Journal of Electromyography and Kinesiology 47 (2019) 121–122

Contents lists available at ScienceDirect

Journal of Electromyography and Kinesiology

journal homepage: www.elsevier.com/locate/jelekin

In regards to motor unit decomposition, are we caring about the right information?

Recently, Prof. Roger Enoka published a very well written, thought-provoking article (Enoka, 2019) regarding the extraction of motor units from the decomposition of surface electromyographic (sEMG) signals. In it, he simultaneously shares his excitement for, as well as his concerns of (no doubt shared by many), the decomposition technique, as well as evidence for which he would still like to see (e.g., reproducing results from intramuscular recordings). While in agreement with most of what Prof. Enoka discusses, I can't help but wonder, are we focusing on the right information here?

Over the past 50 years, the vast majority of human motor unit research has been performed using intramuscular recordings during isometric contractions maintained at a relative intensity of approximately 5–10% of maximal voluntary force. These recordings detect the smallest, low-threshold motor units in the pool. Unfortunately, when decomposing sEMG signals recorded at higher force levels, it is these same small, low-threshold motor units that are the most susceptible to poor accuracy. The superposition of larger motor unit action potentials overshadows the smaller units, leading to missed firings and a reduced confidence in their firing behavior. If a researcher's focus is the accuracy of these smaller motor units, then there is, in my opinion, legitimate reason for concern. As mentioned in Prof. Enoka's paper, some decomposition approaches may neglect or discard the motor units that would be recruited near minimal recorded force. For example, of 270 motor units detected prior to training, and 281 motor units used after training, Pope et al. (2016) detected only 7 total motor units recruited from 0 to 10% of maximal force (see Fig. 3-B). In fact, the higher the force level of the contraction, the less likely it seems that motor units with recruitment thresholds < 10% of maximal force will be detected (personal observations). However, I believe it is the ability to detect a higher yield of larger, higher-threshold motor units (from a much larger pick up area than intramuscular permits), and extrapolate to the motor unit population, that is decomposition's greatest asset and innovation. Furthermore, in regards to superposition, I don't believe there are any concerns, at least not publicly shared, regarding the accuracy of firing times of the large motor units (i.e., under well controlled conditions, the identification of their action potentials remains unhindered).

This high yield of larger, high-threshold motor units may indeed come at the expense of the accuracy of small, low-threshold motor units; but I ask, which are more important? Presuming certain relationships between muscle fiber properties and motor unit properties, I'd like to remind the readers of 3 important points: (1) It is the large, high-threshold motor units that are likely the first to be affected with advanced age (e.g. Lexell et al., 1988), (2) It is the large, high-threshold motor units that are likely to be the most adaptable to training interventions (e.g. Aagaard et al., 2001), and (3) It is the large, high-threshold motor units that are likely the most sensitive to fatigue (i.e. less fatigue resistant). Despite this, due to technological limitations with intramuscular recordings, it is the large, high-threshold motor units that have been widely neglected from the literature.

I would like to add that the inconsistent findings of instantaneous firing rates (IFR) (e.g. initial firing rates during quickly increasing contractions, or force oscillations) was also discussed, but it should be noted that many decomposition studies have utilized a long window (e.g., 2 s) for averaging their firing rates. Whether differences in firing rates are the result of different decomposition algorithms or rather the back end processing (i.e. over-filtering), which may smooth IFR's too much, remains unknown.

I also suggest caution in presuming that the behavior of motor units recorded at very low force levels would apply to, or be shared by, the larger motor units at higher force levels. The smallest motor units in the pool have been examined *ad nauseam*, and there is now a critical need for more research of the large, high-threshold motor units at higher force levels. Yet, how do you validate a portion of the motor unit pool that was previously neglected from the literature? The problem with true innovation is that there might not be a gold standard for which to validate against. As a result, and in agreement with Prof. Enoka, it may be critically important for additional, rigorous secondary accuracy analyses (e.g. interspike interval variability, spike-triggered averaging) to be performed. However, I respectfully disagree at the premise that limiting our "trusted" findings to those that match intramuscular recordings should become the standard. Abraham Maslow once famously said, "If your only tool is a hammer, you tend to see every problem as a nail". Well when our only tool was intramuscular recordings, and with the exception of a few seminal studies, we tended to approach every motor unit problem only as it related to a low number of small, low-threshold units at low force levels. Thanks to technological advancements, we now have another tool at our disposal; perhaps our approach to examining motor units should appropriately evolve as well.

Declaration of Competing Interest

I, Jason M. DeFreitas, have no financial or personal relationships with other people or organizations that could inappropriately influence the content of my letter.

Appendix A. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jelekin.2019.05.001.

References

Aagaard, et al., 2001. A mechanism for increased contractile strength of human pennate muscle in response to strength training: changes in muscle architecture. J. Physiol. 534, 613–623.

Enoka, R.M., 2019. Physiological validation of the decomposition of surface EMG signals. J. Electromyogr. Kinesiol. 46, 70–83.

Lexell, J., Taylor, C.C., Sjostrom, M., 1988. What is the cause of ageing atrophy? Total number, size and proportion of different fiber types studied in the whole vastus

https://doi.org/10.1016/j.jelekin.2019.05.001
Received 18 April 2019; Accepted 1 May 2019

lateralis muscle from 15- to 83-year-old men. J. Neurol. Sci. 84, 275–294.
Pope, Z.K., Hester, G.M., Benik, F.M., DeFreitas, J.M., 2016. Action potential amplitude as a noninvasive indicator of motor unit-specific hypertrophy. J. Neurophysiol. 115, 2608–2614.

Jason M. DeFreitas
Applied Neuromuscular Physiology Lab, Oklahoma State University, Stillwater, OK 74078, USA
E-mail address: Jason.defreitas@okstate.edu.