

# Statistical Motor Unit Number Estimate : Size - and Number - Weighted Modifications

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## Reproducibility of Statistical Motor Unit Number Estimate in Amyotrophic Lateral Sclerosis: Comparisons between Size- and Number-Weighted Modifications

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**Background:** Motor unit number estimation (MUNE) can directly assess motor neuron populations in muscle and quantify the degree of physiologic and/or pathologic motor neuron degeneration. A high degree of reproducibility and reliability is required from a good quantitative tool. MUNE, in various ways, is being increasingly applied clinically and statistical MUNE has several advantages over alternative techniques. Nevertheless, the optimal method of applying statistical MUNE to improve reproducibility has not been established.

**Methods:** We performed statistical MUNE by selecting the most compensated compound muscle action potential (CMAP) area as a test area and modified the results obtained by weighted mean surface-recorded motor unit potential (SMUP).

**Results:** MUNE measures in amyotrophic lateral sclerosis (ALS) patients showed better reproducibility with size-weighted modification.

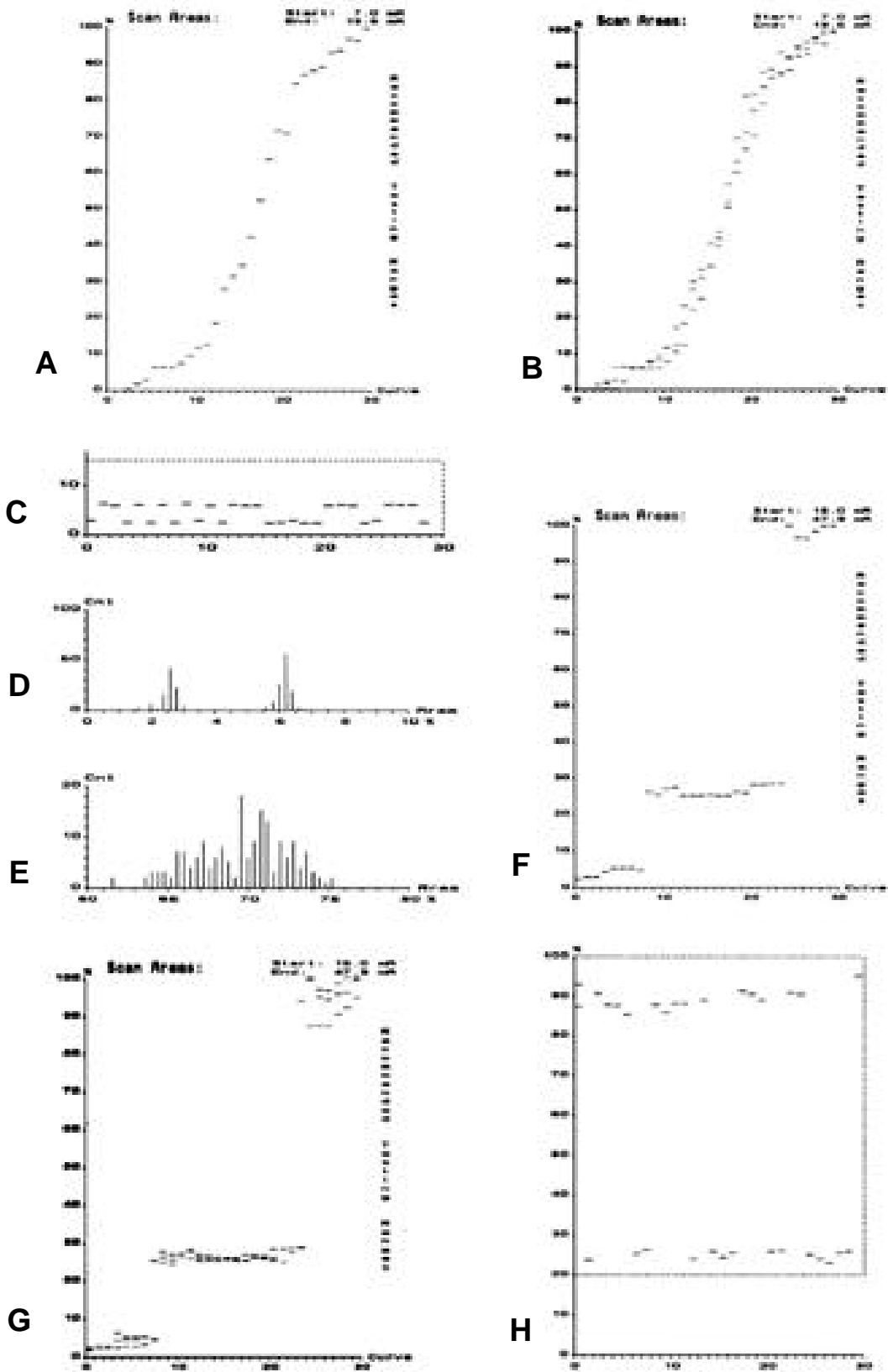
**Conclusions:** We suggest size-weighted MUNE testing of " neurogenically compensated " CMAP areas present an optimal method for statistical MUNE in ALS patients.

