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# CONCENTRIC NEEDLE SINGLE FIBER ELECTROMYOGRAPHY

## Normative jitter values on voluntary activated *Extensor Digitorum Communis*

*João Aris Kouyoumdjian[1], Erik V. Stålberg[2]*

ABSTRACT - Single fiber electromyography (SFEMG) is the most sensitive clinical neurophysiological test for neuromuscular junction disorders, particularly myasthenia gravis. Normal values for jitter obtained with SFEMG electrode have been published, but there are few publications for concentric needle electrode (CNE). The aim of this study was to discuss the possibilities to analyse the jitter in CNE recordings and to get normal values of jitter for voluntary activated *Extensor Digitorum Communis* using disposable CNE. Fifty normal subjects were studied, 16 male and 34 female with a mean age of 37.1±10.3 years (19-55). The jitter values of action potentials pairs of isolated muscular fibers were expressed as the mean consecutive difference (MCD) after 20 analysed potential pairs. The mean MCD (n=50) obtained was 24.2±2.8 μs (range of mean values in each subject was 18-31). Upper 95% confidence limit is 29.8 μs. The mean jitter of all potential pairs (n=1000) obtained was 24.07±7.30 μs (range 9-57). A practical upper limit for individual data is set to 46 μs. The mean interpotential interval (MIPI) was 779±177 μs (range of individual mean values was 530-1412); there were no potentials with impulse blocking. The present study confirms that CNE is suitable for jitter analysis although certain precautions must be mentioned. Our findings of jitter values with CNE were similar to some other few reports in literature.

KEY WORDS: single fiber electromyography, jitter, concentric needle electrode.

**Eletromiografia de fibra única com agulha concêntrica: valores normativos do *jitter* no estudo por contração voluntária do músculo *Extensor Digitorum Communis***

RESUMO - Eletromiografia de fibra única (SFEMG) é o método eletrofisiológico mais sensível para diagnóstico das desordens de junção neuromuscular, particularmente miastenia gravis. *Jitter* obtido por meio de eletrodo de SFEMG já foi padronizado, porém há poucas publicações com uso de eletrodo de agulha concêntrica (CNE). O objetivo deste estudo é discutir as possibilidades de analisar o *jitter* por registro com CNE e obter valores normativos para o músculo *Extensor Digitorum Communis* por ativação muscular mínima. Foram estudados 50 indivíduos normais, 34 do sexo feminino e 16 do sexo masculino, com média de idade de 37,1±10,3 anos (19-55). Os valores do *jitter* para pares de potenciais de fibras musculares isoladas foram medidos por meio da média das diferenças consecutivas (MCD) em 20 análises de pares de potenciais. A média de MCD (n=50) foi 24,2±2,8 μs (variação de 18 a 31). O limite superior (95%) foi 29,8 μs. O *jitter* médio de todos os pares de potenciais obtidos (n=1000) foi 24,07±7,30 μs (variação de 9 a 57). O limite superior de normalidade prático para os dados individuais foi 46 μs. O valor médio dos intervalos interpotenciais (MIPI) foi 779±177 μs (variação de 530 a 1412); não foram obtidos potenciais com bloqueio. O presente estudo confirma a viabilidade da análise do *jitter* por CNE embora certas precauções devam ser mencionadas. Nossos valores de *jitter* obtidos por CNE são parecidos com os poucos relatos da literatura.

PALAVRAS-CHAVE: eletromiografia de fibra única, *jitter,* eletrodo de agulha concêntrica.

Single fiber electromyography (SFEMG) was developed in the early 1960s by Erik V. Stålberg and Jan Ekstedt in Sweden. The goal at that time was to record and identify action potential from individual muscle fibers (SFAPs) to investigate muscle fatigue[1,2]. Subsequently SFEMG was applied in the study of muscles in healthy controls and in diseases. Findings were summarized by Stålberg and Trontelj, who published

Faculdade de Medicina de São José do Rio Preto SP, Brazil (FAMERP); Neuromuscular Investigation Laboratory, Department of Neurological Sciences: [1]MD, PhD, Professor of Neurology; [2]MD, PhD, Professor Emeritus, Department of Clinical Neurophysiology, University Hospital, Uppsala, Sweden.

