Reply to De Luca, Nawab, and Kline: The proposed method to validate surface EMG signal decomposition remains problematic

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TO THE EDITOR: The Letter by De Luca et al. (2) reiterates the arguments presented by them in a previous exchange (1, 3). The issue concerns how to validate a generic algorithm that purports to decompose a surface EMG signal into its constituent motor unit action potentials. De Luca et al. proposed the decompose-synthesize-decompose-compare (DSDC) approach (1) [originally described in (5) as the reconstruct-and-test method]. The approach involves decomposing the surface EMG with an algorithm, summing the trains of action potentials identified by the algorithm, adding noise with power equal to the reconstruction residual, and reapplying the algorithm. The accuracy of the algorithm is quantified by comparing the results of the two decompositions, with identical decomposition results implying 100% accuracy (5).

Despite the strong focus by De Luca et al. on their own algorithm (1, 2), the scope of the issue is much broader and concerns the validation of decomposition algorithms in general. In our review paper (4) and previous letter (3), we argue against the validity of the DSDC approach. In their new letter, De Luca et al. (2) acknowledge that there are algorithms for which the DSDC test would fail by presenting the example of algorithms that decompose a signal into nonoverlapping segments without residual. In doing so, these algorithms would always be judged by the DSDC test as 100% accurate (independent of the actual accuracy) due to the zero residual and the identical decomposition results. The DSDC method would even judge these algorithms as perfectly accurate when they are applied to colored noise without any EMG signal. There are other examples of algorithms that would be judged as acceptable with the DSDC test because of how they were constructed and not because of their accuracy.

To counteract the examples of algorithms for which the DSDC would fail, De Luca et al. state that although these algorithms “...would be inappropriate for DSDC validation,” their algorithm “does not work in this fashion.” We are satisfied that in this way they acknowledge that the DSDC test should not be applied as a general validation for EMG decomposition algorithms, as we pointed out (3, 4). However, they still fail to recognize the critical issue in this discussion, for which their algorithm is not an exception: testing decomposition reliability with residual-dependent noise provides essentially no information about the accuracy of the decomposition, as indicated by their own example of algorithms without residual (2).

We take this occasion to also provide a more general argument. Surface EMG decomposition is a source separation problem and a property of many source separation methods is that the residual noise decreases systematically with an increase in the number of estimated sources. According to the DSDC test, therefore, any component analysis, such as independent or principal component analysis, would be an ideal approach to decomposing surface EMG signals, with perfect accuracy in any conditions (even for colored noise), for a sufficient number of estimated sources.

Our opinion remains that the use the DSDC method to validate decomposition algorithms is problematic and that comparison of the decompositions of concurrently recorded intramuscular and surface EMG signals is currently the best practice for validation (4).

DISCLOSURES

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AUTHOR CONTRIBUTIONS

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