2 **Short Communication**

3 **Force-velocity profiling is a misnomer: Load-jump height**
4 **profiling would be a better name**

5 Daniel J Cleather^{1,2}

6 ¹ St Mary's University, Waldegrave Road, Twickenham, TW1 4SX, UK

7 ² Institute for Globally Distributed Open Research and Education (IGDORE)

8 Email: daniel.cleather@stmarys.ac.uk; Twitter: @dr_jump_uk

9 Citation:

10 Cleather, D. J. (2019). Force-velocity profiling is a misnomer: Load-jump height profiling
11 would be a better name. *SportRxiv*. doi: [10.31236/osf.io/58fu3](https://doi.org/10.31236/osf.io/58fu3)
12

13
14 In recent years a method known as force-velocity profiling has become popular for evaluating
15 jump performance under differing loads (Morin and Samozino, 2016; Samozino et al., 2008,
16 2010, 2012, 2014). The method draws support from a theoretical paper that was published in
17 Journal of Theoretical Biology (Samozino et al., 2010). Unfortunately, there are errors in the
18 mathematics of said paper which reveal that the method certainly cannot be characterised as
19 giving a force-velocity profile.

20 The principal error in the article comes after the authors derive Equation 9. The authors
21 claim that the “equation is only based on the impulse-momentum relationship, and so does

not assume that the CM [centre of mass] acceleration is constant during push-off, as it was done [sic] by Bosco et al. (1983) to show the same result.” However this statement is false, as the authors have implicitly assumed that the force acting on the centre of mass is constant at least twice within their derivation. Firstly, in Equation 3 the authors assume that work is equal to the product of force and distance – this is only true if force is constant. Secondly, in Equation 7, the form of the impulse-momentum relationship that the authors apply is that change in momentum is equal to the product of force and time – again, this is only true if force is constant.

Clearly the claim that there is no assumption that the acceleration of the centre of mass is constant is false, but why does this matter? Well, the authors’ method is based on calculating the average force and the average velocity during the “push off” phase of the jump from the measured jump height. These are then equated to one another to give a “force-velocity” relationship. The push off phase of the jump is defined as being from the deepest point of the countermovement (when velocity is zero) until takeoff. What we have here then is a situation where we have constant acceleration over a period from zero velocity to peak (takeoff) velocity, and so we can proceed using the well known equations of uniform acceleration. Firstly, it is straightforward to calculate takeoff velocity from jump height. If we then make an assumption about the time taken or distance travelled (the authors use distance travelled) during the push off phase we can easily calculate the constant acceleration, and hence the constant force. This constant force is clearly the average force. Similarly, because acceleration is constant the average velocity is just half the takeoff velocity, and thus we have our values of average force and velocity, QED!

The problem is that we are comparing the force and velocity values at an entirely arbitrary point and suggesting that it is significant. However, during the push off phase the force is the

same (it is constant) when velocity is zero and at peak velocity – and at every other velocity in between. There is no relationship between force and velocity here.

How do the authors come to make this mistake? I believe it is because they are expecting to find a force-velocity relationship. In fact, this is an explicit assumption that can be found in a different part of the paper. The presence of this assumption doesn't impact on the mathematical argument that I have presented here. However, it is worth noting that although the existence of a relationship between force and velocity in isolated contractile muscle tissue is well known, it is far from being established that this relationship carries over into the movement of a complex organism. In any case, this expectation seems to manifest itself in the common mistake of conflating the impulse-momentum relationship (a relationship between change in momentum and impulse) with an instantaneous relationship between force and velocity.

Force-velocity profiling for vertical jumping is based on a consideration of how jump height changes as a load is added. Certainly, the relationship between jump height and external load may vary between athletes, and the authors' own research suggests that this variation may be meaningful. However, it is an objective mathematical error to characterise the calculations inherent in the method as providing a force-velocity profile.

References

- Morin J-B, Samozino P. Interpreting power-force-velocity profiles for individualized and specific training. *Int J Sports Physiol Perform*, 2016; 11(2): 267–272
- Samozino P, Edouard P, Sangnier S, Brughelli M, Gimenez P, Morin J-B. Force-velocity profile: imbalance determination and effect on lower limb ballistic performance. *Int J Sports Med*, 2014; 35(6): 505–10
- Samozino P, Morin J-B, Hintzy F, Belli A. A simple method for measuring force, velocity and power output during squat jump. *J Biomech*, 2008; 41(14): 2940–2945

- 71 Samozino P, Morin J-B, Hintzy F, Belli A. Jumping ability: a theoretical integrative
72 approach. *J Theor Biol*, 2010; 264(1): 11–8
- 73 Samozino P, Rejc E, Di Prampero PE, Belli A, Morin J-B. Optimal force-velocity profile in
74 ballistic movements--altius: citius or fortius? *Med Sci Sports Exerc*, 2012; 44(2): 313–
75 22
- 76