**Key Words:** Amyotrophic lateral sclerosis, Motor unit number estimation

1970 McComas<sup>1</sup>, motor unit number estimation (MUNE) (reproducibility)

1995 Daube<sup>2</sup>, MUNE, S-MUNE (Statistical MUNE (Surface-Recorded Motor Unit Potential (SMUP)))

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**Figure 1.** Samples of stimulus response function (“ the scan graph ”)(A, B, E, F) and recording windows spanning an individual testing range(C, D, G). The figure of the superimposed three “ scan graphs ” from patient 3(B) shows consistent gap around CMAP area between CMAP area 3 ~ 7 % which is confirmed by dichotomous distribution in that area (C), and the distribution of CMAP around 70 ~ 80 % of the maximal CMAP demonstrate a typical Poisson distribution (D) although the single “ scan graph ” shows a possible gap of about 10% of the maximal CMAP in that CMAP area(A). The single “ scan graph ” (E) and the figure of the superimposed three “ scan graphs ” (F) from patient 9 demonstrate a relatively consistent a CMAP gap, which is convinced by a 30-successive sub-maximal stimulation (G).

SMUP “scan graph” S-MUNE MUNE 10% gap 5% gap

SMUP MUNE S- (Fig. 1). 3

MUNE “test area” 4

5 가, SMUP 가 (quartile) “test area” SMUP

MUNE - 가 “scan graph”가 sinusoidal pat- tern 4

(size-weighted and number-weighted modifica- tion) (test-retest variability)가 30 submaximal CMAP , CMAP가

6, 7 CMAP Poisson , CMAP가 (dichotomous) CMAP가 30 15~20

MUNE 90% 가 8

가 “scan graph” 가

MUNE가 ALS 가

가 10% sub- maximal CMAP SMUP 가 10% SMUP

10% 30 submaximal CMAP “test area” MUNE

300 10 SMUP 가

SMUP 10 가

MUNE MUNE 가

1. EI Escorial World Federation of Neurology cri- teria 9, definite or probable ALS 18 ( : =9:9, =52.7±10.1 ) MUNE

2. Determination of MUNE MUNE (Nicolet Biomedical Inc., Madison, WI) abductor digitii minimi (ADM) bar electrode 가 CMAP CMAP CMAP 30

“scan graph” 3 4 4 CMAP 80% 가 “ ” (denervation) (reinnervation) , 3 ‘scan graph’ CMAP (area)

