THE EFFECT OF CIRCADIAN RHYTHMS ON OXYGEN UPTAKE KINETICS DURING TREADMILL RUNNING

The physiological responses during exercise are affected by circadian rhythms. In particular, effects have been observed in core temperature and ventilation (Reilly 1982, *British Journal of Sports Medicine*, **16**: 115-116). It has been suggested that the rhythm in $\dot{V}O_2$ observable at rest, with an acrophase of early afternoon, gradually diminishes as exercise intensity increases (Reilly and Brooks 1990, *Chronobiology International*, **7**: 59 – 67). Whilst the steady state pulmonary oxygen uptake ($\dot{V}O_2$) has been investigated previously, the effect that time of day may have on the $\dot{V}O_2$ kinetics in the transition from rest to moderate and heavy intensity exercise has not been verified.

Nine subjects (mean ± S.D: age, 24.9 ± 7.6 years; mass, 70.2 ± 4.7 kg; $\dot{V}O_2$ max, 59.6 ± 5.4 mL.kg^{-1}.min^{-1}) completed a treadmill test to determine ventilatory threshold (VT) and $\dot{V}O_2$ max. Subjects returned to the laboratory on six occasions; twice at 6am, 12pm, and 6pm. During each visit, subjects performed three 'square-wave' rest-to-exercise transitions of 6-min duration: two at a running speed calculated to require 80 % of the $\dot{V}O_2$ at VT (moderate exercise) and one at 50% of the difference between the $\dot{V}O_2$ at VT and $\dot{V}O_2$ max (50% Δ; heavy exercise). For each time of day, data from four moderate, and two heavy exercise rest to exercise transitions were accumulated. Pulmonary gas exchange was measured breath-by-breath, interpolated to provide one value per second and averaged across trials for each of the subjects. The $\dot{V}O_2$ response was fitted with either two (moderate exercise) or three (heavy exercise) exponential terms using non-linear regression techniques (Carter and Jones, 1999, *Journal of Physiology*, **518P**: 98-99). Core temperature, via rectal thermometry, and heart rate were measured throughout exercise, and the difference in blood lactate concentration from pre- to post-exercise (Δ [lac]) was determined. Data were averaged across trials. One-way repeated measures ANOVA were used to test for differences between the conditions with significance accepted at $P<0.05$. Results are presented as mean ± S.E.M.

Resting core temperature was found to be significantly lower at 6am than at the 12pm and 6pm (36.9 ± 0.2°C, 37.4 ± 0.1°C, and 37.4 ± 0.1°C respectively, $P<0.05$). There were no differences in the time based parameters of $\dot{V}O_2$ kinetics during moderate or heavy exercise. The time course of the $\dot{V}O_2$ primary component (τ_1) stayed the same across the three conditions for both moderate (16.6 ± 2.1s at 6am, 17.1 ± 1.9s at 12pm, and 20.5 ± 3.8s at 6pm) and heavy exercise (20.1 ± 0.9s at 6am, 18.6 ± 0.9s at 12pm, 20.1 ± 0.6s at 6pm). In moderate exercise, the amplitude of the primary component (A_1') was independent of the time of day (1943 ± 83 mL.min^{-1} at 6am, 1948 ± 84 mL.min^{-1} at 12pm, 1951 ± 90 mL.min^{-1} at 6pm). However, in heavy exercise, A_1' was significantly lower during the 12pm trial (2859 ± 142 mL.min^{-1} compared to 2955 ±135 mL.min^{-1} at 6am and 2937 ± 137 mL.min^{-1} at 6pm, $P<0.05$). Due to a non-significant tendency (P = *.**) for the size of the $\dot{V}O_2$ slow component (A_2') to be higher at 12pm (206 ± 37 mL.min^{-1} compared to 185 ± 27 mL.min^{-1} at 6am and 175 ± 40 mL.min^{-1} at 6pm) the gross $\dot{V}O_2$ at the end of heavy exercise was not different (3140 ± 131 mL.min^{-1} at 6am, 3066 ± 131 mL.min^{-1} at 12pm, 3112 ± 119 mL.min^{-1} at 6pm). There were no differences with time of day for end exercise heart rate, end exercise $\dot{V}_E$ or Δ [lac] during moderate and heavy exercise.

The results of this study indicate that the time of day does not greatly affect the $\dot{V}O_2$ kinetics observed in moderate and heavy intensity exercise. The slightly lower amplitude of the primary component at 12pm may suggest an improvement in running economy at this time of day.