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Applicability of the digital instrument to improve the reproducibility of motor unit number index

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Background: The motor unit number index (MUNIX) and motor unit size index (MUSIX) refer to the electrophysiological measurement of the motor units using the surface electromyographic interference pattern (SIP) recorded during graded muscle contraction. In order to improve the reliability and reproducibility of MUNIX by the systematization of the graded muscle contractions, we applied a digital hand instrument to the procedure of recording SIP signals.
Methods: We tested the applicability of the digital instrument in the MUNIX technique by assessing the mean values and the reproducibility of the MUNIX involving the abductor pollicis brevis (APB) and the abductor digiti minimi (ADM) muscles in 30 healthy adults.
Results: The digital dynamometer was successfully applied to the MUNIX measurements of the APB and ADM muscles, and showed high reproducibility across trials.
Conclusions: Application of the digital instrument would be useful in improving the reliability and reproducibility of MUNIX.

Key words: Motor neurons; Motor neuron disease; Amyotrophic lateral sclerosis; Electromyography

INTRODUCTION

The motor unit number index (MUNIX) and motor unit size index (MUSIX) provide valuable information regarding the number and average size of motor units, and are practical electrophysiological methods for assessing the amyotrophic lateral sclerosis (ALS).[1-3]

MUNIX and MUSIX depend on the surface electromyographic interference pattern (SIP) recorded during voluntary contraction instead of obtaining the mean single motor unit potential (SMUP) values which are critical in motor unit number estimation (MUNE) techniques.[1-3] In order to gain ten SIPs, the MUNIX software uses five different levels of isometric force to display voluntary surface electromyography (EMG) signals and consequently compute the results from the applicable muscles.[1,2]

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To our knowledge, there have been no MUNIX studies using a digital hand dynamometer during the graded isometric muscle contraction, followed by analyzing SIP signals. Therefore, we applied a digital hand dynamometer to the procedure of recording SIP signals to improve the reliability of graded isometric contractions and the reproducibility of MUNIX. This study was performed to investigate the applicability of the digital instrument to the MUNIX technique by assessing mean values, and the reproducibility of MUNIX and MUSIX in healthy subjects.

MATERIALS AND METHODS

Healthy young adults were recruited consecutively, and the protocol was approved by the Institutional Review Board. We excluded subjects who had history of spinal diseases, cerebral infarction or hemorrhage, diabetes, carpal tunnel syndrome, ulnar neuropathy, or abnormal motor action potentials in the abductor pollicis brevis (APB) and abductor digiti minimi (ADM) muscles (identified through nerve conduction studies [NCS] and EMG). The final sample consisted of 30 adults, selected to be evaluated with MUNIX and MUSIX in the APB and ADM muscles.

The MUNIX measurements were made using a commercially available EMG instrument (Synergy by Oxford Instruments, Hawthorne, NY). The MUNIX method involved assessing the APB and ADM muscles and the compound muscle action potential (CMAP) of the APB and ADM muscles were recorded using 10-mm flat disk electrodes with standard nerve conduction protocols stimulating median and ulnar nerve supramaximally, as has been previously reported.[1-5]

The ADM and APB muscles were fully activated respectively by abduction of the little finger or by abduction of the thumb against a digital instrument calibrated by the manufacturer (Jamar Plus® + Digital Hand Dynamometer, Sammons Preston Inc., Bolingbrook, IL, USA), and thereby the maximal muscle power could be digitally checked.

Each muscle was gradually re-activated at five different levels of isometric force from minimum to maximum (slight, 25%, 50%, 75%, and 100%) using a digital instrument. Unlike any previous study, each SIP signal of muscle contraction was digitally monitored to adjust the force levels based on the initial maximum value. This procedure was ingeminated to record CMAP values followed by ten SIP signals; we then analyzed the MUNIX results following the ideal case motor unit count (ICMUC) using the "MUNIX" program, which is a DOS-based shareware developed by Nandedkar et al.[1-3]

The MUSIX reflecting the average size of the motor units was calculated by dividing the CMAP amplitude by the MUNIX value from the same muscles. To evaluate the reliability of a digital instrument, MUNIX was performed twice on the same day by different operators, both skilled EMG technicians.

Both the re-application of stimulation and the use of recording electrodes were performed under the supervision of a board-certified neurologist. The first and second MUNIX were referred to as trial #1 and #2, respectively.

The paired *t*-test was used to compare trials #1 and #2 to investigate statistical differences between trials. The correlation coefficients between the two trials (trial #1 versus #2) were calculated using the Pearson's correlation analysis. The test-retest reproducibility was also expressed as the percent change in the difference by dividing the difference between the two measurements by the mean value (the coefficient of variation).[2,6] Results with $p < 0.01$ were considered significant. All statistical tests were performed using SPSS v19.0 (IBM Corp., Armonk, NY, USA).