MUNE 1 가 MUNE 가 MUNE 6, 7

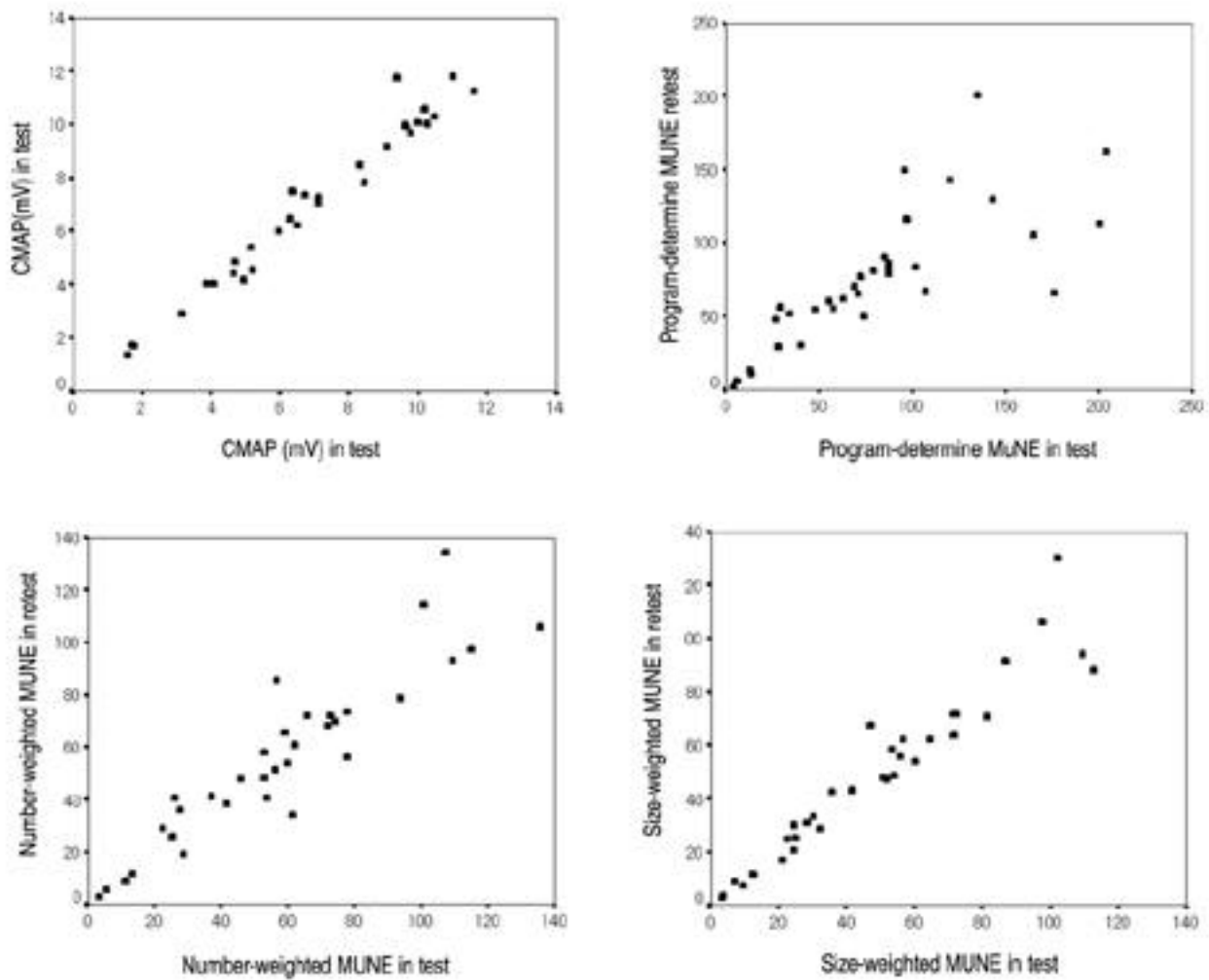
3. Correlation coefficients Pearson's correlation test (percent differ- ence), , coefficients of variation 가 (size-weighted modification) 가 (number-weighted modification), paired t- test

