



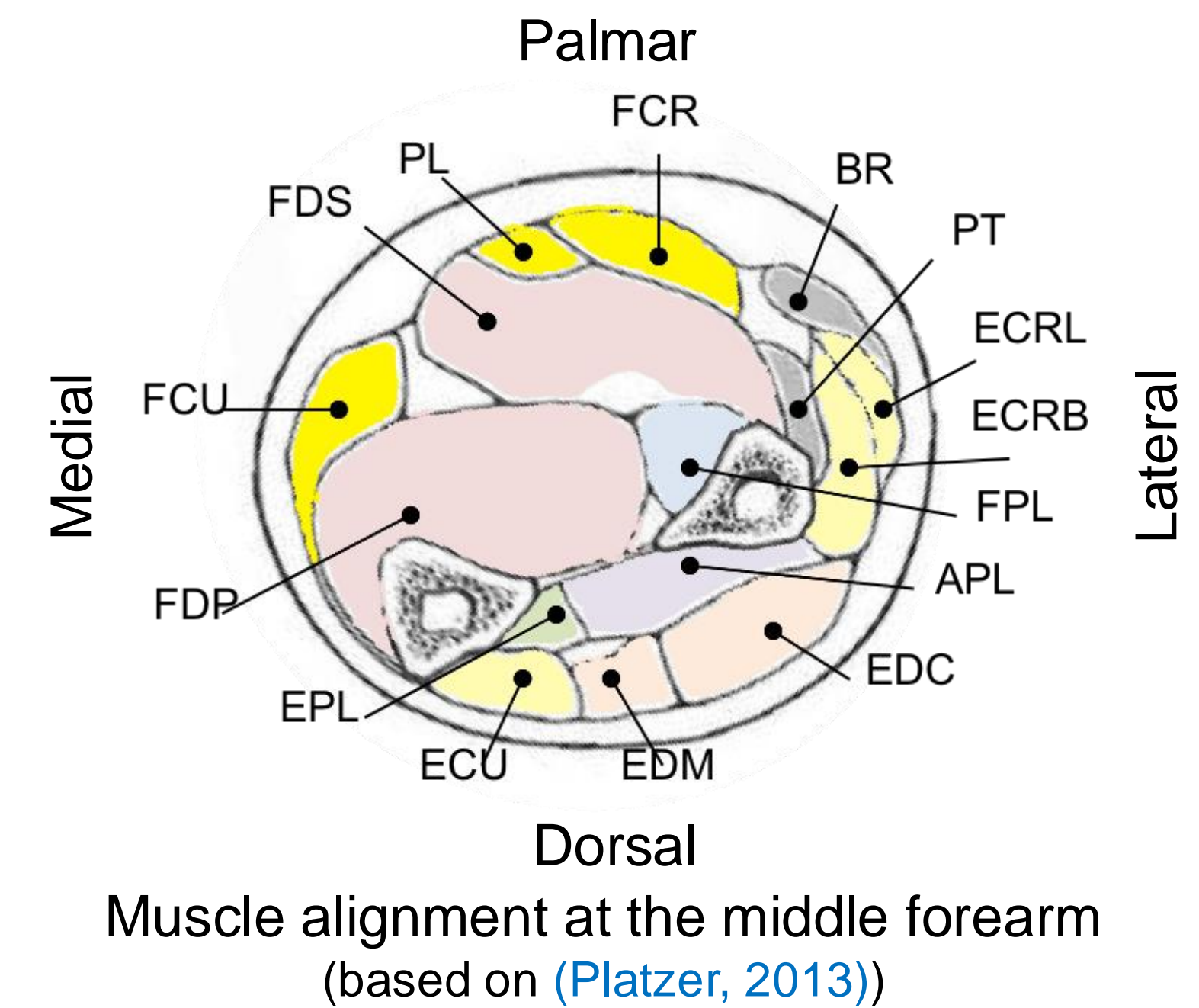
# Individual Muscle Activities Within Forearm During D-W Muscle Testing

