to achieve supramaximal stimulation. Stimulation parameters were – duration 0.2–1.0 ms and intensity 60–100 mA. The maximum duration and intensity of current was 1.0 ms and 100 mA. The best (of the three trials) maximum achievable CMAP (in millivolts) was recorded. CMAP was measured from baseline to peak.

Ultrasound-assisted technique

After the initial recording of CMAP by conventional technique, the femoral nerve was identified with the US using a Philips HD 15 US machine (Massachusetts, USA) with a 12–3 Megahertz linear-arrayed transducer. A neurologist (corresponding author) trained in neuromuscular US performed US in all subjects. He was blinded to the findings of nerve conduction studies. The transducer was first placed over the proximal part of the thigh at the mid-point of the inguinal ligament. The femoral artery was identified first with the help of color Doppler, and the nerve was identified as a honeycombed fascicular structure located just lateral to the femoral artery. The exact location of the nerve was marked. Toggling the transducer was often done to identify the nerve from the adjacent iliacus muscle and subcutaneous fat if it is not identified instantly. The femoral nerve motor conduction study was repeated with stimulation at the marked site, keeping the recording electrodes at the same site as the conventional technique. The best (of the three trials) maximum achievable CMAP was re-recorded [Figure 1].

Parameters

The best CMAP obtained by each technique was averaged, and "Mean CMAP" was computed. This parameter was chosen as it is the most helpful parameter in femoral nerve conduction. Each category's CMAP values were ranked from smallest to largest, and the fifth percentile was calculated. The fifth percentile value of CMAP was chosen for comparison, as was done in a few similar studies.[18] Mean CMAP and fifth percentile value of CMAP, obtained by conventional technique compared to the values obtained by US-assisted technique in various age groups (<40 years vs. ≥40 years), gender, BMI categories of WHO and Asia-Pacific classification system, WC categories by the WHO and IDF classification systems, WHR categories based on the WHO classification. Motor nerve conduction velocity becomes slower, and the CMAP amplitudes decrease with age.[19,20] Therefore, age was subgrouped into two categories as described.

Statistics

Statistical analysis was performed using SPSS version 21.0 (Armonk, NY; IBM Corp.). Descriptive statistics were employed for outcome presentation, with the normality of variables assessed through the Shapiro–Wilk test. Binary and categorical variables were presented using counts and percentages. We used Student's *t*-test to compare the mean CMAP amplitude recorded by both techniques and a $P < 0.05$ was considered statistically significant. The fifth percentile values of CMAP obtained by the two methods were compared.

Table 1: Demographic and anthropometric data

Parameter	*n* (%)
Age (years), mean±SD	45.58 (14.01)
Male: female	2.29:1
BMI (kg/m^2) category - WHO	
<25	34 (20.23)
25–29.9	56 (33.33)
30–34.9	35 (20.83)
≥35	43 (25.59)
BMI (kg/m^2) category for the Asian population	
<23	17 (10.11)
23–24.9	17 (10.11)
25–29.9	56 (33.33)
≥30	78 (46.42)
WC category (cm) in males - WHO	
<102	78 (46.42)
≥102	39 (23.21)
WC category (cm) in females - WHO	
<88	4 (2.38)
≥88	47 (27.97)
WC category (cm) in males - IDF	
<90	29 (17.26)
≥90	88 (52.38)
WC category (cm) in females - IDF	
<80	1 (0.59)
≥80	50 (29.76)
WHR - WHO	
Males ≥0.90	102 (60.71)
Females >0.85	43 (25.59)

Data are presented as *n* (%) unless otherwise specified. BMI: Body mass index, WHO: World Health Organization, WC: Waist circumference, IDF: International Diabetes Federation, WHR: Waist–hip ratio, SD: Standard deviation

Results

A total of 168 subjects (336 femoral nerves) were included in this study. Males accounted for 69.9% of the study population. The mean age of the subjects was 45.58 years, ranging from 19 to 76 years (mean age in each gender: females - 45.49 years, males - 45.63 years). Demographic and anthropometric data are shown in Table 1.

