Hyperaemic responses to forearm exercise

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The hyperaemic response to exercise commences within seconds of the onset of exercise, and reaches a steady-state level after several minutes of constant workload. Although a variety of mechanisms appear to be involved, the interplay between these mechanisms is complex and not fully understood.

Eight seated healthy adult male subjects (21.5 ± 0.9 years of age) performed single 1 s forearm contractions, as well as 2 minutes of rhythmic exercise consisting of forty 1 s forearm contractions with each contraction followed by a 2 s period of rest. Contractions were made by the dominant forearm at 20 and 40% of the maximum strength. Forearm blood velocity was measured with a transcutaneous ultrasound Doppler blood velocity probe placed over the distal brachial artery in the antecubital fossa. Doppler forearm blood velocity signals were averaged over entire cardiac cycles and expressed as changes above baseline levels. The blood velocity response from a single 1 s contraction was added to itself every 3 s over 2 minutes to obtain a theoretical forearm blood velocity response to rhythmic forearm contractions. This response was compared with the blood velocity response measured during 2 minutes of rhythmic forearm exercise at equivalent levels of contraction force.

The hyperaemic response to single 1 s forearm contractions lasted 6.8 ± 2.0 and 7.4 ± 2.5 s respectively for 20 and 40% maximum contractions. The peak change in forearm blood velocity measured during 2 minutes of rhythmic forearm contractions corresponded closely to theoretical values calculated from single 1 s forearm contractions (11.9 ± 5.3 and 11.9 ± 6.7 cm/s respectively at 20% maximum contractions, 17.7 ± 11.5 and 17.8 ± 7.1 cm/s respectively at 40% maximum contractions; both $p > 0.95$ with paired Students t tests). Forearm blood velocity during rhythmic exercise did not always reach a steady-state plateau during the 2 minutes of rhythmic exercise, and reached 80% of the steady-state theoretical plateau more slowly than predicted from the hyperaemic response to a single contraction (52.8 ± 29.1 and 9.8 ± 8.3 s at 20% maximum contractions, 29.2 ± 16.0 and 8.5 ± 3.2 s at 40% maximum contractions; both $p < 0.005$ with paired Students t tests).

The results suggest that a rapidly acting hyperaemic response is initially sufficiently potent to fully match increased metabolic demand during rhythmic forearm exercise. However, precise matching between blood flow and metabolic demand by the rapidly acting hyperaemic response theoretically occurs sooner than is actually observed during rhythmic exercise. We speculate that the rapid hyperaemic response diminishes in potency with repeated forearm contractions and that slower onset autoregulatory mechanisms are then brought into play to precisely match increased metabolic demand.