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NEEDLE ELECTROMYOGRAPHY: A PRELIMINARY NORMATIVE STUDY

Physiology

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ABSTRACT

Background: Needle electromyography (EMG) is the study of electrical activity of muscle1. It localizes lesion, either to nerve, muscle or neuromuscular junction. We aimed to obtain a preliminary normative EMG data for our local population.

Methods: We investigated twenty (m=10, f=10) healthy adults of age 17-50 years using convenient sampling and based on inclusion and exclusion criteria. Digital Nihon Kohden machine (NM-420S, H636, Japan) and needle electrodes were used to evaluate six muscles in all limbs. Anthropometric, motor unit action potential (MUAP) amplitude and MUAP duration recorded were analyzed using descriptive statistics.

Results: The mean duration of APB, ADM, FDI, EDC, TA, and EDB were 6.24±1.71, 5.9±1.6, 6.20±1.71, 7.9±1.73, 10.82±1.81, and 9.12±1.98 ms respectively.

Conclusion: Similar differences in normative values have been reported. This study provided a preliminary normative data for our local population, so that the inferences made on further are objective and valid.

KEYWORDS

electromyography, MUAP, muscle, normative

INTRODUCTION:

Needle electromyography (NEMG) is an extension of nerve conduction study (NCS) [1]. It refers to the methods of studying the electrical activity of muscle in terms of latency, amplitude, duration, and phases. Moreover, it provides information regarding the integrity of the motor unit. If done along with NCS, it yields better diagnostic value[2]. They are indicated in virtually all suspected neuromuscular disorder studies[3].

EMG findings are per se never pathognomonic of specific diseases and cannot provide a definitive diagnosis, although they may justifiably be used to support diagnosis advanced on clinical or other grounds [1]. The goals of EMG are localization of lesion, either, localized to nerve, muscle or neuromuscular junction (NMJ); to understand nerve pathophysiology in case of nerve disorders; and to assess the severity and temporal course of the disorders [2].

Differences in normative / reference values in different populations for EMG have been reported by various authors. Available literature showed no published data on Nepalese population so far. Still we have been depending on international (western) reference values while interpreting EMG results. Therefore, this study aimed to obtain a preliminary normative (reference) EMG data for the local population, so that the inferences made on subjects are objective and valid.

METHODS:

EMG study investigated twenty (m=10, f=10) healthy adult volunteers of age 17 to 50 years at the departmental Neuophysiology Lab. The subjects were selected using convenient sampling method following the inclusion and exclusion criteria. Anyone with bleeding disorders or any medical illness or drugs associated with the NMJ disorders were excuded. Informed written consent was obtained. Their health status was assessed with medical history and physical examination. Digital Nihon Kohden machine (NM-420S, H636, Japan) and needle electrodes were used for EMG recordings. The sample size was limited because EMG responses have less variability, more robust and also due to BPKIHS grant ceiling. The muscles studied in upper limbs were abductor pollicis brevis, abductor digiti minimi, first dorsal interosseous, extensor digitorum communis, biceps, and deltoid. In lower limbs, were tibialis anterior, peroneous longus, gastrocnemius, extensor digitorum brevis, biceps femoris short head, and vastus medialis. The anthropometric and electromyography variables recorded were as follows.

A. **Anthropometric variables**: recorded were age (in years), height (in centimetres), weight (in kilograms) and body mass index (in Kg/m^2).

B. Electromyography variables: recorded were as follows.

1. Motor unit action potential (MUAP) amplitude: MUAP amplitude is defined as the height of the main negative spike potential in the discharge, measured from the preceding positive peak[4].

2. Motor unit action potential (MUAP) duration: It is the time elapsed from the discharge's first deviation from the baseline to its return to the baseline. It was measured in milliseconds. Duration is related to the time required for all muscle fiber action potentials within the recording distance of the electrode to reach its recording surface. The onset of the MUAP waveform represents the arrival of the fastest muscle fiber action potential[4].

Recording procedure:

All the recordings of this study were done in the Neuro-electro-physiology lab of Department of Physiology, BPKIHS under standard laboratory and instrument conditions (see table 2) at a room temperature of 26±2 C (thermo neutral zone).