Overall comparison of the mean CMAP amplitude obtained by both techniques showed a significantly higher CMAP by the US-assisted technique than the conventional technique (9.22 ± 2.89 vs. 7.90 ± 2.86; $P < 0.01$). The mean CMAP amplitude obtained by the US-assisted technique was higher than the conventional technique in age groups and gender ($P < 0.01$). The mean CMAP amplitude was higher than the conventional technique in all the BMI categories of the WHO criteria ($P < 0.01$). CMAP amplitude obtained by the US-assisted technique was also higher than the conventional technique in all BMI categories of Asia-Pacific criteria except BMI category <23 kg/m^2 ($P < 0.01$). The CMAP amplitude was higher in the US-assisted technique in all the WC categories (WHO and IDF criteria) except in the WHO category (females) <88 cm ($P < 0.01$). The CMAP

Table 2: Comparison of compound muscle action potential amplitude (mV) between conventional and US-assisted techniques

		CMAP amplitude		
Variable	***n* (%)**	**Conventional technique (mean±SD)**	**US-assisted technique (mean±SD)**	***P***
Total cohort	336 (100)	7.90 (2.86)	9.22 (2.89)	<0.01
Age (years)				
<40	128 (38.09)	8.13 (3.05)	9.44 (3.02)	<0.01
≥40	208 (61.90)	7.73 (2.77)	9.11 (2.85)	<0.01
Gender				
Female	102 (30.35)	6.44 (2.62)	7.51 (2.52)	<0.01
Male	234 (69.64)	8.51 (2.77)	9.99 (2.76)	<0.01
BMI (WHO)				
<25	68 (20.23)	8.65 (2.89)	10.29 (2.66)	<0.01
25–29.9	112 (33.3)	8.45 (2.48)	9.68 (2.55)	<0.01
30–34.9	70 (20.83)	8.13 (3.22)	9.51 (3.14)	0.011
≥35	86 (25.59)	6.42 (2.49)	7.58 (2.65)	<0.01
BMI (Asia-Pacific)				
<23	34 (10.11)	8.26 (2.70)	9.52 (2.72)	0.059
23–24.9	34 (10.11)	9.04 (3.05)	11.06 (2.41)	<0.01
25–29.9	112 (33.3)	8.45 (2.48)	9.68 (2.54)	<0.01
≥30	156 (46.4)	7.18 (2.96)	8.44 (3.02)	<0.01
WC (males)				
<102	156 (46.42)	9.12 (2.50)	10.53 (2.56)	<0.01
≥102	78 (23.21)	7.29 (2.88)	8.90 (2.82)	<0.01
WC (females)				
<88	8 (2.38)	8.63 (3.15)	9.38 (3.15)	0.641
≥88	94 (27.97)	6.26 (2.50)	7.35 (2.40)	<0.01
WC males (IDF)				
<90	58 (17.26)	10.17 (2.33)	11.64 (2.26)	<0.01
≥90	176 (52.38)	7.96 (2.68)	9.44 (2.69)	<0.01
WC females (IDF)				
≥80	100 (29.76)	6.39 (2.62)	7.48 (2.53)	<0.01
WHR males				
<0.9	30 (8.29)	8.83 (2.49)	9.67 (2.55)	0.201
≥0.9	204 (60.71)	8.46 (2.81)	10.03 (2.78)	<0.01
WHR females				
<0.85	16 (4.76)	6.38 (1.85)	7.19 (1.51)	0.185
≥0.85	86 (25.59)	6.45 (2.74)	7.57 (2.66)	<0.01

CMAP: Compound muscle action potential, BMI: Body mass index, WHO: World Health Organization, WC: Waist circumference, IDF: International Diabetes Federation, WHR: Waist–hip ratio

amplitude recorded by the US-assisted technique was also higher in those with higher WHR [Table 2]. A higher fifth percentile of CMAP amplitude was noted with the US-assisted technique than with the conventional technique in both age groups and genders. The fifth percentile of CMAP amplitude by US-assisted technique was higher than conventional in all the BMI categories of WHO and Asia-Pacific criteria, all the WC categories of WHO and IDF criteria, and both categories of WHR by WHO criteria [Table 3].

