ONLINE SUPPLEMENT

Technical Considerations

Surface Quadriceps Integrated EMG. We observed that the change in EMG of the vastus lateralis muscle during the time trial generally followed those in power output, both with increasing distance covered and with alterations in C_aO_2. Thus, with each increment in C_aO_2 group mean iEMG increased significantly and individually all eight subjects showed a higher iEMG throughout most of the time trial in hyperoxia vs. hypoxia. Separate studies of EMG measurements during incremental submaximal exercise (N = 5) showed that a significant 14 ± 6% increase in EMG corresponded to a 25 W increment in work rate and at a constant work load, changes in pedal frequency of 20 rev min^{-1} (90 – 110 rev min^{-1}) caused only a 7% change in EMG. However, we also caution that there are several potential problems with the accuracy of surface EMG measurements, including amplitude cancellation which may attenuate changes in motor unit activity (Keenan *et al.*, 2005) and the fact that we obtained EMG measurements from only one of the several limb locomotor muscles potentially responsible for variations in total power output. Accordingly, we believe that the observed changes in EMG of the vastus lateralis with ΔC_aO_2 permit the qualitative conclusion that changes in locomotor muscle power output were in a similar direction to those in central neural locomotor output, but we cannot quantify the proportion of the observed changes in force output attributable to changes in central neural drive.

Underestimation of Fatigue. Repeated contractions during cycling increases the threshold of motor axons due to activity-dependent hyperpolarization, which reduces the population of axons excited by the same stimulus intensity after vs. before exercise, even in the face of a slight increase in M-wave amplitude (Vagg *et al.*, 1998). Since mean power output and exercise duration were different between the time trials, the diverse trials might have caused various degrees of activity-dependent hyperpolarization and consequently might have affected the levels of measured quadriceps fatigue.

Temperature. Substantial variations from resting core/muscle temperature have been shown to affect twitch forces, within twitch responses, and neural processes (Davies & Young, 1983; Ranatunga *et al.*, 1987; Montgomery & Macdonald, 1990; Bigland-Ritchie *et al.*, 1992) as well as exercise performance (Nielsen *et al.*, 1993; Gonzalez-Alonso *et al.*, 1999; Walters *et al.*, 2000; Nybo & Nielsen, 2001) and the development of central fatigue during isometric exercise (Nybo & Nielsen, 2001; Todd *et al.*, 2005). Eosophageal temperature increased from rest (37°C) to end-exercise in all time trials (2.1 to 2.7°C; Table 1) which, if reflected in similar increases in muscle and brain temperature (Saltin & Hermansen, 1966; Jiang *et al.*, 1991), might have affected some of the aforementioned fatigue-related variables. On the other hand, the differences in oesophageal temperature between the hypoxic and hyperoxic time trial were only in the range of 0.4 to 0.7°C and therefore were unlikely to exert a significant (additional) influence on performance and fatigue at varying C_aO_2s.

Potentiation. Activity-dependent muscle potentiation, affected by prior contractile activity, has been shown to enhance the contractile responses of skeletal muscle. Therefore, the coexistence of potentiation and fatigue – with one enhancing and one decreasing muscle performance – might attenuate the level of fatigue assessed immediately following exercise (Rassier & Macintosh, 2000). Various exercise trials in this study, characterized by significantly different levels of muscular performance, could have induced diverse degrees of activity-dependent potentiation and thus might have affected ΔQ_{tw}. To circumvent this problem we determined the pre- to post-exercise changes in the 1 Hz potentiated twitch (Kufel *et al.*, 2002). Using this approach we found that the comparison of various post-exercise reductions in potentiated twitch force revealed the same results as the unpotentiated stimulation frequencies (1-100 Hz), indicating that activity-dependent muscle potentiation did not significantly affect twitch responses.

REFERENCES

BIGLAND-RITCHIE, B., THOMAS, C. K., RICE, C. L., HOWARTH, J. V. & WOODS, J. J. (1992). Muscle temperature, contractile speed, and motoneuron firing rates during human voluntary contractions. *J Appl Physiol* **73,** 2457-2461.

DAVIES, C. T. & YOUNG, K. (1983). Effect of temperature on the contractile properties and muscle power of triceps surae in humans. *J Appl Physiol* **55,** 191-195.

GONZALEZ-ALONSO, J., TELLER, C., ANDERSEN, S. L., JENSEN, F. B., HYLDIG, T. & NIELSEN, B. (1999). Influence of body temperature on the development of fatigue during prolonged exercise in the heat. *J Appl Physiol* **86,** 1032-1039.

JIANG, J. Y., LYETH, B. G., CLIFTON, G. L., JENKINS, L. W., HAMM, R. J. & HAYES, R. L. (1991). Relationship between body and brain temperature in traumatically brain-injured rodents. *J Neurosurg* **74,** 492-496.

KEENAN, K. G., FARINA, D., MALUF, K. S., MERLETTI, R. & ENOKA, R. M. (2005). Influence of amplitude cancellation on the simulated surface electromyogram. *J Appl Physiol* **98,** 120-131.

KUFEL, T. J., PINEDA, L. A. & MADOR, M. J. (2002). Comparison of potentiated and unpotentiated twitches as an index of muscle fatigue. *Muscle Nerve* **25,** 438-444.

MONTGOMERY, J. C. & MACDONALD, J. A. (1990). Effects of temperature on nervous system: implications for behavioral performance. *Am J Physiol* **259,** R191-196.

NIELSEN, B., HALES, J. R., STRANGE, S., CHRISTENSEN, N. J., WARBERG, J. & SALTIN, B. (1993). Human circulatory and thermoregulatory adaptations with heat acclimation and exercise in a hot, dry environment. *J Physiol* **460,** 467-485.

NYBO, L. & NIELSEN, B. (2001). Hyperthermia and central fatigue during prolonged exercise in humans. *J Appl Physiol* **91,** 1055-1060.

RANATUNGA, K. W., SHARPE, B. & TURNBULL, B. (1987). Contractions of a human skeletal muscle at different temperatures. *J Physiol* **390,** 383-395.

RASSIER, D. E. & MACINTOSH, B. R. (2000). Coexistence of potentiation and fatigue in skeletal muscle. *Braz J Med Biol Res* **33,** 499-508.

SALTIN, B. & HERMANSEN, L. (1966). Esophageal, rectal, and muscle temperature during exercise. *J Appl Physiol* **21,** 1757-1762.

TODD, G., BUTLER, J. E., TAYLOR, J. L. & GANDEVIA, S. C. (2005). Hyperthermia: a failure of the motor cortex and the muscle. 10.1113/jphysiol.2004.077115. *J Physiol (Lond)* **563,** 621-631.

VAGG, R., MOGYOROS, I., KIERNAN, M. C. & BURKE, D. (1998). Activity-dependent hyperpolarization of human motor axons produced by natural activity. *J Physiol* **507 (Pt 3),** 919-925.

WALTERS, T. J., RYAN, K. L., TATE, L. M. & MASON, P. A. (2000). Exercise in the heat is limited by a critical internal temperature. *J Appl Physiol* **89,** 799-806.