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## Background and Objective

- Finger, thumb, and hand motions → Intricately controlled by complex activities of many muscles in the forearm
- Observation of muscle cooperative activities or muscle synergy → Evaluating the physiological functions
- Electromyography Computed Tomography (EMG-CT)** (Nakajima et al., J Electromyogr Kinesiol, 2014)  
→ Muscle activity distribution within a cross section of the forearm from surface EMG signals around the forearm
- In previous study, the muscle activities in the forearm were measured by EMG-CT during external loadings applied to each finger and thumb in the various directions (Toyota et al., ICBME2016).
- Daniels and Worthingham's muscle testing (D-W muscle testing)** (Hislop et al., 2014)  
→ Evaluation of the individual muscle functions
- Objective:** To elucidate the individual muscle activities in the forearm during the D-W muscle testing of each forearm muscles by using EMG-CT



## EMG-CT (Nakajima et al., J Electromyogr Kinesiol, 2014)

- Effect of muscle activity  $m_k$  (mA) on EMG  $\bar{V}_{ik}$  (mV)

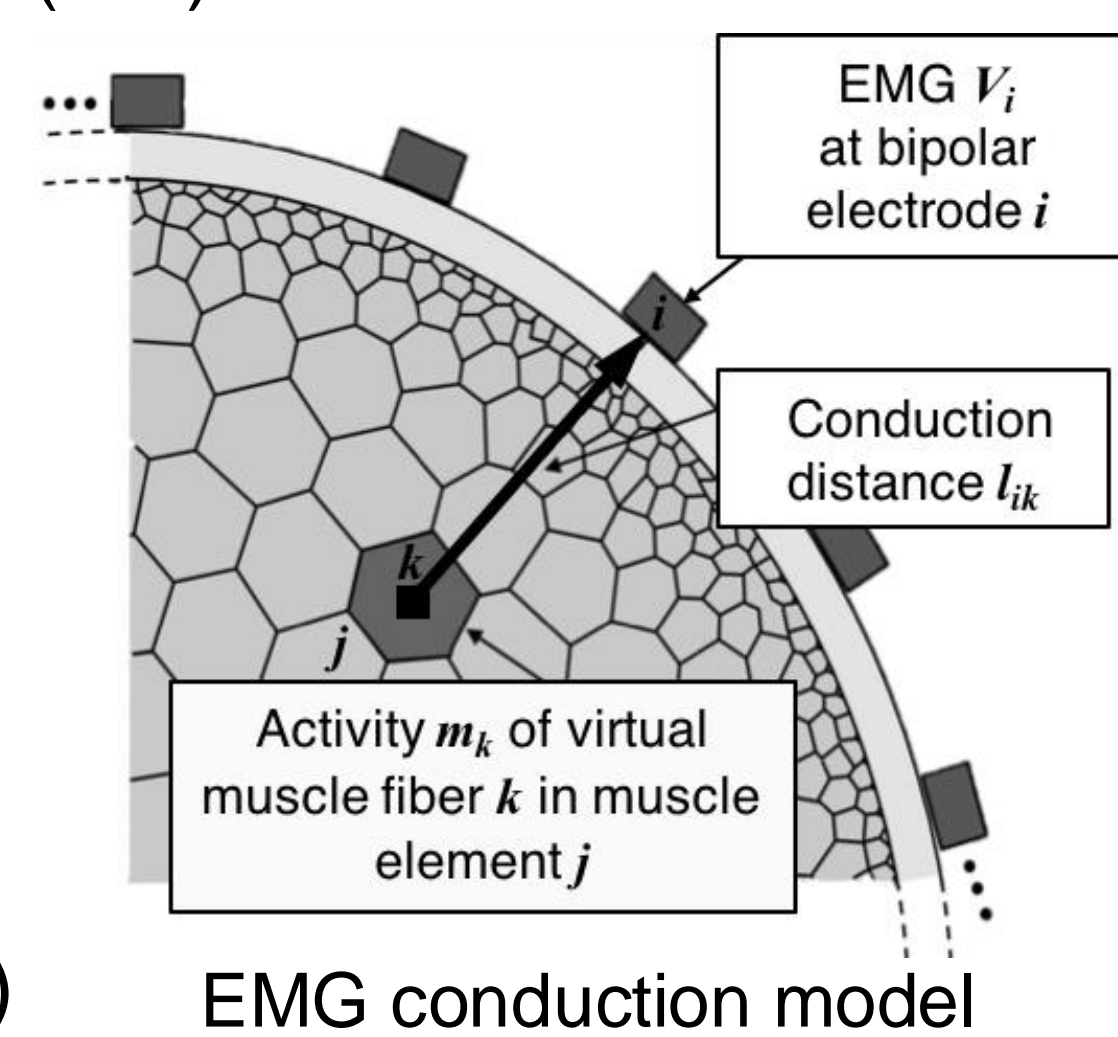
$$\bar{V}_{ik}^2 = V_0^2 m_k^2 \left( \frac{l_{ik}}{l_0} \right)^{2b}$$

