Moderate Intensity Resistance Exercise, 
Plus or Minus Soy Intake: Effects on Serum Lipid Peroxides in Young Adult Males

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Lipid peroxides can be both a product and an initiator of oxidant stress. Conceivably, exercise can either increase concentrations of lipid peroxides (by causing oxidant stress), or decrease them (by accelerating peroxide breakdown). The net effect could depend on exercise intensity and nutritional intake of antioxidants. The present study examined the response of serum lipid peroxides to the combination of moderate intensity, weight resistance exercise plus intake of soy protein, a source of antioxidant phytochemicals. Recreationally trained, young adult men (N = 18) consumed soy protein or antioxidant-poor whey protein for 4 weeks (40 g protein/d) before a session of moderate intensity, weight resistance exercise. In the soy group, exercise decreased values for serum lipid peroxides at 5 min, 3 h, and 24 h post-exercise. The whey group showed the depression only at 24 h. In both the soy and whey groups, a small rise was seen for interleukin-8, which is consistent with the idea that the exercise session induced a moderate muscle stress. In summary, a moderate intensity, weight resistance exercise session, despite inducing mild inflammation, depressed plasma serum peroxide values, especially when combined with 4 weeks of soy consumption.

Key Words: antioxidant, phytochemicals, dietary intervention

Introduction

Minimization of oxidant stress during exercise may have some practical value in delaying fatigue and lowering risk of muscle injury (2, 8, 9). Furthermore, oxidant stress due to some types of exercise may have long term, negative effects on health. In support of this concept, some athletes show increases in histochemical muscle lesions, unrelated to lactate accumulation, as well as high cancer mortality, which have been linked to prolonged periods of exercise (9, 21). In light of these issues, it would be useful to understand how exercise, especially in combination with variations in nutritional antioxidant intakes, affects processes relevant to oxidant stress. Much of the work done so far in this regard has included measures of concentrations
of lipid peroxides (i.e., 6, 7, 10, 13–19, 23). This is reasonable considering that lipid peroxides can be both products of oxidant stress as well as initiators of further oxidant stress (1, 11). In principle, exercise could both increase the production of lipid peroxides (by initiating oxidant stress; 2, 8, 9) and accelerate breakdown of peroxides, particularly during recovery, in part by altering enzyme activities related to glutathione metabolism (6, 7, 10, 14, 23). The net effect of exercise on values for lipid peroxides would depend on the balance between peroxide production and breakdown.

Studies on exercise and lipid peroxides have yielded highly variable results, with some showing increased values, some no change, and some finding an actual depression (6, 7, 10, 13–19, 23). Possibly, when depressed values are seen, exercise stimulation of peroxide breakdown exceeds stimulation of peroxide formation. Such a depression in concentration of lipid peroxides may sometimes be useful for delaying fatigue during exercise and for long range prevention of disease. However, it remains uncertain as to how to consistently produce this effect.

Possibly, the most likely circumstances for exercise-induced depressions in concentrations of lipid peroxides involve acute, moderate intensity, aerobic or weight resistance exercise. In support of this assertion, one study (15) reports decreased plasma values for lipid peroxides with moderate to low intensity aerobic exercise but increased values with higher intensity exercise. In another study, exercise classified as sub-maximal lowers platelet concentrations of lipid peroxides (10). However, not all studies see this depression with moderate intensity or sub-maximal exercise, but instead find increases (6, 7). Therefore, factors other than exercise intensity alone may help promote exercise-induced depression in plasma concentrations of lipid peroxides.

One such factor could be intake of dietary antioxidants, which are capable of slowing formation of lipid peroxides (1, 11). Such slowing of peroxide formation may sometimes tip the balance between peroxide formation and degradation so that the net content of peroxides decreases. The effects on peroxides by antioxidants such as vitamin E have been considered in exercise studies (18, 19). Vitamin E can lessen a rise in values for lipid peroxides after aerobic or weight resistance exercise (18, 19), but it has not been shown to produce an actual post-exercise depression in values. Perhaps, a mixture of antioxidants would be more apt to produce the depression. A mixture of antioxidants could exert more than one antioxidant action, plus a variety of agents may target a variety of molecular sites better than a single antioxidant.

