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Supplementary Information for

The functional importance of human foot muscles for bipedal locomotion

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www.pnas.org/cgi/doi/10.1073/pnas.1812820116

Supplementary text - Full details of methods

Nerve block procedure. A tibial nerve block was administered 2-4 cm proximal to the level of the medial malleoli of both legs. Under ultrasound guidance a hypodermic needle was used to inject no more than 30 mg·kg^{-1} of 2% lignocaine plain solution around the tibial nerve. An effective block of motor function was confirmed using the electromyographic response of the flexor digitorum brevis (FDB) muscle to percutaneous electrical stimulation of the tibial nerve, before and after the block was administered. A pair of electrodes (Ag-AgCl, 24 mm diameter, Tyco Healthcare Group, Ireland) were placed along the path of the tibial nerve at the popliteal fossa and, with the participant standing comfortably upright, a series of increasing magnitude single pulse stimuli (width 500 µs) were delivered at least 5-s apart using a constant-current stimulator (DS7AH, Digitimer, UK). Before the nerve block, stimulation current was increased in 5 mA increments until the peak-to-peak compound potential (M-wave) response of FDB plateaued (observed using Spike 2 software, CED, UK). Following the nerve block, the same range of currents was applied and the response recorded.

Electromyography techniques. A bipolar fine-wire intramuscular electrode pair with a detection length of 2 mm (0.051 mm stainless steel, Teflon coated, Chalgren, USA) was inserted under sterile conditions using a delivery needle (0.5 x 50 mm) into the FDB muscle under ultrasound guidance, as has been previously described (1, 2). The fine-wires were connected to a preamplifier (MA-411, Motion Lab Systems, USA) of a wired EMG system (MA300, Motion Lab Systems, USA) and sampled using a 16-bit analogue-digital converter (Power1401, CED, UK) and recorded in Spike2 software (CED, UK). EMG data were exported to Matlab (The Mathworks, USA) for analysis of the compound potential M-wave data.

Metabolic cost of transport in experiment 2. Rates of metabolic energy consumption were determined via indirect calorimetry. A portable gas analysis system (MetaMax 3B, Cortex, Germany) was used to record rates of oxygen consumption and carbon dioxide production via analysis of inspired and expired air, respectively. Baseline rates were recorded during a 5-min period of quiet standing before control and nerve block walking and running trials. Mass specific rates of energy consumption were calculated according to the equations of Brockway (3) using steady-state data from the final 2 min of standing, walking and running. Values from walking and running trials were normalised to their condition-specific baseline to account for any effect of the nerve block procedure on baseline rates. Metabolic rates were divided by treadmill speed to compute the CoT (J·kg^{-1}·m^{-1}).

