EXTERNAL MECHANICAL WORK IN THE GALLOPING RACEHORSE

Biology Letters

Self Davies, Z.T., Spence, A.J., Wilson, A.M.

SUPPLEMENTARY INFORMATION

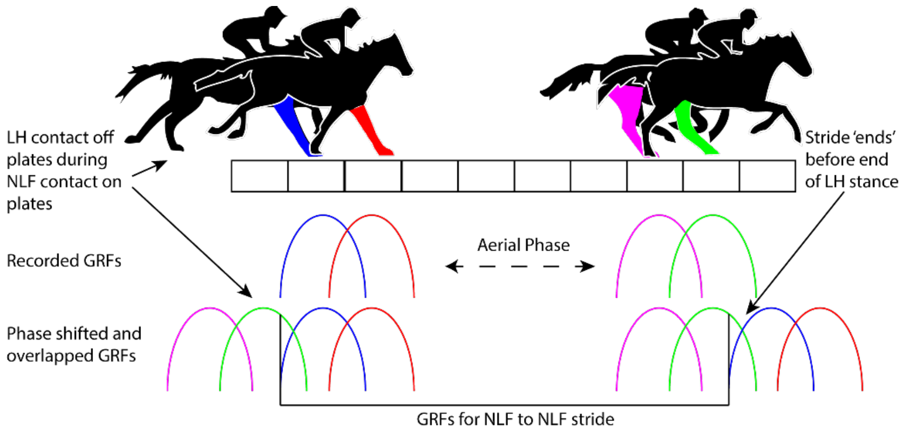

Figure 1. Diagram to show how force plate traces were phase-shifted, using stride time from high speed video, to account for footfalls occurring off the plates which would affect external work calculation. This assumes steady-state and that all strides are the same.

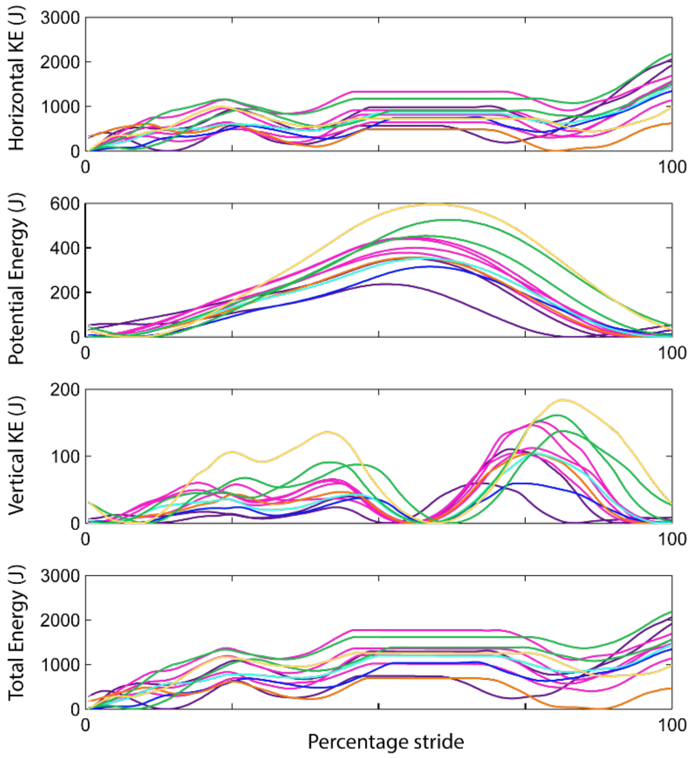

Figure 2. Overlay of energy fluctuations during a stride for 12 trials (NLF-NLF) across 7 individuals. Galloping speeds range from $10.2 ms^{-1}$ to $13.1 ms^{-1}$. Line colours represent different individuals. Energy traces have had the offset of their minimum value removed. This diagram includes the same trial as in Figure 1 of the main paper.

Notes on Materials and Methods and calculations

Video analysis:

2 AOS high-speed cameras were set back 5 m from the track, with a view of approximately 5 m before the plates and 5 m after the plates with an overlap of approximately 1 m in the middle to ensure that full strides were captured. The cameras were set to 1280 x 560 pixels and were calibrated using a 31cm calibration frame throughout the field of view. The velocity of the COM was estimated by tracking a fixed point on the horse, the girth (strap on the saddle), as this was an area of decent contrast that remained in a fixed position on the trunk of the horse. The equations used require initial velocity conditions, we used the average velocity from the video as this allowed the most accurate estimation (the velocity was taken as the average velocity across a stride since velocity is displacement over time and the shorter the time interval the greater the effect of any errors in measurement of displacement.)

Aerodynamic drag:

Here we considered the horse and jockey to be a bluff body and in comparison with a bicyclist with known Cd of 0.9. This is somewhat conservative and, as with the other calculations in the discussion, this is an assumption. The aim was to give an idea of the proportion of mechanical work that is drag.

Efficiency calculation:

Efficiency defines the ratio of how much mechanical work is performed for a given amount of metabolic work and relates to the efficiency of the locomotor muscles.

Efficiency = (external mechanical work + internal mechanical work)/metabolic cost

Here we use our measured value for external work of 876J (we used the decrements value here as this is most conservative) and values from the literature for internal work and metabolic cost.

We take the internal work value from Minetti et al. for an equivalent speed of 2000J. This value is approximated from Figure 4 of the paper which shows an internal work value of approximately $0.7 Jkg^{-1}m^{-1}$ (the horses in the study were around 500kg, and the stride length of a horse at $12ms^{-1}$ is around 6m). To give an idea of range and sensitivity of this calculation, we present the effect here of varying these values as this value is based on a number of assumptions (we are estimating stride length, horse mass and reading from a figure). If we consider the internal work value to range between $0.7Jkg^{-1}m^{-1}$ and $0.8Jkg^{-1}m^{-1}$, stride length to range between 5-6m and horse mass to range between 500-550kg, this gives us a range of internal work values: 1750-2640J. This would give a range of efficiency values of 34-45%.

These calculations are made as discussion points for the reader to take at whatever level they wish.