Discussion

We obtained higher CMA*P* values with a US-assisted setup than with a conventional setup irrespective of other variables known to influence CMAP, such as age, gender, and BMI. Besides these physiological variables, CMAP recordings are influenced by several non-biological factors such as lower skin temperature, inaccurate waveform measurements, submaximal or overstimulation, inaccurate stimulator and electrode placement, and recording from a site far away from the motor point.[21] We ensured the maximum to avoid these errors in our recording techniques. Proper and uniform temperature controls were maintained throughout the recording. Supramaximal stimulation was used during both techniques. We ensured the fixed stimulation site in the conventional technique and the fixed recording site during both techniques.

It is a well-established fact that peripheral nerves undergo age-related changes in several electrophysiological studies.[22,23] Further, increased age is associated with reduced motor nerve conduction velocity and the CMAP amplitude.[23] Anatomical studies also show a significant age-related decrease in the mean

Table 3: Comparison of 5th percentile compound muscle action potential amplitude (mV) between conventional and US-assisted technique

Variable	*n* (%)	Conventional technique	US-assisted technique
Age (years)			
<40	128 (38.09)	5.10	6.94
≥40	208 (61.90)	2.43	4.24
Gender			
Female	102 (30.35)	2.72	4.51
Male	234 (69.64)	3.82	4.5
BMI (WHO)			
<25	68 (20.23)	3.44	4.28
25–29.9	112 (33.3)	3.46	4.46
30–34.9	70 (20.83)	3.24	4.41
≥35	86 (25.59)	3.17	4.63
BMI (Asia-pacific)			
<23	34 (10.11)	3.42	4.65
23–24.9	34 (10.11)	2.10	5.55
25–29.9	112 (33.3)	4.60	5.36
≥30	156 (46.4)	2.19	3.77
WC males			
<102	156 (46.42)	5.0	6.85
≥102	78 (23.21)	2.95	3.95
WC females			
<88	8 (2.38)	4.0	5.0
≥88	94 (27.97)	1.75	4.0
WC (IDF) males			
<90	58 (17.26)	6.0	8.0
≥90	176 (52.38)	4.0	4.85
WC (IDF) females			
≥80	100 (29.76)	2.0	4.0
WHR males			
<0.9	30 (8.29)	4.0	4.0
≥0.9	204 (60.71)	4.0	5.0
WHR females			
<0.85	16 (4.76)	4.0	5.0
≥0.85	86 (25.59)	1.35	4.0

BMI: Body mass index, WHO: World Health Organization, WC: Waist circumference, IDF: International Diabetes Federation, WHR: Waist–hip ratio

transverse area of axons of the femoral nerve.[22] This point was evident in our study by lower mean CMAP amplitude and the fifth percentile value of the CMAP in subjects over 40 years. Furthermore, the present study showed significantly higher CMAP amplitude with the US-assisted technique than the conventional one in both age groups. Similar results were noted in the US-assisted sural nerve conduction study.[22]

Obesity is a significant and common impediment to inaccurate localization of the nerves at the thigh. Therefore, it will often acquire less than normal CMAPs or sensory nerve action potentials (SNAPs) while recording from nerves around the thigh. A conduction study of lateral femoral cutaneous nerve by Andrea J. Boon *et al*.[18] has provided evidence supporting this fact. They showed absent SNAPs in those with BMI >32 kg/m^2.[18] The present study observations suggest that the US-assisted technique may be ideal for the femoral nerve. This was evident by a significant change observed in the CMAP amplitude by the US technique in controls with high BMI ($P < 0.01$), high WC ($P < 0.01$), and high WHR ($P < 0.01$). There was also a more significant change in the fifth percentile value of the CMAP amplitude in the higher BMI category ≥35 kg/m^2 (WHO criteria). However, this was not evident in higher BMI categories of Asia-Pacific and higher WC of the female gender. This could have been due to the fewer participants in lower BMI (Asia-Pacific) categories and more obese female participants than male participants in our cohort.