RESULTS

Age of the sample ranged from 19 to 50 years, with a mean of 27.5 ± 8.0 years (standard deviation, SD), and women represented a slightly lower proportion of the sample (14 of 30 participants). Their MUNIX and MUSIX measurements are summarized as the mean values (±SD) in Table 1.

From the results of examination on the APB muscle, the mean values of MUNIX, MUSIX and CMAP amplitude were 191 (±56) vs. 194 (±59), 63 (±17) vs. 64 (±15) and 11.7 mV (±2.7) vs. 11.9 mV (±2.4) by the trial #1 and trial #2 respectively.

Similarly, from the results of examination on the ADM muscle, the mean values of MUNIX, MUSIX and CMAP amplitude were 160 (±44) vs. 153 (±40), 72 (±19) vs. 73 (±14) and 11.3 mV (±2.7) vs. 10.9 mV (±1.8) by the trial #1 and trial #2 respectively. The paired *t*-test showed that all measures were reproducible, and no significant differences were de-

tected between trial #1 and trial #2 for any MUNIX or MUSIX measurements.

The reproducibility of MUNIX and MUSIX performed on APB and ADM muscles is summarized in Table 1. The coefficient of variation (COV)s of MUNIX were 14.3 (APB) and 13.6 (ADM), and furthermore COVs of MUSIX were 12.7 (APB) and 14.1 (ADM), within the acceptable range for healthy subjects.[2-6] In addition, the correlation coefficients of MUNIX and MUSIX values measured by the different operators were significant by applying the digital instrument (Table 1, Fig. 1).

DISCUSSION

Our study demonstrated the applicability of the digital instrument in assessing the SIP signals of graded isometric muscle contractions of the MUNIX technique. The results of the study indicate high inter-operator reproducibility after the application of a digital instrument. Previous studies have reported high reproducibility of MUNIX in a few muscles including the APB, ADM, fist dorsal interossei (FDI), biceps brachii (BB), tibialis anterior (TA), abductor hallucis (AH), nasalis and orbicularis oculi (OO) muscles, in healthy subjects or in patients with ALS.[2-6]

Practically, the MUNIX would be influenced by the variability of CMAP amplitude, and furthermore the MUNIX depends on the SIP recorded during voluntary muscle contraction, a critical element of all MUNIX techniques. Therefore, MUNIX can be limited by unreliable SIP signals, which may not reflect the state of the motor neuron with fidelity. To our knowledge, there have been no MUNIX studies applying a digital instrument to improve the reliability of the graded isometric muscle contraction described in previous articles.

Improvement in the reproducibility of the MUNIX test requires reliable and systematized graded muscle contractions. Therefore, we applied a digital hand dynamometer to the SIP signal recording procedure. Furthermore, systematization and digitalization of signals of this nature are valuable for the clinical applications of the MUNIX.

Previously, the reproducibility of MUNIX has been studied by Nandedkar who reported an intra-operator COV of 16.8 in ADM muscle of normal controls, and our previous MUNIX study identified intra- and inter-operator COV correlation of 15.3 and 17.5 in ADM muscle of normal subjects.[2,3]

In conclusion, the mean values of MUNIX, the inter-operator COV (APB; 14.3, ADM; 13.6, Table 1), and the correlation coefficients (0.849 and 0.807, Table 1) indicate that the measurements after applying the digital dynamometer were much more reliable compared to those obtained in previous MUNIX and MUNE investigations.[2,3,5-11]

This technical improvement can be attributed to our efforts to reduce the test-retest variability while recording SIP signals by assuring close monitory through the digital dynamometer. In addition, our study revealed excellent test-retest reproducibility of MUSIX when assessing the average size of the motor units by using the digital instrument.

However, this study has some limitations. First, we did not apply the digital instrument in studies of elderly subjects or ALS patients. Second, a digital hand dynamometer used in this study is not the exclusive equipment for MUNIX. Therefore, more optimized digital instruments to perform the MUNIX, would be necessary to further improve the quality of

Table 1. Mean values and reproducibility of MUNIX and MUSIX measurements with using the digital instrument in the APB and ADM muscles of 30 healthy subjects ranged from 19 to 50 years

	Mean values Trial #1	Mean values Trial #2	Coefficient of variation (%)	Correlation coefficient	*p*-value
MUNIX (APB)	191 (±56)	194 (±59)	14.3	0.849	<0.01
MUNIX (ADM)	160 (±44)	153 (±40)	13.6	0.807	<0.01
MUSIX (APB)	63 (±17)	64 (±15)	12.7	0.733	<0.01
MUSIX (ADM)	72 (±19)	73 (±14)	14.1	0.742	<0.01

Data are expressed as the mean values (± standard deviation). The results were analyzed using the paired *t*-test and Pearson correlation analysis, significance: $p < 0.01$.