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*Dr. João Aris Kouyoumdjian - Rua Luiz Antônio Silveira 1661 - 15025-020 São José do Rio Preto SP - Brasil. E-mail: jaris@famerp.br*

the monograph Single Fiber Electromyography[3] going now to the third edition. For SFAPs identification a specific needle electrode is used with a small recording surface (25 μm in diameter) which is exposed at a port on the side of the electrode, 3 mm from the tip[2]. The recording allows a high recording selectivity, which is further increased by filtering the low-frequency components (high pass filter) to reduce the contribution from distant muscle fibers which contains relatively more low frequency components than high frequency components compared to signals adjacent to the recording tip[2]. When the SFEMG electrode is positioned to record from two muscle fibers in a voluntarily activated motor unit, the neuromuscular jitter is seen as variation in the time intervals between pairs of SFAPs from these fibers[2]. This represents the combined jitter in two end-plates[2]. The normal jitter values for voluntary activated *Extensor Digitorum Communis* (EDC) has been already established in the literature[4-6]; the mean of 20 mean consecutive difference (MCD) values in each subject ranges from 27.7 to 40.9 μs for all ages.

The jitter measurements is the most sensitive clinically used electrophysiological test *in vivo* for diagnosing myasthenia gravis (MG)[8-11]. Jitter measurements are now performed as an integral part of the evaluation of patients with MG in most major medical centers. A large number of doctors have learned the technique after training courses led by Professor Erik V. Stålberg in Uppsala, Sweden[9]. The use of a reusable electrode as the specific SFEMG has raised concern regarding the risk of transmission of infectious agents such as prion disease[10,11]. Because of that, attempts are being in course to use disposable concentric needle electrode (CNE)[8,10,11]. The low-frequency filter should then typically be raised from 500 Hz to 1-2 kHz in order to suppress activity from distant muscle fibers[10,11]. The differences between jitter recorded by SFEMG electrodes and CNE were discussed in an International Federation of Clinical Neurophysiology congress in Edinburgh by Stålberg (personal communication, 2006).

The aim of this study was to describe the used of CNE and to estimate the normal jitter parameters after voluntary activated EDC in a Brazilian population using a CNE for recording the SFAPs.

## METHOD

*Subjects* – From April to September 2006, we prospectively studied 50 normal subjects with a quantitative SFEMG studies using CNE in voluntary activated EDC. There were 16 men and 34 women with the mean age of 37.1±10.3 years (19-55). None had symptoms of a medical condition, particularly neuromuscular, and none was taking medication that reasonably could have interfered with the study.

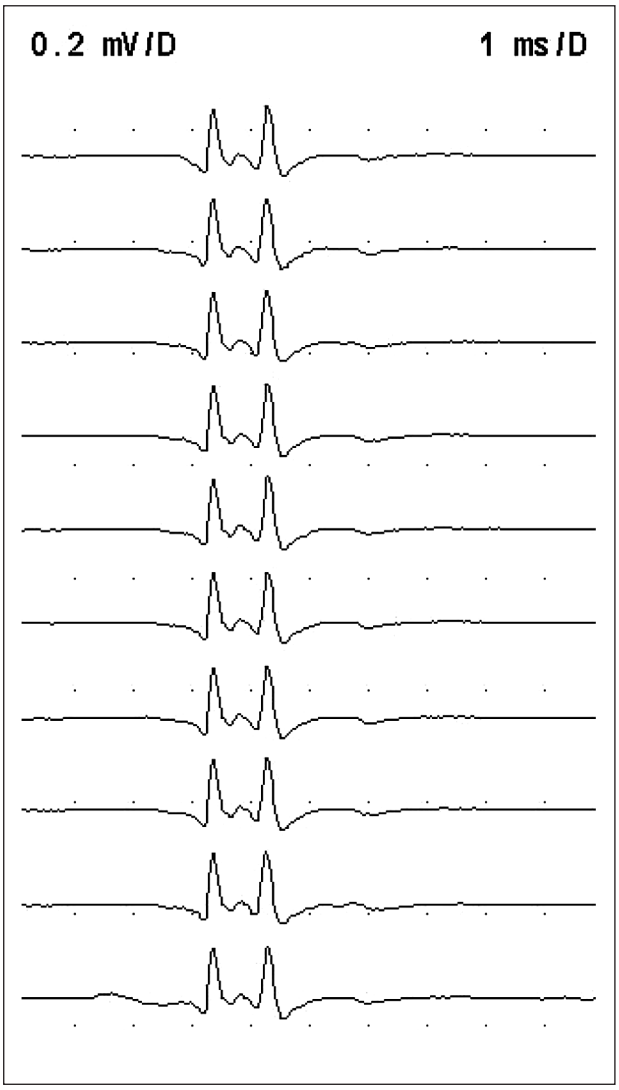


*Figure. Consecutive single fiber action potentials of the same motor unit registered from Extensor Digitorum Communis of a normal subject (female, 27 years) by concentric needle electrode during minimal voluntary activation. Filter setting 2 kHz / 10 kHz. Calculated jitter 18* μs.

