Validity and Reliability Study of a Cutaneous Mechanical Stimulator for Measuring Tactile Threshold

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IASP 2024 WORLD CONGRESS ON PAIN
Amsterdam, Netherlands • 5-9 August

Background and Aims:

Accurate somatosensory evaluation is crucial for diagnosing and monitoring neurological conditions.[1,2] Reliable instruments exist for thermal and pain detection thresholds,[3,4] but assessing the mechanical detection threshold (MDT) has been challenging due to a lack of dependable electronic tools for evaluating Aß fibers. The recently developed Cutaneous Mechanical Stimulator (CMS) can deliver precise mechanical stimuli to measure MDTs and sensitivity across different body areas. [5] This study aims to determine whether the CMS can validly and reliably evaluate MDTs in healthy subjects, potentially offering a more consistent alternative to traditional monofilaments.

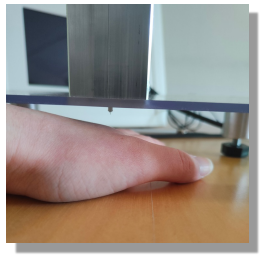
Methods:

Participants: 27 healthy, right-handed volunteers, consisting of 14 women and 13 men, with a mean age of 24.07 ± 3.76 years.

Test-retest design: MDT assessments in two sessions (S1 and S2), ~2 weeks apart, each session ~2 hours.
Two raters assessed MDTs for each subject. Four MDTs were measured per subject using SWM and the CMS on the left hand and left foot. The measurement order and rater order were counterbalanced among subjects.

Measuring MDT with Monofilaments & CMS:

- MDT measured using SWM (7 forces, 0.39-13.73 mN).
- via method of limits (10 ascending/descending blocks).
- Geometric mean of 5 supra-threshold & 5 infra-threshold values calculated.



Cutaneous Mechanical Stimulator (CMS):

- 123×40×79 mm, 300 g probe; 5 mm stainless steel tip.
- Force 0.25-700 mN, precision 0.2 mN.
- Controls intensity, duration, speed; tip moves 0.1-40 mm/s.
- Force and duration programmable.
- Real-time force monitoring.

Statistical Analysis:

- **Wilcoxon rank-sum tests** compared thresholds between SWM vs. CMS, two raters, two sessions.
- **Intraclass Correlation Coefficient (ICC)** analyzed test-retest reliability.

Assessment of Agreement Between SWM and CMS

Stimulation Site	ICC	p	95% confidence interval	Interpretation of ICC	Mean MDTs Differences Between SWM and CMS	p	Upper levels of agreement	Lower levels of agreement
The hand	0.84	< 0.01	0.40 - 0.93	Excellent	0.33 (±0.43) mN	0.07	1.80	-0.52
The foot	0.90	< 0.01	0.78 - 0.95	Excellent	-0.20 (±0.67) mN	0.14	1.13	-1.54

Analysis of Reliability Between Two Sessions (For Hand Measurements)

Measurement Tool	ICC	p	95% confidence interval	Interpretation of ICC	Mean MDTs Differences Between Both Sessions	p	Upper levels of agreement	Lower levels of agreement
SWM	0.63	< 0.01	0.19 - 0.83	Good	0.10 (±0.86) mN	0.27	1.82	-1.62
CMS	0.73	< 0.01	0.42 - 0.88	Good	-0.20 (±0.63) mN	0.12	1.07	-1.46

Analysis of Inter-rater Reliability (For Hand Measurements)

Measurement Tool	ICC	p	95% confidence interval	Interpretation of ICC	Mean MDTs Differences Between Both Raters	p	Upper levels of agreement	Lower levels of agreement
SWM	0.66	< 0.01	0.27 - 0.85	Good	0.10 (±1.06) mN	0.51	2.22	-2.01
CMS	0.82	< 0.01	0.60 - 0.92	Excellent	0.26 (±0.65) mN	0.24	1.55	-1.03

Conclusions:

The study demonstrated that both CMS and SWM provide reliable measurements of MDTs, with high ICCs indicating strong agreement between sessions. No significant differences were found between MDTs measured by CMS and SWM, suggesting both methods yield comparable results. Inter-rater reliability was higher for CMS compared to SWM, indicating superior consistency among raters. Limitations include the modest sample size and the focus on healthy young adults, necessitating further research to assess CMS reliability in clinical settings and its capability to measure mechanical pain thresholds.

References:

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