The kinetics of central & peripheral fatigue during repeated-sprint exercise

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Introduction
- Fatigue, defined as an exercise-induced decrease in maximal voluntary force (MVC), occurs due to impairments within the exercising muscle (peripheral fatigue) and central nervous system (central fatigue). Supraspinal fatigue, a subset of central fatigue, occurs due to a suboptimal output from the motor cortex and can be measured using transcranial magnetic stimulation (TMS; Gandevia, 2001, Phys Rev. 81:1725 -1789).
- The ability to maximally reproduce short sprints (<10 s) with incomplete recovery (<60 s) is an important component of performance in intermittent sports.
- An inevitable consequence of repeated maximal efforts is fatigue of the exercising musculature which manifests as a reduction in exercise performance and mechanical output.
- Peripheral mechanisms of fatigue predominantly limit performance of repeated-sprint running and cycling, but central fatigue is also prominent (Girard et al., 2013, PLoS One. 8:6179; Racinais et al., 2007, Med Sci Sports Exer. 39:268-274).
- However, the kinetics of neuromuscular fatigue during and prominence of supraspinal mechanisms of fatigue following repeated sprint running have not been investigated.

Thus, our aim was to investigate the pattern of neuromuscular fatigue that manifests during repeated sprint running exercise.

Methods
- Twelve male participants (mean ± SD age, 25 ± 6 yr; stature, 180 ± 7 cm; body mass, 77 ± 7 kg), currently training and competing in intermittent sprint sports, performed a repeated maximal sprint running protocol (12 × 30 m, 30 s rest periods).
- Pre- and post-exercise twitch responses to transcutaneous motor point stimulation and TMS were obtained to assess knee extensor neuromuscular and corticospinal function, respectively.
- Throughout the protocol, during alternate rest periods, blood lactate samples were taken and a single knee extensor maximal voluntary contraction (MVC) of the knee extensors was performed, with motor point stimulation delivered during and 2 s following, to determine voluntary activation (VA) and peripheral fatigue (Figure 1).

Results
- The repeated-sprint protocol induced significant increases in sprint time and blood [lactate] from the third sprint onwards (P < 0.001) (Figure 2). Furthermore, knee extensor MVC, resting twitch amplitude and VA were all significantly reduced after two sprints, and reached their nadir after sprint ten (Δ12%, Δ24%, Δ8%, P < 0.01, respectively). In line with a reduction in motor point derived VA, there was also a reduction in VA measured with TMS (Δ9%, P < 0.05) immediately post-exercise (Figure 3).

![Figure 1. The Experimental Protocol. Participants sprinted down to the bottom end of the track (A), here during the 30 s rest period blood samples were taken (B), participants then sprinted back up the track (C) and during the subsequent 30 s rest period neuromuscular fatigue was measured.](image1)

![Figure 2. Sprint time (A) and blood lactate concentration (B) during the repeated sprint protocol. * = P < 0.05 vs. sprint 1 (panel A) or pre (panel B). Values are means ± SD for 12 participants.](image2)

![Figure 3. Maximum voluntary contraction (A), quadriceps twitch force (B) and voluntary activation (VA; open bars, panel c) pre, during and immediately post the protocol. Data for voluntary activation measured using TMS (VA_{TMS}; closed bars, panel c) is shown pre and immediately post the repeated sprint protocol. * = P < 0.05 vs. the pre-exercise value. Values are means ± SEM for 12 participants.](image3)

Peripheral, central and supraspinal factors all contribute to the performance decrement and fatigue of the knee extensors following maximal, repeated-sprint activity.