*Recording* – For all studies, a portable Keypoint electromyograph (Medtronic Skovlunde, Denmark) with an inbuilt specific SFEMG software was used for recording and analysis. SFEMG studies were done by Dr. João Aris Kouyoumdjian at the Laboratório de Investigação Neuromuscular, Faculdade de Medicina de São José do Rio Preto, Brazil, after a training period at the Department of Clinical Neurophysiology, University Hospital, Uppsala, Sweden. Digitalized recording were sent to Dr. Erik V. Stålberg in Uppsala for revision. CNE with a diameter of 0.3 mm and a recording area of 0.03 mm$^2$ (Medtronic, Denmark) was performed in all cases. Filter setting was 2 kHz to 10 kHz. Recording was performed during voluntary contraction of the EDC mus-

cle. For jitter analysis both the examiner and the Keypoint software selected only individual potentials (spikes) with a "stable shape" and a short rise time and a well defined peak. The triggering potential was often a compound signal composed of more than one spike, while the other signal (occurring after or occasionally before the trigger) was sharp and with constant shape at consecutive discharges. Care was taken to get a stable recordings SFAP components with a clear separation with no or minimal "riding" of one signal on the other. The measurements were made between software extrapolated peaks of the signals. For each jitter analysis, a minimum of 50 and an ideal 100 consecutive traces of pairs were recorded (Figure). The jitter values of 20 different SFAP pairs were calculated for each subject study. Mean value of MCD, and mean sorted-data difference (MSD)[3] were calculated. If the MCD/MSD ratio was greater than 1.25, MSD value was used instead of MCD value as the jitter value. Up to 3 separate needle insertions into the EDC were performed, with a few different recordings sites of various depth in the muscle at each skin insertion. The Keypoint software also calculated the mean interpotential interval (MIPI). Fiber density was not considered in CNE studies.

*Ethics* – The study was approved by FAMERP's ethic committee and informed consent was obtained from each subject.

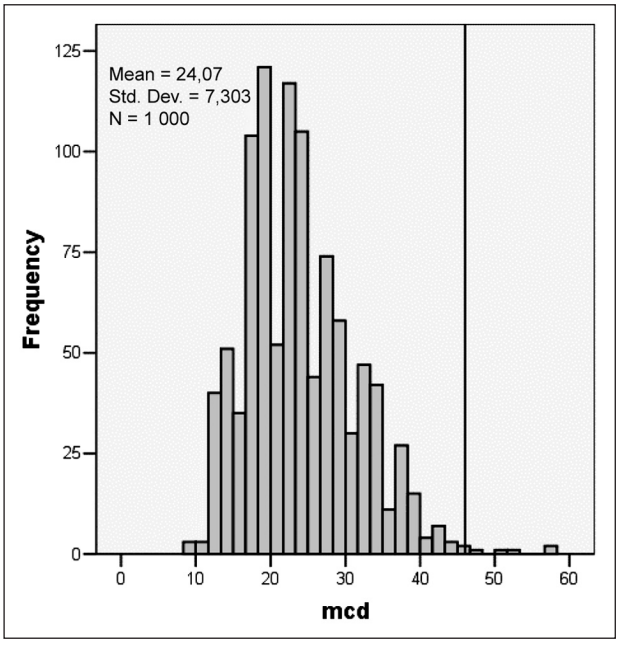


*Table. Jitter of individual recordings; line indicates highest 19th value ever found, 46 μs. This is suggested as upper limit for individual recordings. mcd, mean consecutive difference.*

## RESULTS

The mean jitter (±standard deviation) was analyzed according to the standards, i.e., the calculation of the mean MCD of at least 20 consecutive discharges[12]. There was no correlation to age in this material (p>0.5). There were no recordings with impulse blocking. The mean of the 50 mean MCD values in each subject was 24.2±2.8 μs ranging from 18 to 31 μs. In all cases MCD was used. The upper 95% confidence limit was 29.8 μs. The mean value of MIPI values was 779±177 μs ranging from 530 to 1412 μs.