The present study tested the hypothesis that values for serum lipid peroxides could drop following moderate intensity, weight resistance exercise in males who had regularly consumed antioxidant-rich soy protein isolate. Soy protein isolate was chosen because it contains a mixture of antioxidants, including isoflavones, saponins, and copper, a component of a number of antioxidant enzymes (4). In addition, a previous study shows that soy can exert antioxidant actions during exercise (22). Although that study used strenuous aerobic exercise and did not measure lipid peroxides, the study provides a basis that soy has exercise-relevant antioxidant actions. The present study used weight resistance exercise to extend, and not just repeat, previous work. Previous work claiming a post-exercise depression in values for lipid peroxides have all used aerobic exercise (10, 13, 15–17). This type of exercise involves a lot of mitochondrial respiration, which is one source of free
radicals (11). Therefore, this study sought to establish that a different form of exercise, with less mitochondrial respiration, could have the same effect.

**Methods**

**Subjects**

Participants in the study were males (N = 18), aged 18 to 25, recruited from the undergraduate and graduate student population at The Ohio State University in Columbus, Ohio. Exclusion criteria included smoking and consumption of soy more than once per week. Subjects were required to lead an active lifestyle that incorporated resistance training for at least the previous 6 months. Competitive lifters and athletes were excluded. Subjects who met these criteria were instructed to maintain their current lifestyle habits throughout the course of the study. This study was approved by the Human Subjects Review Committee for Biomedical Sciences at The Ohio State University. All subjects signed an informed consent form.

This study was double blinded and randomized. Subjects were given either SUPRO(R)SOY Isolated Soy Protein, part of the Solae™ brand from DuPont Protein Technologies (St. Louis, MO, USA) or the antioxidant-poor protein whey (39 g of protein per day for 4 weeks). The soy protein daily service contained 88 mg of naturally occurring total isoflavones (aglycone weight)/53 mg of genistein; or 151 mg total isoflavones (conjugated weight)/90 mg of genistein. Protein was consumed as a mixture with water and an approved flavoring containing neither protein nor antioxidants (generally artificial chocolate syrup provided to the subjects). Each subject was provided enough protein to complete the treatment period plus 3 extra servings. Anyone returning 5 servings above the extra protein would have been considered noncompliant, but this never occurred. Each subject completed a written, anonymous exit interview that included questions about compliance. During the 4 weeks of protein consumption, subjects kept a log of exercise activity. All subjects’ records showed regular weight resistance exercise with some resemblance to the study exercise session in terms of types of exercise and duration.

At least 14 h after the last consumption of the soy or whey product, subjects participated in a resistance training session supervised by study personnel. By this time, serum levels of antioxidant isoflavones should be close to baseline (12), which means any antioxidant effects should result mostly from long term soy effects. The regimen of this exercise session included the following: 3 sets of bench presses, 3 sets of machine lat-pull downs, 3 sets of machine military presses, and 3 sets of machine leg presses. Subjects were instructed to use a weight that they could lift for a maximum of 10 repetitions. Subjects were given a 60-s rest between each set, which made for a total exercise session of about 25 min. Blood samples were taken at four time intervals: pre-exercise, post-exercise (within 5 min), 3 h post-exercise, and 24 h post-exercise. Approximately 5 ml of blood was drawn into a tube lacking anticoagulant, which was then stored on ice and, within a short time, centrifuged at about 2,500 × g for 30 min at 8 °C. Serum supernatants were stored frozen at −80 °C.

**Assays and Statistical Analysis**

Lipid peroxides were assayed by a kit from Calbiochem-Novachem Inc. (San Diego, CA, USA) using the manufacturer’s instructions for assessing the combination
of malondialdehyde plus 4-hydroxy-2(E)-nonenal. This kit was evaluated favorably in a recent study (3). Interleukin-8 was assessed by an ELISA kit from R&D Systems (Minneapolis, MN, USA). Statistical analysis was done using the program called Jump from the SAS Institute in Cary, NC, USA (significance set at $p < .05$). A repeated measures ANOVA was used to test for the significance of the response of lipid peroxides or interleukin-8 to time in relation to the exercise. A two-way repeated measures ANOVA compared the soy versus the whey group as well as Time. Finally, least significant difference (LSD) analysis compared time points to each other.

**Results**

Subjects’ physical characteristics (age, height, weight, BMI) for the soy and whey groups are outlined in Table 1. No significant differences in the averages of the physical characteristics were observed between the two groups. Compliance was very good based on product return and anonymous exit interviews.

Based on repeated measures ANOVA, serum concentrations of lipid peroxides were reduced after a session of moderate intensity, weight resistance exercise (Figure 1). A two-way repeated measures ANOVA also showed a difference between protein groups. Further analysis by LSD indicated that this decrease in the soy group was significant at 5 min post exercise, as well as at 3 h and 24 h (Figure 1). For the whey group, only the 24-h time was significantly different from the pre-exercise value.

