A high fat meal has no direct effect on the brain BOLD response in young adults

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Introduction

It is well known that the blood oxygen level-dependent (BOLD) response used in functional MRI relies on the hemodynamic response associated with neuronal activity (1). A portion of the variability in brain BOLD response may therefore be attributed to factors that influence brain blood flow or oxygen uptake. For example, caffeine, a potent vasoconstrictor, has been shown to result in reduced resting blood flow and therefore to enhance BOLD responses to stimuli (2). Dietary factors such as fat composition may also influence the hemodynamic response by altering vascular function (3,4). Recently, Noseworthy et al. (5) reported that BOLD responses during a motor task of finger tapping were remarkably diminished following the ingestion of a liquid meal high in fat. The 50% reduction in brain BOLD response (5) was suggested to be caused by the postprandial elevation in blood triglycerides, although triglycerides were not measured. In the current study, the effects of a high fat liquid meal on blood triglycerides, task performance and the brain BOLD response were evaluated during three common fMRI tasks (motor, visual and addition).

Methods

Eight healthy adults (19-30 yrs old) participated in two sessions. Each session included measuring fasting and postprandial blood triglycerides, ingestion of either a high carbohydrate "Control" meal or a high fat "Lipid" meal, and an MRI before (pre) and approximately 210 minutes after (post) meal ingestion. Postprandial blood triglycerides were measured at 90, 180 and 240 minutes. These are the identical meals used by Noseworthy et al (5). The Control meal consisted of 235 ml Ensure Plus [Abbot Labs]; total calories: 350, 57% carbohydrates, 28% fat (2 g saturated, 5 g monounsaturated, 5 g polyunsaturated). The Lipid meal consisted of Ensure Plus with 50 ml added canola oil; total calories: 765, 26% carbohydrates, 67% fat (5 g saturated, 22 g monounsaturated, 30 g polyunsaturated). During the MRI, subjects were supine in a GE 3T Excite System and axial, single-shot gradient-recalled echo-planar images were acquired continuously throughout each functional paradigm using an 8-channel head coil (27-33 slices, 4.5 mm slice thickness, 0.5 mm slice gap, 22 cm field-of-view, 64 x 64 matrix, TR 2 s, TE 30 ms, 90° flip angle). The block-design paradigms included a motor task (30 s bilateral bulb squeezing at 2 Hz followed by 30 s rest), a visual task (10 s flashing checkerboard at 8 Hz followed by 50 s rest), and an integrative/addition task (30 s of serial addition followed by 30 s rest). Tapping rate during bulb squeezing (motor task) and sum totals (addition task) were recorded. Anatomical T1-weighted images (sagittal 3D inversion-prepped fast spoiled gradient-recalled-echo images, 256 x 192 acquisition matrix, 1 mm slice, 22 x 22 x 17.4 cm FOV, TR 2 s, TE 1.5 ms, TI 450 ms, 15° flip angle) were acquired at the end of each imaging session. The functional images were temporally cross-correlated against a boxcar wave form using AFNI software (6). Fixed-location clusters of activated voxels were quantified and the average time course and magnitude of the BOLD response were analyzed in each condition. Repeated measures ANOVA was used to detect differences in blood triglycerides, number of active voxels and the magnitude of the BOLD response over time and condition. Data are reported and displayed as mean ± SE.

Results and Conclusion

Postprandial (180 minutes) blood triglycerides were 33% higher after the Lipid meal (100±13 mg/dL) compared to the Control meal (76±8 mg/dL). Tapping rate during the motor task averaged 2.1(0.3) Hz and was not different in any of the four trials, eliminating any potential influence of tapping rate differences on motor cortex activation. There were also no differences in addition performance. There was no significant effect of meal composition on the number of active voxels in any task (shown in Figure 1). In all paradigms, there were also no differences in the time course or the magnitude of the BOLD response between meal types (motor response shown in Figure 2). The results indicate that moderately increased blood triglycerides attained by ingesting a high fat meal with predominantly unsaturated fat do not directly alter the hemodynamic BOLD response to neural activity in young, healthy adults. However, this does not rule out the potential effects of higher postprandial lipids on the BOLD response that may occur in response to meals with different nutrient composition, or in individuals with higher blood triglycerides, hypertriglyceridemia or impaired vascular function. Supported by the Honors College and the Radiology Department at Michigan State University.

References

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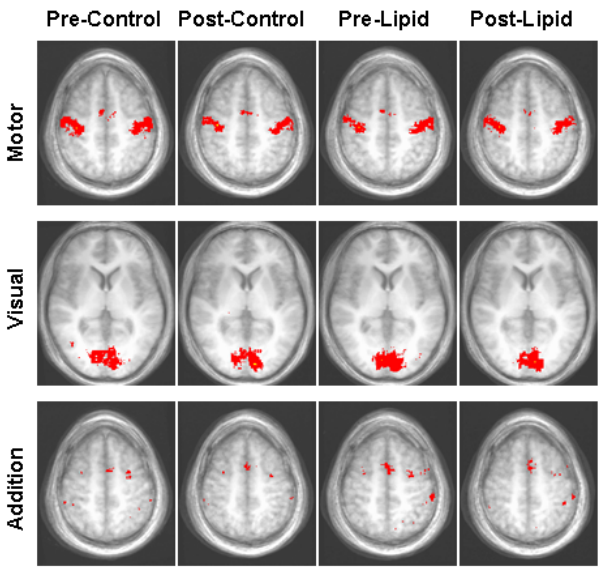

FIGURE 1: BOLD activation maps before (pre) and after (post) ingestion of Control (Ensure) and Lipid (Ensure with added canola oil) meals during three tasks (motor, visual, addition).

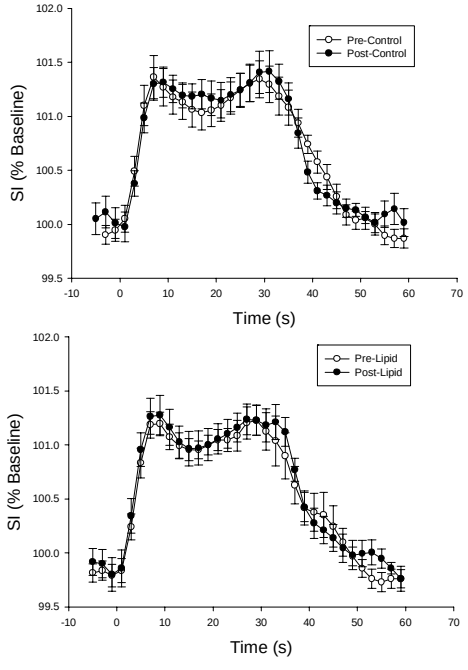

FIGURE 2: The magnitude and time course of the BOLD response in the sensorimotor cortex during bilateral finger tapping before (open circles) and after (closed circles) the Control meal (top) and the Lipid meal (bottom). Data plotted as mean ± SE.