



Let's all play with the same rules

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Reporting trends/tendencies towards significance for $p > 0.05$ in one of our recent publications has been criticized by Drs. Héroux and Gandevia (2019). Tendencies towards significance have been frequently reported in the literature, including experiments from Dr. Gandevia's lab. Indeed, we found over 25 papers from his group where statistical trends or tendencies, i.e., convoluted and self-serving interpretations of p values (to quote the authors), are reported. Here are two examples:

'There was a *tendency* for training with fast contractions to produce a *greater increase* in contralateral strength than slow training ($p = 0.08$) (Abstract)' (...) 'The effect of training speed on contralateral strength *was not statistically significant, but there was a tendency* for training at the higher speed to have a *greater effect* on strength of the contralateral limb than training at the lower speed ($p = 0.08$)' (...) 'There was a *non significant trend* for training at higher speeds to produce a greater contralateral effect than training at lower speeds ($p = 0.08$).' (...) 'The *trend* seen in favor of training at higher speeds on contralateral strength increases may be related to the greater magnitude of strength gained in the trained arm when training at faster speeds.' (...) 'There is a *trend* toward greater contralateral training effects when the training load is lifted quickly.' (Munn et al. 2005) (our emphasis).

'The estimated resting twitch was significantly larger than the motor nerve resting twitch ($p = 0.004$), which only *showed a trend* for a decline in size with fatigue ($p = 0.12$).' (...) 'For the resting twitch evoked by motor nerve stimulation, there was only a *trend for fatigue-induced slowing*

in the peak relaxation rate ($p = 0.14$) and half relaxation time ($p = 0.09$).' (...) 'In heated muscle, the half relaxation time was shorter ($p = 0.048$) but there was only a *trend* for a faster peak relaxation rate ($p = 0.12$). (...) 'there was an *overall trend for a faster time* to peak than in fresh muscle ($F_{1,12} = 4.4$; $p = 0.08$)' (...) 'However, there was a *trend for an increased* time to peak amplitude at 85 s ($p = 0.07$) and 110 s ($p = 0.053$) compared with at 25 s' (Todd et al. 2007).

We were very surprised when we realized that a paper that may have been finalized while writing the letter about our paper states the following.

'The duration of the inhibitory response showed a similar trend for surface and intramuscular EMG recordings with *non-significant decreases* during larger breaths. *Duration decreased* from 63.3 ± 28.7 ms to 33.3 ± 19.1 ms in surface ($p = 0.126$) and from 61.7 ± 20.9 ms to 39.5 ± 18.5 ms for intramuscular ($p = 0.151$) recordings. While the non-significance may be due to a small sample size ...' (Luu et al. 2019).

This shows that despite recommending that p values between 0.05 and 0.1 should not be interpreted as a trend (Diong et al. 2018), the authors push the interpretation of a trend to p values greater than 0.1.

While we have been innovative in the methods we have used to measure fatigue (Doyle-Baker et al. 2018), we acknowledge that we have been classical in our use of statistics. Additionally, everyone would appreciate that it is much harder to train more subjects for another 9 weeks to confirm the tendencies in our study than testing more subjects for a single 1-h session. More importantly, while we are willing to recognize the overuse of tendencies in this particular paper, this can be explained by the following reason: the two previous papers investigating the effects of endurance training on fatigue tolerance showed that tolerance was upregulated. Here we found no difference and even a tendency in the opposite direction. In other words, the use of tendencies is not necessary to reach the same conclusion. These are original results that worth publication in our opinion. We also reported all exact p values (including what we refer to as tendencies) to ensure transparency as recommended

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by the authors of this letter (Diong et al. 2018). In addition, it would have been easier to only report peak twitch as most researchers do in the field of neuromuscular fatigue. We decided to report also high-frequency doublet (Db_{100}), which is less subject to potentiation, as well as low- to high-frequency doublet ($Db_{10:100}$), considered as an index of excitation–contraction coupling failure when it is decreased.

Importantly, by the way the authors of this letter selected some sections of our abstract, they imply that the conclusion ('This study confirms fatigue attenuation at isotime after training') is solely based on non-significant results. This is totally incorrect. Indeed, at isotime, MVC force, peak twitch and high frequency doublets (100 Hz) showed significantly less decline in $POST_{ABS}$ compared to PRE (all $p < 0.05$), all of which support our conclusion. Since we do not question the scientific integrity of Drs. Héroux and Gandevia's, we conclude that the authors did not take the time to carefully read our paper.

We believe our paper addresses an important physiological question on an under-investigated topic and adds to the current knowledge by showing that fatigue tolerance is not upregulated after endurance training. This is still true if we do not consider the tendencies. These results were obtained with an innovative ergometer (Doyle-Baker et al. 2018) that in our opinion is a step forward in the field of fatigue.

The authors of this letter are correct that the current application of statistics in science is not always appropriate, including in some of our papers, but we suggest that, as one of the leaders in the field, Prof Gandevia shows the right way by not describing tendencies in his own papers. In conclusion, we agree with the authors, that it is very important that statistics are correctly reported. But this must apply to all research groups. Let's all play with the same rules!

Author contribution GM wrote the manuscript.

Compliance with ethical standards

Conflict of interest The author declares that he has no conflict of interest.

References

- Diong J, Butler AA, Gandevia SC, Héroux ME (2018) Poor statistical reporting, inadequate data presentation and spin persist despite editorial advice. *PLoS ONE* 13(8):e0202121. <https://doi.org/10.1371/journal.pone.0202121>
- Doyle-Baker D, Temesi J, Medysky ME, Holash RJ, Millet GY (2018) An innovative ergometer to measure neuromuscular fatigue immediately after cycling. *Med Sci Sports Exerc* 50(2):375–387. <https://doi.org/10.1249/MSS.0000000000001427>
- Héroux M, Gandevia SC (2019) Neuromuscular fatigue and cycling: a master spin class. *Eur J Appl Physiol* in press
- Luu BL, McBain RA, Taylor JL, Gandevia SC, Butler JE (2019) Reflex response to airway occlusion in human inspiratory muscles when recruited for breathing and posture. *J Appl Physiol* 126(1):132–140
- Munn J, Herbert RD, Hancock MJ, Gandevia SC (2005) Training with unilateral resistance exercise increases contralateral strength. *J Appl Physiol* 99(5):1880–1884. <https://doi.org/10.1152/jappphysiol.00559.2005>
- Todd G, Taylor JL, Butler JE, Martin PG, Gorman RB, Gandevia SC (2007) Use of motor cortex stimulation to measure simultaneously the changes in dynamic muscle properties and voluntary activation in human muscles. *J Appl Physiol* 102(5):1756–1766. <https://doi.org/10.1152/jappphysiol.00962.2006>

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