- Muscle activity in element  $j$   $m_j$  vs EMG  $\bar{V}_i$

$$\bar{V}_i^2 = V_0^2 \sum_j \left\{ m_j^2 \sum_{k \in j} \left( \frac{l_{ik}}{l_0} \right)^{2b} \right\} \quad (m_k = m_j)$$

- To obtain muscle activity  $m_j$ ,  $f \rightarrow \min$

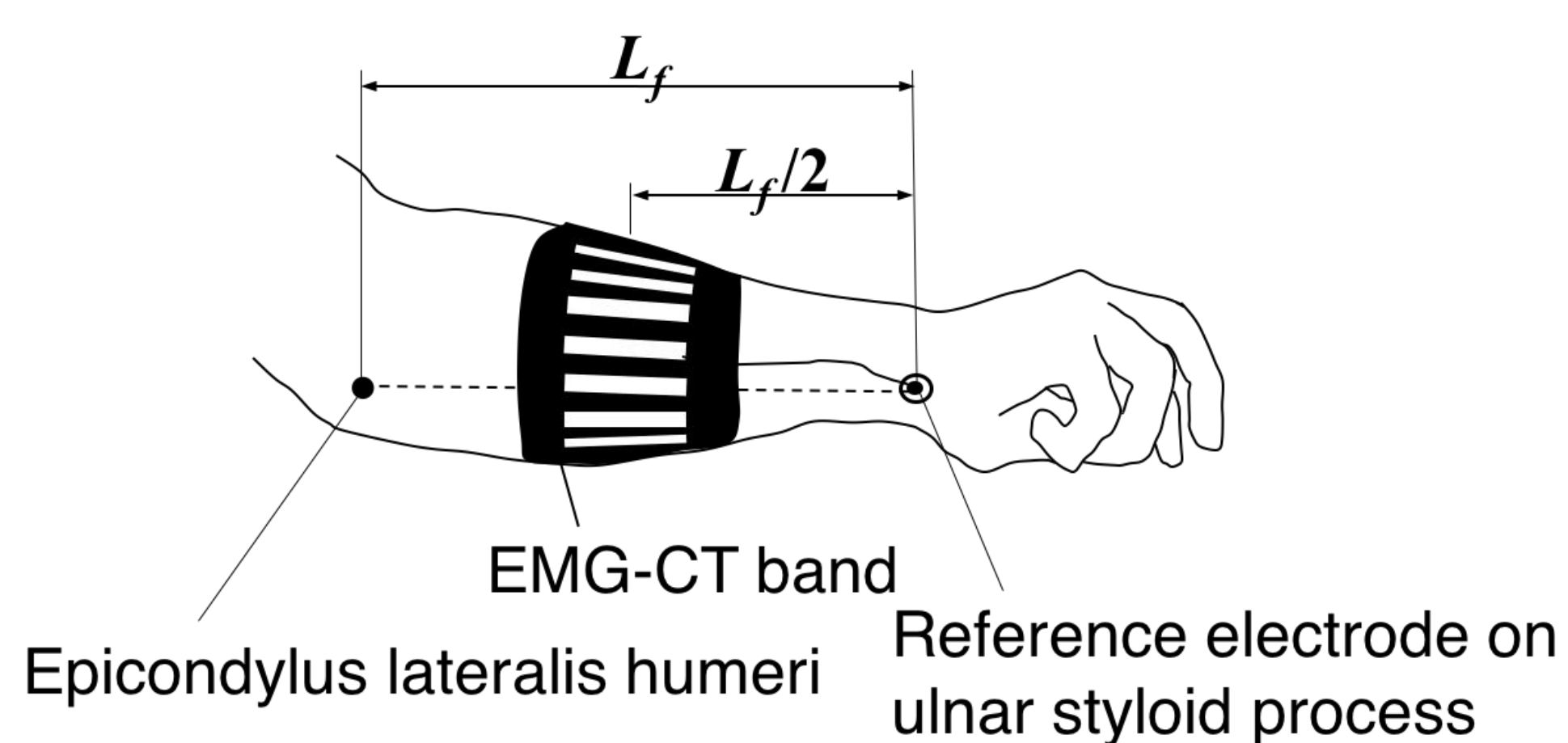
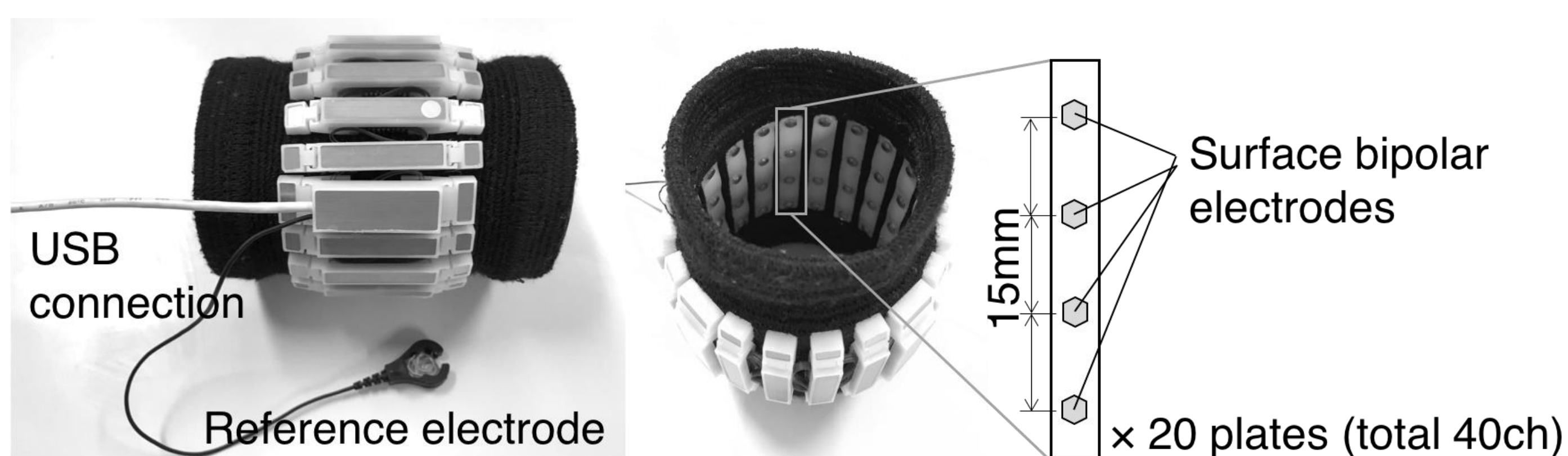
$$f = \sum_i (\bar{V}_i - \bar{V}_{Mi})^2 \quad (\bar{V}_{Mi}: \text{Measured EMG})$$