MUNIX, motor unit number index; MUSIX, motor unit size index; APB, abductor pollicis brevis; ADM, abductor digiti minimi.

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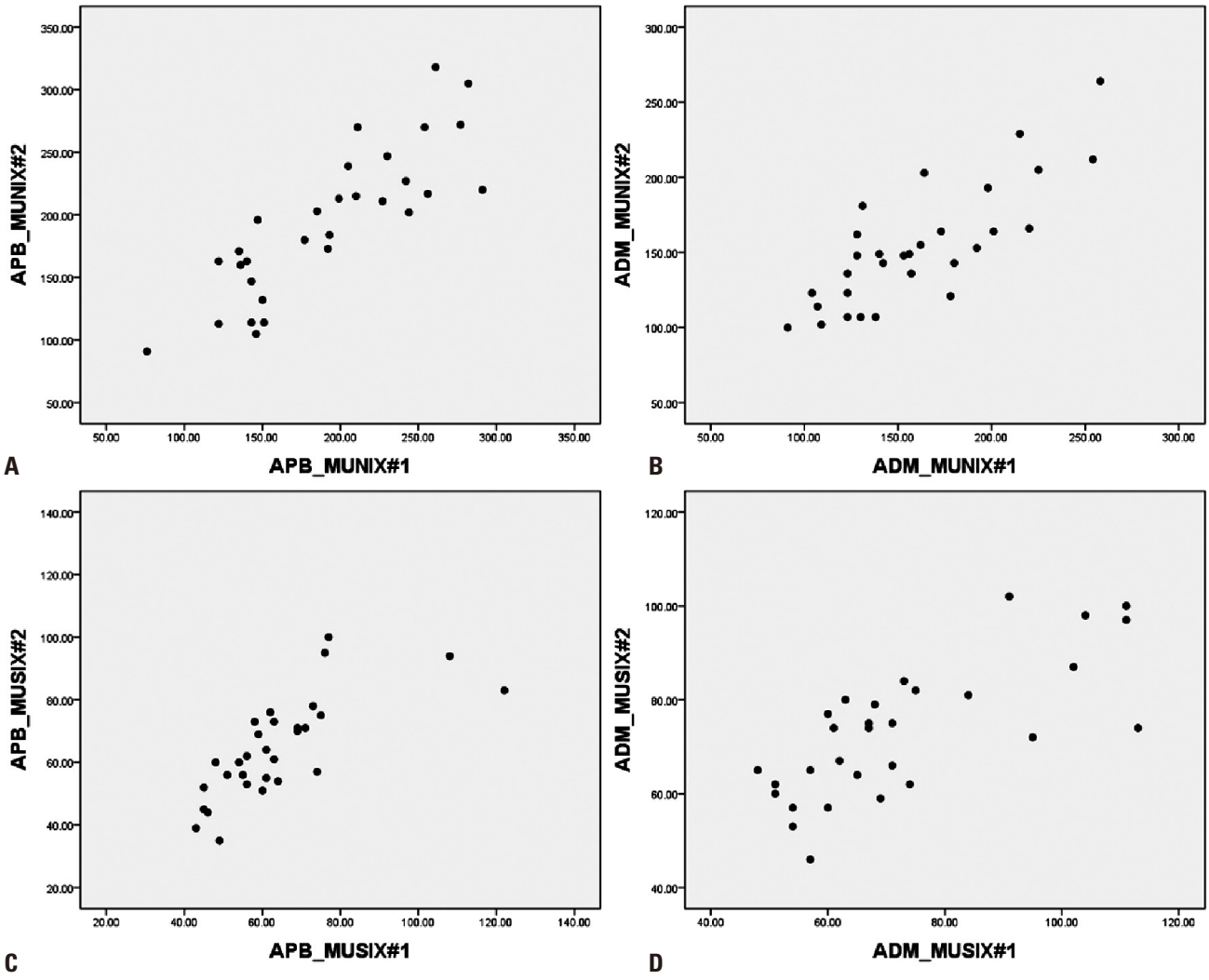

Fig. 1. Scatter plots of the results between operators (#1 and #2) of the motor unit number index (MUNIX) and motor unit size index (MUSIX) measurements with using the digital instrument in the abductor pollicis brevis (APB, A and C) and abductor digiti minimi (ADM, B and D) muscles of 30 healthy subjects.

MUNIX measurements.

Nevertheless, MUNIX combined with the digital instrument can provide valuable information regarding the number of motor units in a given muscle, which makes it possible to perform the test under technically reliable monitoring. The present study reported the clinical trial on the application of the digital instrument to MUNIX measurement, in order to assess its applicability and reliability. Our results indicate high reliability and reproducibility of this novel digital instrument-guided MUNIX technique.

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Conflicts of Interest

The authors have no conflicts to disclose.

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