The study did not include the strength and number of the stimuli used to obtain the supramaximal CMAP. DML is another parameter of interest in motor nerve conduction studies. We did not include this parameter in the present study as it is not as helpful as CMAP in studying the femoral nerve. Side-side comparison of CMAP and DML is often done to identify the abnormal side during femoral nerve recordings. However, our methodology ensures comparison before and after the US localization of the femoral nerve. Hence, side-side comparison is of little value in the present study.

Identifying the femoral nerve in the US is essential to mastering this technique. This requires adequate knowledge of the US anatomy of the inguinal region and the acquisition of manual ability. Tilting the transducer slightly cranially or caudally helps to bring out the image of the nerve, making it distinct from the background. Applying slight pressure to the transducer often helps optimize the image of the femoral nerve. However, it may collapse the femoral vein, obscuring it from the examiner's eye.[23]

This study has several limitations. First, we have not considered the number and strength of the electrical stimulation used to obtain optimal CMAP in both techniques. When we designed the study, we did not include these parameters to avoid exposing otherwise healthy controls to high current multiple times. Second, DML is another important parameter of interest in motor nerve conduction studies. We did not include it in our protocol as it was not as crucial as CMAP in ascertaining the femoral nerve function. Third, the overall thickness of the subcutaneous tissue overlying the nerve and the depth of nerve position was not studied. The correlation between the depth of the nerve and current strength could have provided more insights. Fourth, studying the disease and disease controls could have helped in knowing the broader practical applicability of the technique. Therefore, future studies designed by considering all these limitations will be helpful to validate these results and better understand the role of US assistance in femoral nerve motor conduction studies.

Conclusion

Our study shows that US-assisted motor conduction studies of femoral nerves are feasible and may be of benefit in a broad spectrum of anthropometric features, including obese subjects. These findings have potential implications for future research on the utility of US assistance in performing nerve conducting studies of deeper nerves.

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Nil.

Conflicts of interest

There are no conflicts of interest.

