Oxygen availability and fuel utilisation during intermittent exercise

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In continuous exercise fat oxidation is lower and carbohydrate oxidation is higher in both relative and absolute terms at high (85% VO_{2max}) compared to moderate (65% VO_{2max}) exercise intensity. Sahlin (1) implicated increases in lactate, pyruvate and declining O_2 availability as potential mediators of this effect. Such suggestions are confounded by differences in circulating catecholamines and muscle fibre type activation between the two exercise intensities. Increased work and recovery duration at the same exercise intensity during intermittent exercise (IE) results in higher muscle lactate (4). Using this principle we compared fuel oxidation during two protocols of IE performed under steady state conditions and at identical exercise intensity. Near-infrared spectroscopy (NIR) was used to monitor changes in muscle O_2 availability during IE.

Subjects (n=7) completed 40 min of IE on two occasions. The IE involved running on a motorised treadmill (individual subject range 18-24 km.hr-1; 0 % grade) with a work : recovery cycle of either 6 s : 9 s or 24 s : 36 s. Arterialised capillary blood was obtained at 10 min intervals. Capillary plasma was analysed for lactate, pyruvate and NEFA. Blood samples (10 ml) were collected by venepuncture pre- and post-exercise for plasma catecholamine determination. Expired gas was collected in Douglas bags and analysed for fractions of O_2 and CO_2. Carbohydrate and fat oxidation were estimated by indirect calorimetry. A RunMan® NIR spectroscopy unit (NIM, Philadelphia, Pa) was used to non-invasively monitor changes in haemoglobin saturation of the vastis lateralis during IE.

Measurement	Protocol		P value
	6s : 9s[1]	24s : 36s[1]	
VO_2 (l.min-1)	3.02 ± 0.10	2.79 ± 0.13	P=0.051
Respiratory exchange ratio	0.88 ± 0.02	0.96 ± 0.02	P<0.001
Carbohydrate (moles.ATP.min-1)	0.47 ± 0.05	0.67 ± 0.06	P<0.01
Fat (moles.ATP.min-1)	0.31 ± 0.03	0.10 ± 0.04	P<0.001
Lactate (mM)	3.30 ± 0.73	5.40 ± 1.27	P<0.05
Pyruvate (μM)	147 ± 31	219 ± 41	P<0.05
NEFA (μM)[2]	1202 ± 319	823 ± 143	P=0.315
Nor Adrenaline (mM)[2]	10.95 ± 1.87	11.15 ± 1.53	P=0.906
Adrenaline (mM)[2]	1.03 ± 0.35	1.40 ± 0.15	P=0.282
Nadir %Hgb saturation	60.33 ± 4.71	48.85 ± 6.88	P<0.05

[1] mean ± sem for final measurement, [2] n=4

Despite similar VO_2 and catecholamine responses, 24 s work : 36 s recovery resulted in 42% higher carbohydrate and 67% lower fat oxidation compared to 6 s : 9 s. Diminished muscle O_2 saturation and higher plasma lactate and pyruvate concentrations were observed during the 24 s : 36 s protocol.

Although plasma NEFA tended to be lower during 24 s : 36 s, reduced availability of NEFA is unlikely to account for the decline in fat oxidation. We hypothesise that limited muscle O_2 availability during 24 s : 36 s results in elevated muscle lactate and pyruvate concentrations which in turn are linked to the suppression of fat oxidation.

1. Sahlin K. Muscle carnitine metabolism during incremental dynamic exercise in humans. Acta Physiol Scand 1990;138:259-262.
2. Åstrand I, Åstrand P-O, Christensen EH, Hedman R. Myohaemoglobin as an oxygen store in man. Acta Physiol Scand 1960b;48:454-460.