Table 2: Stimulus and recording parameters for EMG[3]

Parameter	*Resting*	*Motor unit*	*Recruitment*
Gain	50µV/div	200 µV/div	1 mV/div
Time base	10ms/div	10ms/div	10ms/div
Low-frequency filter	10Hz	10Hz	10Hz
High-frequency filter	32kHz	32kHz	32kHz

***Subject Preparation and Needle Electromyography Examination[2]* included following steps:**

a. Explaining electromyography procedure to subject to allay any fears.
b. Selecting first muscle for study.
c. Locating muscle by anatomical landmarks.
d. Demonstrating the subject how to activate muscle.
e. Palpating the muscle during contraction.
f. Asking subject to relax muscle.
g. Inserting needle into relaxed muscle.
h. Asking subject to contract slightly to ensure proper placement.
i. Asking subject to relax muscle fully.
j. Assessing insertional and spontaneous activity (sweep speed: 10 ms/div; sensitivity: 50 microvolt per division).
k. Performing 5-10 brief insertions in all four quadrants.

l. Assessing motor unit action potentials (sweep speed: ms/div; sensitivity: 200 µV/div).
m. Asking subject to contract muscle slightly, and gently move needle until MUAPs become "sharp".
n. Assessing several locations for MUAP duration, amplitude, phases, recruitment, and activation.
o. Proceeding to next muscle.

Recordings can be summarized as follow:

Single motor unit activation: The subject was asked to make a slight contraction of the sampled muscle. This evoked motor unit action potentials (MUAP) generated by each motor axon activating many muscle fibers and its duration, amplitude, and phases were noted.

Maximal Contraction: Interference pattern was recorded by asking the subject to maximally contract the muscle. Increasing force of contraction resulted in recruited units discharging at a faster rate and new units being recruited. The baseline was not visible and individual units were not discernible.

Statistical Analysis: Data were first entered in the Microsoft Excel Work Sheet. Descriptive statistics was then used to obtain the mean ± SD.

Ethical Consideration: Ethical clearance was obtained from the Institute Ethical Review Board (IERB) of the Institute.

RESULTS:

Table 3: Anthropometric parameters

	Anthropometric parameters			
	Age (Years)	Height (cm)	Weight (Kg)	BMI (Kg/m^2)
Mean±SD	30.6±8.44	157.25±8.27	60.7±6.94	24.52±1.87

Table 4: Upper limb muscles with MUAP parameters

Muscle	MUAP	
	Duration (ms)	Amplitude (µV)
Abductor pollicis brevis	6.24±1.71	365±150
Abductor digiti minimi	5.9±1.6	366±169
First dorsal interosseous	6.20±1.71	314.6±88.5
Extensor digitorum communis	7.9±1.73	316±114
Biceps	8.2±1.46	287±85
Deltoid	8.7±0.79	265±57

Table 5: Lower limb muscles with MUAP parameters

Muscle	MUAP	
	Duration (ms)	Amplitude (µV)
Tibialis anterior	10.82±1.81	314±78
Peroneous longus	10.15±1.98	336±95
Gastrocnemius	9.27±1.43	297±89
Extensor digitorum brevis	9.12±1.98	246.48±113.46
Biceps femoris short Head	10.28±1.27	307.68±123.46
Vastus medialis	9.86±1.75	316±139

DISCUSSION:

The basic component of the peripheral nervous system is the motor unit, defined as an individual motor neuron, its axon, and associated neuromuscular junctions (NMJs) and muscle fibers. The extracellular needle EMG recording of a motor unit is the MUAP[2]. The normative values of MUAP differ from population to population and lab to lab. Our study was aimed to obtain a preliminary normative data for the local Nepalese population. Available literature showed no such published data on Nepalese population so far. We have been depending on international reference values while interpreting EMG results. This study greatly attributed establishing our preliminary normative data of the commonly tested muscles in the upper and lower limbs. The data obtained were to quite extent dissimilar with western population on comparison with others.

The durations of MUAPs in a muscle have a normal distribution that can be described by a mean and standard deviation[5]. In upper limb (see table 6), the mean MUAP duration of the tested muscles (abductor policis brevis, abductor digiti minimi, first dorsal interosseous, extensor digitorum communis, biceps, and deltoid) were 6.24±1.71, 5.9±1.6, 6.20±1.71, 7.9±1.73, 8.2±1.46 and 8.7±0.79 ms respectively. The mean MUAP duration of biceps, and deltoid agree with those reported by Preston & Shapiro[2], whereas the other muscles showed lower value than reported by Hasan A[8], Buchthal[6], Joe F[7] and Doherty TJ[10]. This could be due to several reasons. It may be due to different maneuvering, setting and recording of different labs. The lower MUAP duration in abductor policis brevis, abductor digiti minimi, first dorsal interosseous, and extensor digitorum communis may be attributed to the relatively smaller size of muscle fibers as compared to western population. Duration is related to the time required for all muscle fiber action potentials within the recording distance of the electrode to reach its recording surface. The lesser the size of the muscle fibers faster will be depolarization resulting in shorter duration[2]. It is evident that the muscle bulk is comparatively larger in western population than ours. Duration also varies with synchronization of motor units recruited. The better synchronization would result in shorter MUAP duration.