33 MUNE 가 ADM Table 1 CMAP, MUNE SMUP Table 2 Fig. 2

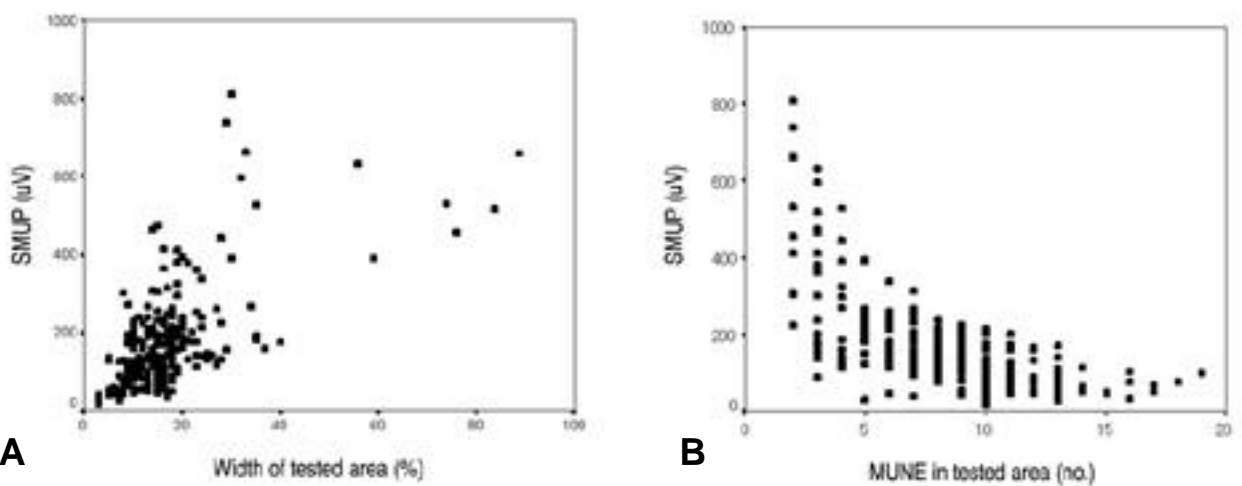
**Table 1.** Preliminary results of the statistical MUNE