References

1. Preston DC, Shapiro BE. Routine lower extremity nerve conduction techniques. In: Electromyography and Neuromuscular Disorders. Fourth ed. Philadelphia, PA: Elsevier; 2020. p. 124-33.
2. Butler K, Morris J, Scott KR, Simmons Z. Neuroanatomy for Nerve Conduction Studies. 1st ed. Rochester: Johnson Printing Company Inc.; 2010.
3. Chopra JS, Hurwitz LJ. Femoral nerve conduction in diabetes and chronic occlusive vascular disease. J Neurol Neurosurg Psychiatry 1968;31:28-33.
4. Gassel MM. A study of femoral nerve conduction time. Arch Neurol 1963;9:607-14.
5. Johnson EW, Wood PK, Powers JJ. Femoral nerve conduction studies. Arch Phys Med Rehabil 1968;49:528-32.
6. Rosenfalck A, Rosenfalck P. Electromyography-Sensory and Motor Conduction: Findings in Normal Subjects. Copenhagen: Laboratory of Clinical Neurophysiology, Rigshospitalet; 1975.
7. Stöhr M, Schumm F, Ballier R. Normal sensory conduction in the saphenous nerve in man. Electroencephalogr Clin Neurophysiol 1978;44:172-8.
8. Uludag B, Ertekin C, Turman AB, Demir D, Kiylioglu N. Proximal and distal motor nerve conduction in obturator and femoral nerves. Arch Phys Med Rehabil 2000;81:1166-70.
9. Gonzalez NL, Hobson Webb LD. Neuromuscular ultrasound in clinical practice: A review. Clin Neurophysiol Pract 2019;4:148-63.
10. Kim KH, Yoo JY, You BC. Ultrasonographic evaluation of sural nerve for nerve conduction study. Ann Rehabil Med 2014;38:46-51.
11. Nakano H, Shima H, Tei K, Saura R. Ultrasound-assisted near nerve method in nerve conduction study for the diagnosis of tarsal tunnel syndrome. A case report. Clin Neurophysiol Pract 2020;5:135-8.
12. Cartwright MS, White DL, Hollinger JS, Krzesniak Swinarska M, Caress JB, Walker FO. Ultrasound guidance for sural nerve conduction studies. Muscle Nerve 2019;59:705-7.
13. Evangelopoulos ME, Humpert S, Rösler KM. Ultrasound-guided electrodes for conduction studies of the saphenous nerve. J Clin Neurophysiol 2017;34:243-7.
14. Kim KH, Park BK, Kim DH, Kim Y. Sonography-guided recording for superficial peroneal sensory nerve conduction study. Muscle Nerve 2018;57:628-33.
15. Park BJ, Joeng ES, Choi JK, Kang S, Yoon JS, Yang SN. Ultrasound-guided lateral femoral cutaneous nerve conduction study. Ann Rehabil Med 2015;39:47-51.
16. Misra A, Chowbey P, Makkar BM, Vikram NK, Wasir JS, Chadha D, *et al.* Consensus statement for diagnosis of obesity, abdominal obesity and the metabolic syndrome for Asian Indians and recommendations for physical activity, medical and surgical management. J Assoc Physicians India 2009;57:163-70.
17. WHO. Waist Circumference and Waist-Hip Ratio: Report of a WHO Expert Consultation, Geneva, 2011. 8-11 December 2008.
18. Boon AJ, Bailey PW, Smith J, Sorenson EJ, Harper CM, Hurdle MF. Utility of ultrasound-guided surface electrode placement in lateral femoral cutaneous nerve conduction studies. Muscle Nerve 2011;44:525-30.
19. Mallik A, Weir AI. Nerve conduction studies: Essentials and pitfalls in practice. J Neurol Neurosurg Psychiatry 2005;76 Suppl 2:i23-31.
20. Scheidegger O, Kihm C, Kamm CP, Rösler KM. Sural nerve conduction studies using ultrasound-guided needle positioning: Influence of age and recording location. Muscle Nerve 2016;54:879-82.
21. Kurokawa K, Mimori Y, Tanaka E, Kohriyama T, Nakamura S. Age-related change in peripheral nerve conduction: Compound muscle action potential duration and dispersion. Gerontology 1999;45:168-73.
22. Amimoto K, Goto N, Goto J, Ezure H, Yanagisawa K. Morphometric analysis of the human femoral nerve and its ageing process. Okajimas Folia Anat Jpn 2002;78:259-62.
23. Muhly WT, Orebaugh SL. Ultrasound evaluation of the anatomy of the vessels in relation to the femoral nerve at the femoral crease. Surg Radiol Anat 2011;33:491-4.

Supplementary Table 1: Various techniques of femoral nerve motor nerve conduction study

Technique	Stimulation site	Stimulation Electrodes	Sampled Muscle	Recording site	Recording Electrodes	Parameters Measured	Reference
Johnson's method	Above inguinal ligament, Below inguinal ligament, and Hunter's canal	Surface	Vastus medialis	-	Surface	Compound muscle action potential	5
Rigshospitalet method	Below inguinal ligament	Concentric needle	Rectus femoris	20 cm below inguinal ligament	Concentric needle	Distal motor latency	6
Storhr's method	At inguinal ligament	Surface	Vastus medialis	30 cm below inguinal ligament	Surface		7
Uludag's methods	At inguinal ligament, and At lumbar roots	Surface/ Needle	Rectus femoris	40 cm below inguinal ligament	Surface/ Needle	Distal motor latency, compound motor action potential	8
Method described in David C. Preston and Barbara E. Shapiro's text book	At inguinal ligament	Surface	Rectus femoris	Over the mid-thigh between inguinal ligament and knee joint	Surface	Compound muscle action potential	1