Recommendations for the use of double differential EMG to record and detect the nociceptive withdrawal reflex in humans

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THE nociceptive withdrawal reflex (NWR) constitutes a valuable surrogate measure to non-invasively probe the excitability of central nociceptive pathways. It is generally elicited by electrical stimulation over the sural nerve or under the sole of the foot and measured over muscles in the lower extremities using electromyography (EMG). To facilitate comparison of results from various studies and to promote clinical usefulness, extensive work has been carried out to achieve reliable standardized scoring criteria for detection of the NWR from EMG. The interval peak z-score has been reported as being highly accurate and reliable [1]. We have recently documented that the evaluation of standard single differential (SD) EMG does not allow reliable muscle-specific reflex detection due to the volume conduction of interfering myoelectric signals from nearby muscles [2]. The negative implications of this phenomenon, denoted crosstalk, may be significantly reduced by the use of double differential (DD) EMG recordings. However, it has not yet been reported how the use of a different recording technique influences the cut-point of the standardized scoring criterion. In this paper, the accuracy of reflex detection based on SD and DD EMG respectively is compared and recommendations for the optimal interval peak z-score cut-points are presented.

Methods: Reflexes were elicited by electrical stimulation at the sole of the foot and measured using both SD and DD surface (sEMG) and intramuscular (iEMG) EMG from the tibialis anterior and soleus muscles in 15 healthy subjects. The interval peak z-score were calculated for 489 individual recordings. Two sets of ROC-curves were produced for both SD and DD sEMG respectively using two different gold standards; 1) visual examination of sEMG only and 2) visual examination of both sEMG and iEMG (enabling distinction between genuine reflexes and crosstalk).

Results: The ROC-curves produced considering gold standard 1 indicated that evaluation of interval peak z-scores calculated for both SD and DD sEMG allows reflex detection with high accuracy with areas under the ROC-curve (AUC) of 0.99 and 0.98 respectively. The corresponding sensitivity and specificity plots indicated optimal cut-points at $z=12.6$ and $z=14.3$ for SD and DD sEMG, respectively. However, the ROC-curves produced considering gold standard 2 revealed a significant difference in accuracy between the evaluation of SD (AUC=0.95) and DD (AUC=0.99) sEMG ($p<0.001$).

Conclusion: The present results support the use of a cut-point around 12 for interval peak z-scores calculated for SD sEMG as suggested in the literature [1, 3]. However, whenever muscle-specific evaluation is desirable, the superior accuracy obtained by evaluating DD instead of SD sEMG is strongly advised. In that case, the present results suggest a slightly higher cut-point for the interval peak z-score, around 14. In conclusion, use of DD sEMG as the general approach for recording of the NWR is recommended.

REFERENCES

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