The distribution of muscle activity within the forearm was calculated from the surface EMG signals by minimizing measured and estimated surface EMG using the conduction model.

## Experiments

- Subjects
  - 3 healthy male subjects (23.7 ± 0.5 years old)
- Customized EMG-CT band (Harada Electronics, JP2016-131689A)
  - 40 pairs of bipolar electrodes placed circumferentially
  - Positioned at the middle of the forearm to detect the surface EMG

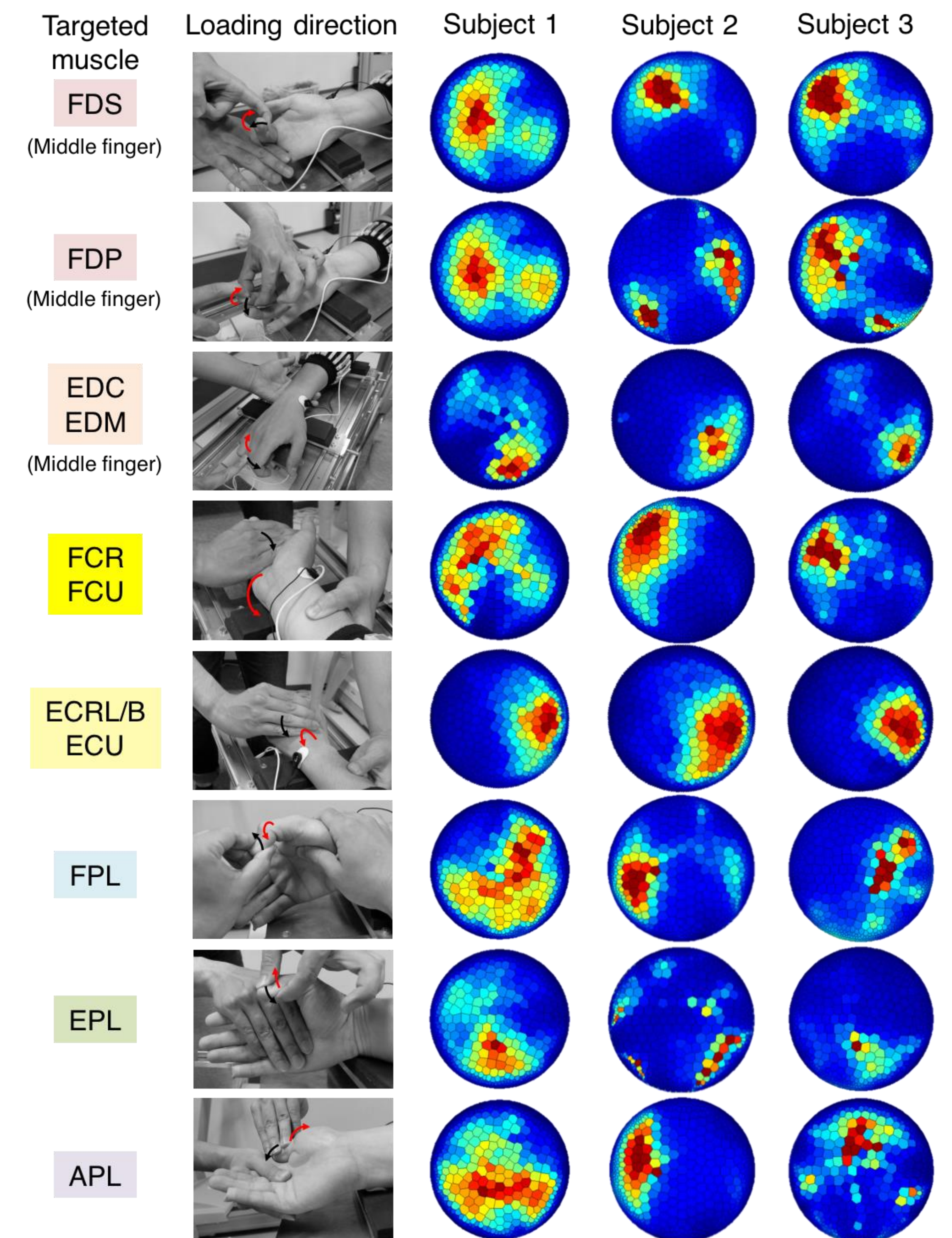


- Loading pattern
  - Index, middle, ring, and little fingers and thumb were loaded, respectively.
  - 8 loading patterns, following Daniels and Worthingham's muscle testing of each forearm muscles
  - Applied 5 s three times with 5 s intervals
  - EMG signals recorded 35 s
  - Averaged muscle activity distribution during loading was calculated.

## Acknowledgments

The device development in the project was collaborated with NIPRO Corporation (Japan). The project was partially supported by the Adaptable & Seamless Technology Transfer Program through Target-driven R&D (A-STEP) of Japan Science and Technology Agency.

## Results and Discussion



← Resistance by the examiner  
→ Movement of a body part actively  
0 50 100%

- Limitations
  - A small number of subjects
  - Difficult to exactly identify the activated muscles
  - Non-uniform loading level

## Conclusions

- Finger and wrist motions** in D-W muscle testing
  - Finger flexion: FDS/FDP with EDC/EDM coordination activities
  - Finger extension: mainly EDC/EDM with clear distribution
  - Wrist motion: mainly targeted muscle activities with clear distribution
- Thumb motions** in D-W muscle testing
  - High individual differences
  - Coordination activities of muscles related to fingers and wrist motions

## References

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