Intense aerobic training has no effect on BOLD-based brain functional imaging

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Introduction

The blood-oxygenation level-dependent (BOLD) effect commonly exploited for brain functional imaging (fMRI) depends on the local vascular response to neuronal activity. Therefore, variability of the observed fMRI responses between different subjects in response to a task might, in principle, arise in part from differences in vascular response rather than from differences in neural activity. For example, previous studies suggest that normal aging alters the brain hemodynamic response (1), perhaps by decreasing vascular compliance (2). Similarly, several studies have examined if commonly-used vasoactive substances such as caffeine (3) or nicotine (4) alter the fMRI response. It is well-known that aerobic exercise training profoundly improves systemic vascular fitness, and the vascular effects of aerobic training extend beyond the muscles recruited during the training. For example, regular leg exercise improves endothelium-dependent vasodilation in the arms of sedentary adult men (5). If the vascular effects of aerobic training extend to the cerebrovascular system, this might modify the hemodynamic response to neural activity, and contribute to between-subject variability in fMRI studies. Therefore, the purpose of this study was to examine if intense aerobic training influences the fMRI response to standard visual and motor tasks.

Methods

Eight trained male subjects (19-23 yrs old) were recruited from the University cross-country team. The study was performed after the spring track season, during which these subjects ran an average of 104±9 (SE) km/week. Seven sedentary male subjects (20-30 yrs old) were recruited from the University community. Subjects lay supine in a GE 3T Excite system (GE Medical Systems, Milwaukee, WI), and single-shot echo-planar images (TR 2000, TE 30 ms, 64x64 matrix, 22 cm field-of-view, 4 mm slice, 27-31 slices) were continuously acquired via an 8 channel head coil during two tasks: visual stimulation (50 s rest, 10 s square checkerboard pattern alternating at 8 Hz), and motor stimulation (50 s rest, 10 s finger tapping in the pattern 1324 with the dominant hand). During the rest periods of both tasks the subjects were instructed to focus on a small cross-hair centered in the blank screen of the visual display system (IFIS-SA, In-Vivo, Orlando, FL). Both tasks were repeated through 5 cycles with a final 50 s rest period (total 350 s or 175 images per slice). A high resolution (Fast GRE, TR 4.4, TE 1.1, TI 450) anatomical scan was acquired after the functional data. Active pixels were identified by cross-correlation with a set of idealized waveforms using the AFNI analysis package (6).

Results and Conclusion

Figure 1 shows representative activation maps (r>0.6) from one subject during the visual (top row) and motor tasks (bottom row). As expected from many previous fMRI studies of these tasks, clusters of highly-correlated voxels were identified in the primary visual, and in the contralateral motor and somatosensory areas, respectively. Similar patterns of activation occurred in all subjects. There was no significant difference between groups in either the number of active voxels, or in the percent signal change within those voxels, at any statistical stringency setting, for either task. As shown in Figure 2, there was also no difference between groups in the time course of the signal changes (mean ± SE, n=7-8) within a cluster of the 20 highest-correlated voxels in response to the visual (top) or motor (bottom) stimulation. The results show that intense aerobic training has no significant effect on the hemodynamic response to neural activity in young male subjects. Therefore, it is not likely that differences in the aerobic fitness of subjects significantly contribute to the between-subject variance of most brain fMRI studies.

References

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FIGURE 1.

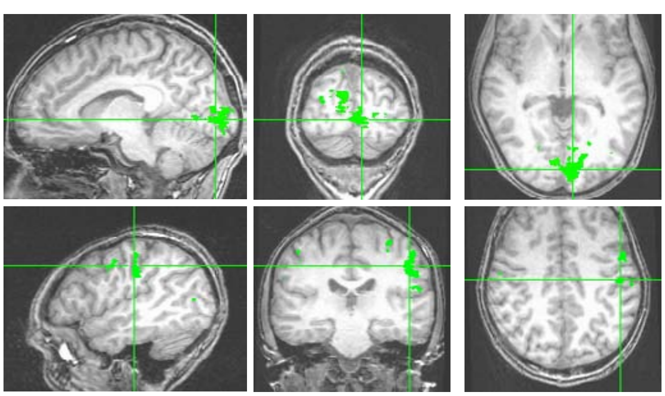

FIGURE 2.