The recommendations of the Ad Hoc Committee of the AAEM[7] for abnormalities are: 1. a value for the mean MCD above 95% upper limit for age for that muscle; and, 2. jitter greater than the 95% upper limit for action potential pairs in more than 2 action potential pairs in a muscle.

In daily routine, the most sensitive parameter in SFEMG has shown to be the jitter of individual recordings (action potential pairs). The mean value of jitter in all 1000 individual recordings was 24.07±7.30 μs (Table). Upper limit for that has been given in different ways. In large material, 95% confidence limits are given. In our, still relatively small material this is 38.7 μs. By expressing 3SD limit, a value of 46 μs is found. Since the distribution is not exactly Gaussian, we have used another definition. In practice, a study is abnormal if one of 20 recordings has a MCD value above a given limit. In our material, the highest 19th value is 46 μs, seen in one subject. In SFEMG, this value is 55 μs. If one value out of 20 is above 46 μs, the study is normal; if 2 values exceed 46 μs, the findings are borderline, and if more than 2 are found, the study indicated abnormality.

The picture may change somewhat, when a larger material is collected. In SFEMG this value is also age dependent, not seen here.

## DISCUSSION

This is the first SFEMG study for normative jitter analysis in Brazil using a CNE. We decided to use a CNE because of the increasing concern about possible transmission of prion, because of the cost of electrode, and because of the fact that no electrode maintenance is necessary. Often, the spikes obtained with CNE are not obtained from single muscle fibres[13]. Therefore normative date should be collected from CNE as already done from SFEMG electrode in spite of reported good correlation between jitter values from SFEMG electrode and jitter or jiggle from CNE either in normal or in MG[8,10,11]. Our result of jitter values (24.07±7.30 μs) in 50 voluntary activated EDC (n=1000) using CNE was found to be the same when compared to the study in 10 normal subjects (23.3±8.0 μs) from Ertas et al.[8], but a little less than

found (30.6±9.2 μs) by Sarrigiannis et al.[11] in 20 normal subjects. Benatar et al.[10] also using CNE found a "jiggle" value of 29.1±12.0 μs for *Frontalis* muscle in 23 normal subjects. The jitter values for voluntary activated EDC using a SFEMG electrode ranged from 27.7 to 40.9 μs[4-7] for all ages. In comparison, the jitter values obtained using CNE ranged from 23.3 to 30.7 μs including our study[8,11].

The limits for outliers have not been reported for CNE studies. Our own data suggest that the second highest value should not exceed 46 μs, compared to 55 μs for EDC in SFEMG recordings.

Despite only a few reports, it seems that the jitter obtained from CNE is smaller than those obtained from SFEMG needle. The variation in reported jitter values is greater in studies using CNE, than in a multicenter study using SFEMG electrode. This is probably a sign of difficulties to define exactly which signals that can be used for analysis. As soon as there is a summation of single fibre action potentials in a "spike", the obtained value will be slightly distorted from the true value. Often the jitter is reduced. If the definition of acceptable signal is unclear, the normal values will differ. In SFEMG recordings, the definition is much more precise. Therefore, there is an urgent need to define recording conditions (signals to be accepted, filters), analysis procedures (peak or level trigger) in order to make reference material comparable.

In conclusion, besides the safety and the low cost, the use of the CNE reveals to be easy in acquiring SFAP pairs. The spike amplitude is lower compared to specific SFEMG needle. The disadvantage is the fact that often the "spikes" in CNE SFEMG are composed of activity from many single muscle fibres, which will influence the measured jitter value. Fiber density could not be estimated using CNE, but this is not a primary parameter in the MG diagnosis. Jitter measurements from CNE seems to give a confident values in normal. Our own experience and other authors studies[8,10,11] confirm that CNE jitter measurements can be used in the diagnosis of MG. If the obtained value is abnormal, it is very likely indicating a disturbed neuromuscular transmission. If the jitter is borderline normal, a disturbed neuromuscular transmission cannot yet be excluded, before more well defined conditions have been defined.

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