HIGHER CENTRES MAY ENCODE CARDIORESPIRATORY RESPONSES TO EXERCISE WITHOUT MOVEMENT FEEDBACK IN HUMANS


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INTRODUCTION

How humans can match the cardiorespiratory responses to the increase in metabolic rate of exercise has proved difficult to unravel. We have used Positron Emission Tomography (PET) to identify the neuroanatomical correlates underlying ‘central command’ during imagination of exercise under hypnosis whilst at rest, in order to uncouple ‘central command’ from peripheral feedback.

METHODS

Experimentally naive and athletically untrained subjects were familiarised with leg exercise ergometry in the semi-reclined position (Figure 1). On another day subjects were hypnotised on the scanning table, after which the head was positioned to minimise movement under laser beam alignment (Figure 2A-B). The positron emitting 15O in the form of 5mCi of H215O was given iv and breathing and HR were recorded.

Positron emission tomography

Three cognitive conditions were used: I, ‘imagination of cycle freewheeling downhill’ (no change in heart rate, HR, or ventilation, V̇E; II, ‘imagination of exercise’ cycling uphill (increased HR by 12% and V̇E by 30%), as a control for the actual exercise response; III, voluntarily-driven hyperventilation to match that achieved in II (no change in HR). We employed cognitive subtraction methodology to create two contrasts (A and B) in two separate studies with different subjects (n=4 for both; eight scans per subject). Contrast A (II minus I) highlighting cerebral areas involved in the imagination of exercise and Contrast B (III minus I) highlighting areas activated in the direct volitional control of breathing. End-tidal Pco2 was held constant throughout PET scanning. (n=4 for both; eight scans per subject).

RESULTS

The supplementary motor area (SMA), superolateral sensorimotor areas, the lateral sensorimotor areas and the cerebellum had activations in both Contrasts, whereas the right dorso-lateral prefrontal cortex, premotor area (PMA), left insula cortex, parietal association areas and the thalamus were activated in Contrast A alone. The SMA/PMA, cerebellum and the dorso-lateral prefrontal cortex are concerned with volitional/motor control, including that of the respiratory muscles, whereas the left insula cortex is concerned with vagal modulation of HR.

Table 1. Stereotactic coordinates (mm) in Talairach space of voxels maximally activated within sites; vessels are unit cubes of 2 mm side length, significant after correction for multiple comparisons (a) from SMV (b) 3D correlation between vocal activation and y, Z=-4: ; x, lateral to midline, we to right; y, anterior/posterior to anterior/posterior commissure, +ve anterior, z, superior/ inferior to anterior/posterior cranium, +ve superior.

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CONCLUSIONS

A significant component of the respiratory response to ‘exercise’, in the absence of both movement feedback and an increase in CO2 production, can be generated by what appears to be a behavioural response, given the identified neuroanatomical areas activated.

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