



Reference Standards for F-wave of Individual Nerves of 4 Extremities With Expanded Uncertainty in Healthy Korean Adults

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Introduction

- The normal ranges and reference standard values for the F-wave of the median and tibial nerves vary among institutions and hospitals because of their variability and multi-factor dependency.
- There were no reference standard for F-wave onset latencies in Korea.
- The aim of the present study was to develop a set of reference standards for F-wave of the median and tibial nerves of four extremities with expanded uncertainty in a healthy Korean population.

Materials and Methods

- Study population**
 - Total 429 healthy subjects (112 in twenties including 56 men and 56 women, 115 in thirties including 56 men and 59 women, 111 in fifties including 43 men and 68 women, and 91 in sixties including 32 men and 59 women) were recruited from four university hospitals.
- Data collection**
 - We conducted standardized nerve conduction study for the median and the tibial F-wave parameters (minimal, maximal, and mean latencies) according to a standardized protocol in four university hospitals (Figure 1).
 - Distance measurement with a tapeline, skin temperature, and resolution of the instruments were considered as uncertainty factors.
- Outcome measures**
 - Minimal, maximal, and mean F-wave latencies of the median and the tibial nerves were measured and analyzed.
 - Side-to-side differences in each individual was also conducted.
 - Expanded uncertainty of each parameter was calculated under the international guide to the expression of uncertainty in measurement (Figure 2).

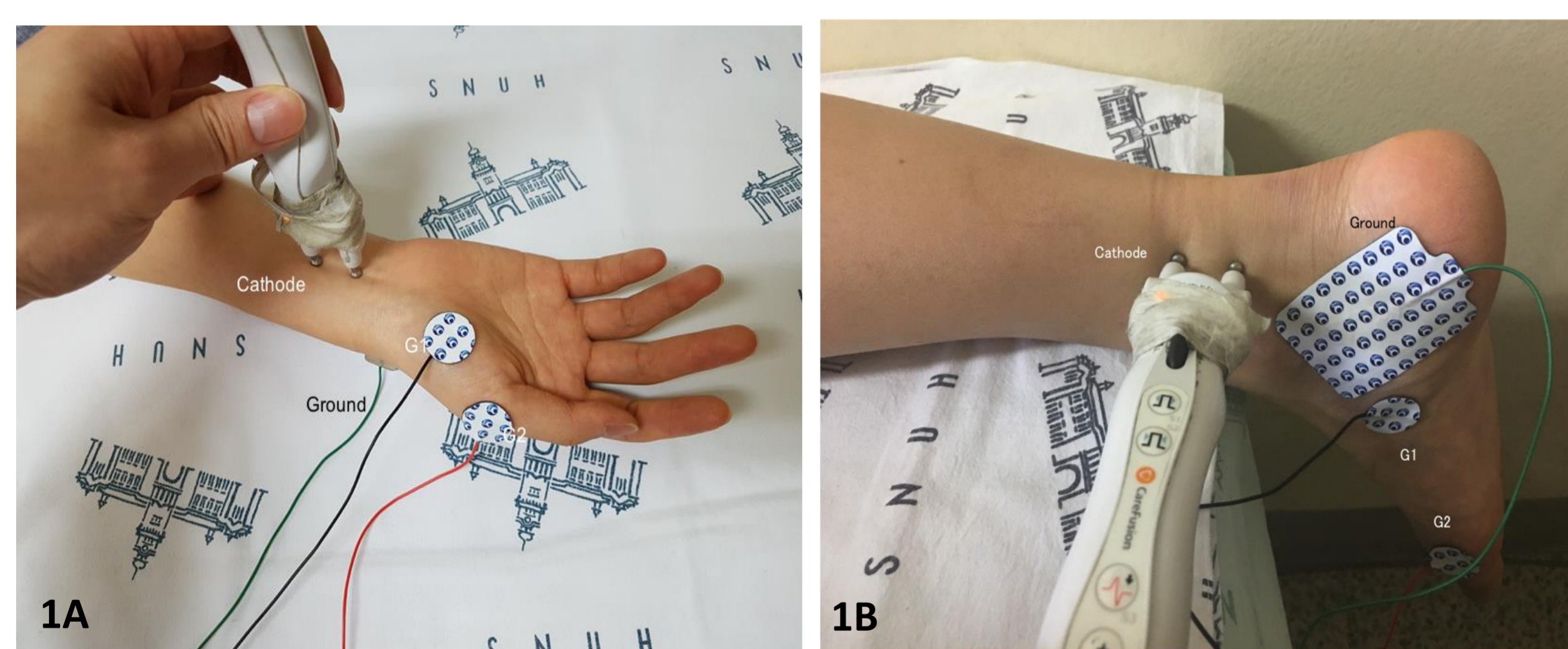


Figure 1. Standard procedure for the median and tibial nerve F-wave studies.

$$F_l = X_l$$

(F_l : Measured value, X_l : Reading value)

