Brief Communication: Effects of Soy-Protein Diet on Elevated Brain Lipid Peroxide Levels Induced by Simulated Weightlessness

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Abstract. The influence of soy-protein diet on brain lipid peroxidation in female rats was studied using a tail-suspension model of weightlessness. The study tested the efficacy of diets containing 0% or 11.1% soy-protein in 4 groups of female Sprague Dawley rats that were maintained with or without tail-suspension for a period of 3 weeks. At term, the whole brain was removed, segmented, and analyzed for malondialdehyde (MDA) as an index of lipid peroxidation. Brain levels of MDA were significantly higher in both tail-suspended groups than in the non-suspended control groups on the same diet, (p< 0.05). The high soy-protein diet decreased MDA levels significantly, compared to the 0% soy-protein groups (p <0.05). Furthermore, MDA levels were significantly lower in the tail-suspended group on high soy-protein diet, compared to the corresponding 0% soy-protein group. In conjunction with previous findings in male rats, these data indicate that tail-suspension increases brain MDA levels in rats regardless of gender, and that a diet rich in soy-protein decreases the brain MDA level in both the non-suspended and tail-suspended groups. These observations imply that the soy-protein diet has a protective antioxidant effect during both the basal condition and the stressful condition. (received 2 August 2003; accepted 22 October 2003)

Keywords: tail-suspension, simulated weightlessness, lipid peroxidation, soy-protein diet, malondialdehyde

Introduction

Rat tail-suspension is a valid experimental model of simulated microgravity that mimics weightlessness [1-4]; tail-suspension enhances stress and affects physiological functions in many organ systems [5-8]. In a previous study in male rats, we showed (a) that tail-suspension enhanced the formation of lipid peroxidation products in brain tissue, compared to non-suspended controls, and (b) that diets rich in soy-protein reduce the brain levels of lipid peroxidation products in the basal state [9]. The current study extends these observations to female rats and investigates the effect of soy-protein diet on lipid peroxidation products in rat brain during the basal state and also following tail-suspension to simulate microgravity.

Materials and Methods

Female Sprague-Dawley rats (n = 24) were divided into 4 groups of 6 rats: (a) controls without soy-protein diet, (b) tail-suspended without soy-protein diet, (c) controls with soy-protein diet, and (d) tail-suspended with soy-protein diet. Groups b and d were tail-suspended at an angle of 30° in a room maintained at 23°C and a 12 hr/12 hr light/dark cycle. Groups a and b were fed Purina Chow containing 0% soy-protein; groups c and d were fed the same diet containing 11.1% soy-protein. The diet (from Test Diet, Inc., Richmond, IN) was casein-based (5K96), with calories provided by 22% protein, 11.4% fat, and 66.6% carbohydrate. The rats were maintained on the diets for 3 weeks, with or without tail-suspension. Body weight, food intake, and fluid intake were monitored daily.

At term, the animals were fasted overnight, anesthetized, and sacrificed by exsanguination. The whole brain was removed and segmented into the
frontal cortex, cerebellum, and brain stem; these sections were immediately frozen in liquid nitrogen. Upon thawing, the brain pieces were weighed and placed in a solution containing 10 µL of butylated hydroxytolune (20 mM) to avoid further oxidation. The samples were individually homogenized and centrifuged (10 min, 7,000 x g, 4°C). The supernatants were analyzed for malondialdehyde (MDA) using the Bioxytech LPO-586 lipid peroxidation assay kit (R & D Systems, Minneapolis, MN).

Results were expressed as means ± SE and analyzed by one-way ANOVA. A p value <0.05 was considered statistically significant.

Results

After the initial 48 hr of suspension, food and water intake of the non-suspended and tail-suspended groups did not differ significantly. No difference in body weight gain was noted between the control and corresponding soy-protein group, although significant reduction in body weight occurred in both tail-suspended groups regardless of diet. The body weight shift that occurred with tail-suspension was consistent with our previous data [10,11].

MDA levels in the segmented rat brain extracts from the 4 groups are shown in Fig. 1. Levels of MDA were significantly higher in the tail-suspended groups than in corresponding non-suspended groups on the same diet (p <0.05). The soy-protein diet (11.1% soy-protein) significantly reduced the brain MDA levels compared to the corresponding 0% soy-protein diet groups. The brain MDA levels were lowest in the non-suspended soy-protein diet group; they were significantly lower than the 0% soy-protein diet non-suspended group and the 0% soy-protein diet tail-suspended groups, respectively (p < 0.05). Identical patterns of MDA levels were observed in brain stem, cerebellum, and cerebrum.

Discussion

This study in female rats extends our previous findings in which male rats were used to evaluate the effect of diets with different concentrations of soy-protein [9]. In this study, we used diets containing 0% soy-protein and 11.1% soy-protein on MDA, an index of lipid peroxidation, using the same tail-suspension rat model of weightlessness as the previous study. The MDA level was significantly increased in the brain tissues of tail-suspended rats compared to non-suspended rats. Such findings have been corroborated by other investigators using varied models of stress [12,13]. It is surmised that tail-suspension induces a centrally activated cellular stress response.

Our current investigation demonstrates that the stress induced by the rat tail-suspension model is associated with a “global” elevation of brain MDA levels. Further studies will evaluate the effects of diets containing varied levels of soy isoflavones on the elevated level of products of lipid peroxidation that develops in tail-suspended rats. The effects of soy-protein diets, with or without tail-suspension, on blood isoflavone levels will also be determined.

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References

8. Chowdhury P, Soulsby ME, Pasley JN. Influence of
Fig. 1. Effects of soy-protein diet and tail-suspension on MDA levels in rat brain extracts (mean ± SE).

* p<0.05, 0% soy-protein diet, non-suspended group vs 0% soy-protein diet, tail-suspended group;

** p<0.05, 0% soy-protein diet, non-suspended group vs 11.1% soy-protein diet, non-suspended group;

*** p< 0.05, 11.1% soy-protein diet non-suspended group vs 11.1% soy-protein diet tail-suspended group.