Test no.	Patient no.	CMAP (mV)		Program-determined MUNE (no.)		Number-weighted mean SMUP (V)		Number-weighted MUNE (no.)		Size-weighted mean SMUP (V)		Size-weighted MUNE (no.)	
		Test	Retest	Test	Retest	Test	Retest	Test	Retest	Test	Retest	Test	Retest
1	1	10.19	10.57	135	201	94.9	78.6	107.4	134.5	99.8	81.3	102.2	130.0
2	2	8.31	8.48	72	77	140.5	129.3	59.2	65.6	146.7	136.2	56.7	62.3
3	3	11.61	11.23	143	130	100.8	115.2	115.1	97.5	103.0	127.4	112.7	88.1
4	4	9.79	9.69	96	150	173.0	113.1	56.6	85.7	208.6	144.2	46.9	67.2
5	5	9.38	11.74	63	62	167.1	227.5	56.1	51.6	174.0	240.2	53.9	48.9
6	6	3.87	4.05	28	29	152.4	155.9	25.4	26.0	154.8	161.3	25.0	25.1
7	7	9.58	9.95	165	105	87.4	106.8	109.6	93.2	110.3	108.4	86.8	91.8
8	8	10.00	10.06	85	90	134.7	144.1	74.3	69.8	139.4	158.4	71.7	63.5
9	9	4.06	4.01	48	54	109.6	97.9	37.0	41.0	135.6	120.6	30.0	33.2
10	10	3.15	2.91	40	30	109.9	151.9	28.7	19.2	440.0	320.3	7.2	9.1
11	11	7.10	7.27	97	116	107.8	100.9	65.9	72.1	133.5	124.0	53.2	58.6
12	12	10.01	10.05	120	143	99.5	87.9	100.6	114.3	102.5	94.4	97.6	106.5
13	13	5.20	4.56	14	11	460.3	500.0	11.3	9.1	545.1	593.0	9.5	7.7
14	14	4.70	4.85	87	86	65.2	71.1	72.1	68.2	72.7	77.7	64.6	62.4
15	15	5.17	5.38	29	56	198.9	132.7	26.0	40.5	211.1	179.2	24.5	30.0
16	16	6.29	6.44	34	52	229.1	179.8	27.5	35.8	282.8	258.4	22.2	24.9
17	17	1.78	1.69	13	13	135.2	142.0	13.2	11.9	144.2	145.0	12.4	11.7
18	18	1.68	1.71	4	2	518.0	660.0	3.2	2.6	518.0	660.0	3.2	2.6
19	19	1.59	1.36	6	6	295.2	237.0	5.4	5.7	437.8	386.1	3.6	3.5
20	20	7.12	7.01	102	84	132.7	171.4	53.7	40.9	219.1	244.9	32.5	28.6
21	21	13.48	14.04	79	81	185.0	194.4	72.9	72.2	186.6	195.9	72.3	71.7
22	22	11.00	11.82	176	66	141.2	211.2	77.9	56.0	183.0	218.9	60.1	54.0
23	23	6.35	7.49	55	60	137.9	157.0	46.1	47.7	178.0	175.0	35.7	42.8
24	24	9.11	9.16	74	50	219.2	239.5	41.6	38.2	322.8	297.0	28.2	30.8
25	25	9.62	9.92	58	55	182.2	204.9	52.8	48.4	186.2	210.1	51.7	47.2
26	26	5.96	6.00	27	48	267.9	205.7	22.2	29.2	286.7	358.7	20.8	16.7
27	27	6.48	6.22	71	65	107.9	115.4	60.1	53.9	128.1	129.8	50.6	47.9
28	28	10.46	10.30	204	162	77.1	97.5	135.6	105.7	95.4	109.6	109.7	94.0
29	29	10.26	10.03	87	83	131.7	136.2	77.9	73.6	143.3	139.8	71.6	71.7
30	30	4.67	4.39	200	113	49.9	55.7	93.7	78.8	57.6	61.9	81.1	70.9
31	31	6.70	7.36	69	70	107.9	120.7	62.1	61.0	120.0	132.6	55.8	55.5
32	32	8.43	7.82	87	79	159.7	134.7	52.8	58.1	202.6	180.6	41.6	43.3
33	33	4.94	4.15	107	67	80.3	122.0	61.5	34.0	200.5	203.6	24.6	20.4
Mean		7.21	7.32	81.1	75.6	162.4	169.6	57.7	55.8	202.1	205.3	49.1	49.2
S.D.		3.09	3.29	53.4	45.8	101.2	118.0	33.1	31.8	123.2	134.3	31.1	31.2





**Figure 2.** Scatter-plots of paired test-retest results of CMAP, program-determined, number- and size-weighted MUNE. See text.



**Figure 3.** Scatter-plots of SMUP according to the number of MUNE in a tested area and the width of a tested area. The larger the width of the test area, the larger the SMUP from the test area. (A) The SMUP is inversely proportional to the number of motor units in the test area. (B)

“ test area ” sampling SMUP가  
 SMUP 가 , “ test area ”  
 sampling SMUP 가  
 SMUP  
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 tion”  
 S-MUNE “  
 sampling  
 가 MUNE가  
 ALS  
 가 MUNE가 가

Abbreviations:

- ADM, abductor digitii minimi
- ALS, amyotrophic lateral sclerosis
- CMAP, compound muscle action potential
- MUNE, motor unit number estimation
- r, correlation coefficient
- SMUP, surface-recorded motor unit potential

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