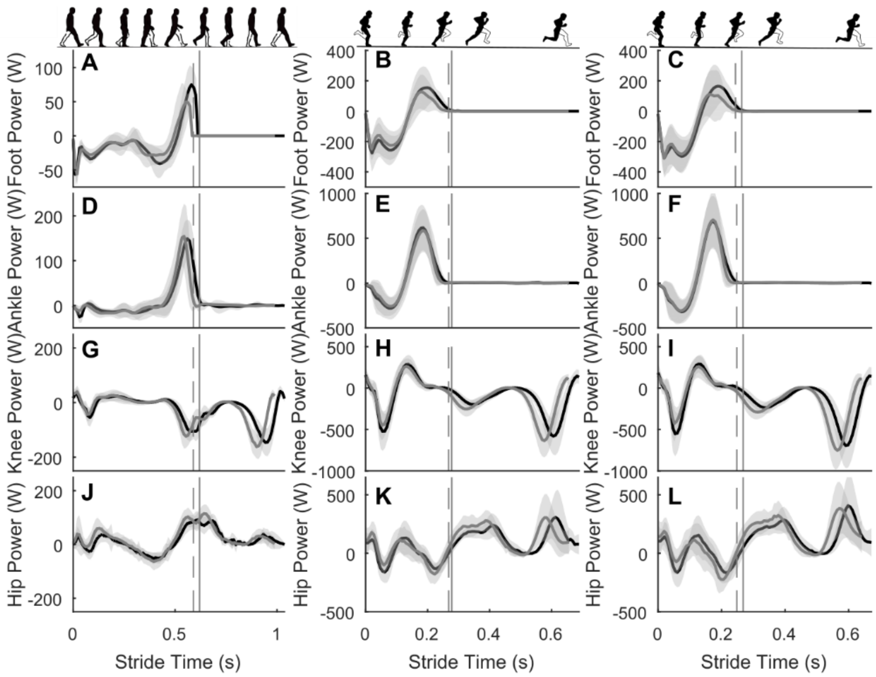

Fig. S1. Positive power produced by the foot and ankle in late stance was reduced by the nerve block, while hip positive power in late stance and early swing increased. Group mean (± s.d.) time series power data for the distal foot (A-C), ankle joint (D-F), knee joint (G-I), and hip joint (J-L). The left column is data from walking (Fr = 0.2) and is scaled differently to the middle column which is slower running (Fr = 1.0) and the right column which is faster running (Fr = 1.25). Across all three speeds the distal foot produced less positive power in late stance in the nerve block condition (grey lines) compared to the control condition (black lines). Ankle positive power in late stance dropped earlier across all speeds for the nerve block condition, and this was linked with reduced stance and stride times when the nerve block was applied. Data are plotted from foot-ground contact to ipsilateral foot-ground contact, and the vertical lines represent the end of the stance phase for control (solid) and nerve block (dashed) conditions, respectively.

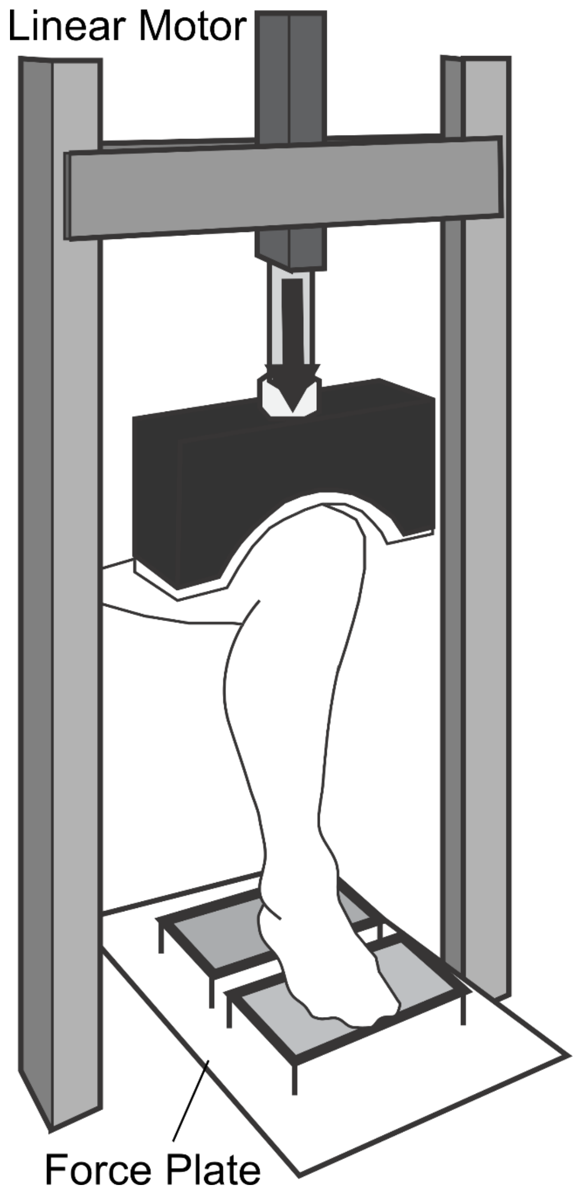

Fig. S2. . Setup for experiment 1. (A) A linear motor mounted on a shop-press was used to apply controlled vertical forces to the foot via the thigh of seated participants. Participants sat with the ball of the foot directly below the motor on one platform and the heel on another platform, both of which were mounted on a single force plate.

References for SI reference citations

1. Kelly LA, Lichtwark G, & Cresswell AG (2014) Active regulation of longitudinal arch compression and recoil during walking and running. Journal of The Royal Society Interface 12(102):20141076-20141076.
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3. Brockway JM (1987) Derivation of formulas used to calculate energy-expenditure in man. Human Nutrition-Clinical Nutrition 41C(6):463-471.