Validation of a correction factor for suboptimal voluntary activation evaluation

Guillaume Ducrocq*[1,2], Romuald Arnold[2], and Thomas Hureau[1,2]

[1]Mitochondrie, stress oxydant et protection musculaire – université de Strasbourg – France
[2]Faculté des Sciences du Sport [Strasbourg] – université de Strasbourg – France

Résumé

Introduction
Central fatigue is characterized by the failure of the nervous system to fully activate motor units of the exercising muscles. The gold standard procedure to measure central fatigue, the twitch interpolation technique (Merton, 1954), has been used for decades and consists of superimposing a supramaximal twitch or high frequency doublets to the peak force developed during a maximal voluntary contraction (MVC)(Gandevia, 2001). The amplitude of the superimposed twitch response is then normalized by the amplitude of a potentiated twitch on resting muscles to calculate voluntary activation (VA) level using the following formula:

VA (%) = 100 – 100 x superImposedTwitch/potentiatedTwitch *(1)*

One key limit of this method arises when the superimposed twitch is not evoked at the peak force developed during the MVC, resulting in a submaximal measurement of the voluntary activation level. To circumvent this limit, a correction factor (CorrFactor) has been developed to extrapolate the maximal VA using the following formula (Strojnik & Komi, 1998):

expectedVA (%) = 100 – 100 x superImposedTwtich * CorrFactor/potentiated twitch *(2)*

CorrFactor = forceAtTwitchDelivery/peakMVCForce

While this correction factor is well known and used across the scientific community, it has never been formally validated experimentally. It is therefore unknown if the recalculated VA is accurate, overestimated or underestimated. This prompted us to determine the scientific validity of the correction factor for VA measurements.

Methods

After a period of familiarization, nine subjects (4 women) visited the laboratory to evaluate their VA before, during (every 50s) and after a 5 minutes all-out exercise consisting in producing 60 MVCs of the right knee extensor muscles. Voluntary activation was measured by superimposing at least two single electrical twitches during a 3s MVC and evoking one potentiated twitch 2s post-MVC. One of the superimposed twitches was delivered as close

*Intervenant

as possible to the peak force of the MVC and the second one at a submaximal force level. The VA level of the near maximal superimposed twitch was calculated using the standard formula (1), whereas the VA level of the submaximal superimposed twitch was calculated using the correction factor (2).

Results

Among all subjects, a total of 148 MVCs were recorded in a rested and fatigued condition during which VA was measured. In average, the near maximal superimposed twitch was evoked at 96 ± 4 % of MVC peak force. In contrast, the submaximal superimposed twitch was delivered at 85 ± 10% of MVC peak force. Both methods calculated a non-corrected VA level of 85 ± 11% and 79 ± 15% ($P < 0.0001$), respectively. When the correction factor was applied, the submaximal VA was increased to 83 ± 11 %, which remained significantly different than the expected VA ($P = 0.0037$). Importantly, in some cases the correction factor underestimated the expected VA, in others it overestimated it. Rarely (19 out of 148), the correction factor provided an accurate estimation of VA (i.e. within ±1% of the expected VA).

Conclusion

Overall, our results show that the correction factor typically used in the literature does not effectively correct for suboptimal superimposed twitch delivery. These results should raise awareness on the importance to deliver superimposed twitch at or near the peak force of MVC. If a correction factor should be applied, a new method should be developed.

References

Gandevia, S. C. (2001). Spinal and supraspinal factors in human muscle fatigue. *Physiological Reviews*, *81*, 1725–1789.

Merton, P. A. (1954). Voluntary strength and fatigue. *The Journal of Physiology*, *123*, 553–564.

Strojnik, V. & Komi, P. V. (1998). Neuromuscular fatigue after maximal stretch-shortening cycle exercise. *Journal of Applied Physiology (Bethesda, Md.: 1985)*, *84*, 344–350.