1) Combined standard uncertainty

$$u(F_l) = \sqrt{u^2(X_l)}$$

2) Expanded uncertainty

$$U(F_l) = k \times u(F_l) \text{ (} k \text{: coverage factor)}$$

Figure 2. Calculation model for uncertainty

Results

- In the median nerve, minimal, maximal, and mean F-wave latency was 24.66 (21.27-28.05) ms, 27.32 (21.82-32.83) ms, and 25.76 (22.12-29.41) ms, respectively. Side-to-side difference was 0.63 (cut-off: 2.33) ms, 1.83 (cut-off: 5.78) ms, and 0.86 (cut-off: 2.50) ms, respectively (Table 3).
- In the tibial nerve, minimal, maximal, and mean F-wave latency was 45.11 (38.37-51.85) ms, 48.65 (41.36-55.93) ms, and 46.74 (40.18-53.30) ms, respectively. Side-to-side difference was 1.03 (cut-off: 3.93) ms, 1.58 (cut-off: 4.52) ms, and 0.99 (cut-off: 2.83) ms, respectively (Table 3).
- The F-wave parameters for the median and tibial nerves by age and sex groups are shown in Table 1 and Table 2.

	Male				Female			
	20s (n=56)	30s (n=56)	50s (n=43)	60s (n=32)	20s (n=56)	30s (n=59)	50s (n=68)	60s (n=59)
Minimal F latency								
Mean (EU)	25.78 (2.48)	25.61 (2.69)	25.99 (2.77)	26.10 (2.99)	23.47 (2.64)	23.93 (2.51)	23.69 (2.84)	23.94 (2.61)
Range	23.29-28.26	22.93-28.30	23.22-28.77	23.11-29.10	20.83-26.10	21.42-26.44	20.86-26.53	21.33-26.55
Maximal F latency								
Mean (EU)	28.21 (5.35)	28.07 (4.52)	28.41 (4.77)	28.98 (4.92)	26.22 (5.54)	26.00 (3.70)	27.09 (6.46)	26.72 (5.18)
Range	22.86-33.56	23.55-32.59	23.65-33.18	24.05-33.90	20.68-31.76	22.30-29.70	20.63-33.54	21.54-31.91
Mean F latency								
Mean (EU)	26.78 (3.04)	26.55 (2.90)	26.98 (3.19)	27.23 (3.19)	24.62 (3.10)	24.84 (2.69)	25.22 (3.62)	25.01 (2.95)
Range	23.74-29.82	23.64-29.45	23.73-30.18	24.04-30.43	21.52-27.72	22.15-27.52	21.61-28.84	22.06-27.96

Table 1. Standard reference of the median nerve F-wave parameters with expanded uncertainty.

	Male				Female			
	20s (n=56)	30s (n=56)	50s (n=43)	60s (n=32)	20s (n=56)	30s (n=59)	50s (n=68)	60s (n=59)
Minimal F-wave latency								
Mean (EU)	46.70 (5.52)	46.63 (5.92)	46.13 (8.88)	47.06 (5.57)	43.17 (5.85)	44.23 (6.32)	44.20 (5.08)	44.12 (6.29)
Range	41.18-52.21	40.71-52.54	37.25-55.01	41.49-52.63	37.33-49.02	37.91-50.55	37.12-49.29	37.83-50.41
Maximal F-wave latency								
Mean (EU)	50.17 (6.47)	49.68 (5.96)	50.21 (8.03)	50.72 (6.34)	46.72 (7.56)	47.72 (6.24)	47.84 (6.14)	47.63 (7.48)
Range	43.70-56.65	43.72-55.65	42.18-58.24	44.37-57.06	39.16-54.29	41.48-53.96	14.70-53.98	40.15-55.11
Mean F-wave latency								
Mean (EU)	48.26 (5.64)	48.01 (5.73)	48.11 (7.75)	48.74 (5.48)	44.76 (6.24)	45.91 (5.51)	45.89 (5.10)	45.68 (6.48)
Range	42.62-53.91	42.28-53.74	40.36-55.86	43.26-54.22	38.52-51.00	40.40-51.41	40.79-50.99	39.20-52.16

Table 2. Standard reference of the tibial nerve F-wave parameters with expanded uncertainty.

	Side-to-side difference	
	Mean (SD)	Mean + 2 SD
Median nerve		
Minimal F-wave latency	0.63 (0.85)	2.33
Maximal F-wave latency	1.83 (1.96)	5.78
Mean F-wave latency	0.86 (0.82)	2.50
Tibial nerve		
Minimal F-wave latency	1.03 (1.45)	3.93
Maximal F-wave latency	1.58 (1.47)	4.52
Mean F-wave latency	0.99 (0.92)	2.83

Table 3. Reference value and upper limits for side-to-side difference.

Conclusion

- This study presented the reference standards of minimal F-wave latencies for the median and the tibial nerves with expanded uncertainty.
- These reference standards are expected to improve diagnostic reliability and accuracy in nerve conduction studies.