The normal values differ from muscle to muscle and also vary with age and temperature. Average duration increases by 35% from infancy to adulthood (biceps) and by 65% (abductor digiti minimi), probably due to dispersion of the endplates when the muscles become larger in size[5]. We could not compare it, as we recruited only adults. The area and duration of the simulated MUAPs were affected by all muscle fibers in front of the active recording surface but mainly by those that were less than 2 and 2.5 mm, respectively, from the active recording surface[11].

In lower limb (see table 7), the mean MUAP duration of the tested muscles (tibialis anterior, peroneous longus, gastrocnemius, extensor digitorum brevis, biceps femoris short head and vastus medialis) were 10.82±1.81, 10.15±1.98, 9.27±1.43, 9.12±1.98, 10.28±1.27 and 9.86±1.75ms respectively. The mean duration of tibialis anterior agree with those reported by Preston & Shapiro[2], whereas were lower than reported by Hasan A[8], Buchthal[6], and Joe F[7]. The shorter duration can be attributed to the relatively smaller size of muscle fibers and better motor unit synchronization. However, the mean duration of gastrocnemius and extensor digitorum brevis agreed with those reported by other authors (Preston & Shapiro[2], Hasan A[8], and Buchthal[6]). Joe F[7] and Stalberg[9] did not report the mean duration of gastrocnemius and extensor digitorum brevis. The mean duration of peroneous longus and biceps femoris short head were comparable with that of Preston & Shapiro[2].

The MUAP amplitudes (see table 6 & 7) in abductor pollicis brevis, abductor digiti minimi, first dorsal interosseous, extensor digitorum communis, biceps, deltoid, tibialis anterior, peroneous longus, gastrocnemius, extensor digitorum brevis, biceps femoris short head, and vastus medialis were 365±150, 366±169, 314.6±88.5, 316±114, 287±85, 265±57, 314±78, 336±95, 297±89, 246.48±113.46, 307.68±123.46, and 316±139 µV. The MUAP amplitudes of biceps and tibialis anterior were close to that reported by Joe F[7] and Stalberg[9]. The abductor digiti minimi, deltoid and extensor digitorum brevis amplitudes were very close to Buchthal[6] but higher than Hasan A[8] and Aminoff MJ[1]. The amplitude of the MUAP reflects the sum of the action potentials of only a few muscle fibers that are closest to the tip of the recording electrode, rather than the area of the fibers in the MU. Thus, the amplitude is less indicative of the size of the MU than the duration. It is more variable for any single MU. Because of these difficulties, acceptable normal values for amplitudes of MUAPs are not available[5].

Table 6: Comparison of MUAP Duration (ms) & Amplitude (µV) authors

Muscle	MUAP	Ours	Hasan[8]	Buchthal[6]	Joe F[7]	Stalberg[9]	Preston[2]
ADB	Duration	6.24±1.71	9.27 (0.23)	9.2-9.4			7.8-14.2
	Amplitude	365±150	180 (33)	260			
ADM	Duration	5.9±1.6	9.30 (0.23)	9.2-9.4			9.0-16.5
	Amplitude	366±169	187 (30)	350			
FDI	Duration	6.20±1.71					
	Amplitude	314.6±88.5					
EDB	Duration	7.9±1.73					
	Amplitude	316±114					

Biceps	Duration	8.2±1.46	10.4 (1.7)	10.0-11.4	20.68(5.26)		7.0-12.8
	Amplitude	287±85	158 (36)	180	315.17 (166.74)	65-180	
Deltoid	Duration	8.7±0.79	10.9 (0.5)	10.2-11.6			8.6-15.7
	Amplitude	265±57	175 (36)	212			
TA	Duration	10.82±1.81	12.9 (0.9)	12.3-14.0	19.38 (5.55)		8.7-15.9
	Amplitude	314±78	154 (39)	220	270.35 (152.69)	65-330	
PL	Duration	10.15±1.98					6.3-11.5
	Amplitude	336±95					
GC	Duration	9.27±1.43	10.17 (0.48)	9.4-10.7			7.0-12.8
	Amplitude	297±89	132 (38)	160			
EDB	Duration	9.12±1.98	10.03 (0.46)	9.4-10.7			6.9-12.7
	Amplitude	246.4±113.4	163 (25)	210			
BFSH	Duration	10.28±1.27					7.8-14.3
	Amplitude	307.6±123.4					
VM	Duration	9.86±1.75	10.87 (0.48)	10.2-11.6			
	Amplitude	316±139	175 (43) 230	230			

Abbreviations:

ADB: Abductor pollicis brevis
ADM: Abductor digiti minimi
TA: Tibialis anterior
PL: Peroneous longus
GC: Gastrocnemius
FDI: First dorsal interosseous
EDC: Extensor digitorum communis
EDB: Extensor digitorum brevis
BFSH:Biceps femoris short Head
VM: Vastus medialis

CONCLUSION:

Similar differences in normative values have been reported. This study provided a preliminary normative data for our local population, so that the inferences made on further are objective and valid.

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