![Figure 1 — Plasma lipid peroxides before and after exercise, after 4 weeks of dietary consumption of whey or soy. Values are in $\mu$M and are expressed as means ±SEM. Data analyzed by repeated measures ANOVA, followed by LSD, showed significant effects ($p < .01$) for Time in relation to Exercise and Protein Treatment. *Significantly different from pre-exercise by LSD following repeated measures ANOVA ($p < .05$). Post-exercise time points were not significantly different from each other within the soy or whey groups.](image-url)
For serum concentrations of interleukin-8, a marker of inflammation that can be proportional to degree of exercise intensity (20), a two-way repeated measure ANOVA found a significant change for Time in relation to Exercise, but not for protein treatment. Further analysis by LSD found significance for a small, post-exercise increase in both protein groups (Figure 2). No significant effects occurred at 5 min or 3 h post-exercise. (Data not shown.)

Table 1  Physical Characteristics of Study Subjects

<table>
<thead>
<tr>
<th>Physical characteristics</th>
<th>Whey group</th>
<th>Soy group</th>
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</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>20.7 ± 1.9</td>
<td>21.8 ± 2.0</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>180.0 ± 8.2</td>
<td>180.7 ± 5.7</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>82.1 ± 8.5</td>
<td>81.1 ± 14.2</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>25.3 ± 2.1</td>
<td>25.6 ± 4.3</td>
</tr>
</tbody>
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*Note. Values are means ± SD.*

Figure 2 — Plasma interleukin-8 pre- and post-exercise, after 4 weeks of dietary consumption of whey or soy. Values are in pg/ml and are expressed as means ± SEM. Repeated measures, two-way ANOVA showed a significant effect ($p < .05$) for Time in relation to Exercise, but not for soy versus whey. LSD analysis found significance for the post-exercise time point (shown in figure), but not for 3 h or 24 h later. (Data not shown.)
Discussion

Previous work on the effects of acute exercise on lipid peroxides has yielded highly variable results (i.e., 6, 7, 10, 13–19, 23). The present study found that exercise could depress concentrations of lipid peroxides, an effect resembling that seen in some but not the majority of previous studies on exercise and lipid peroxides. In two ways, the present study differed from previous work that had seen a post-exercise depression in values for lipid peroxides. First, the other studies use aerobic exercise, and the present study considered weight resistance exercise. Second, for two of the three post-exercise time points examined, the exercise-induced depression in lipid peroxide values only occurred if combined with a dietary antioxidant intervention.

A reasonable question is: Why can exercise depress values for lipid peroxides in some situations but raise them or produce no change in others? This variation occurs not only between studies, but even within studies, including this one. Possibly, the likelihood of a depression in values depends on the combination of several factors including: exercise intensity, fitness level of the exercisers, subject history with the particular exercise session, previous antioxidant intake of the exercisers, and the specific lipid peroxides assay used. The last consideration cannot be the full explanation by itself. A single assay was used for the present study and a previous one (17), which examined three types of subjects and two types of exercise. Yet, within each of these studies, there are post exercise increases, post-exercise decreases, and cases of no change.

Regarding exercise intensity, most of the studies that report a depression in readings for lipid peroxides, including the present one, characterize the exercise as moderate or sub-maximal in intensity (10, 15, 16). The current study’s exercise session could be classified as moderate based on three considerations. First, the exercise session used here has far fewer exercises and sets versus those used by competitive athletes and bodybuilders. Second, in contrast to a previous study from our laboratory on exhaustive aerobic exercise (22), in the present study, no increase was seen immediately after exercise for either plasma myeloperoxidase or creatine kinase activities. (Data not shown.) Third, in the present study, the exercise session produced a very small increase in interleukin-8 values. These values reflect muscle inflammation and can be proportional to exercise intensity (20). The percent increase seen here would be consistent with a moderate muscle stress (20).

Fitness level may also be a factor, since one study reports getting a depression in values for lipid peroxides in trained but not untrained subjects (13). The present study examined recreationally trained subjects. The role of previous adaptation to a particular exercise session has not been tested directly. Nonetheless, it is noteworthy that the exercise session studied here was similar to what the subjects were used to doing.

Antioxidant intake was not characterized in the previous studies, showing an exercise-induced depression in values for lipid peroxides, nor was a general characterization done here. However, the subjects studied here were not users of antioxidant supplements, and the soy intervention represented a major addition of dietary antioxidants. Possibly high antioxidant intake may help with exercise-induced depression in values for lipid peroxides, though it may not be needed to see this depression for every circumstance. The 24-h time point of the present study could be one of those circumstances. The reason may have to do with considerations about peroxide formation and breakdown. As noted above, exercise could both stimulate
production of lipid peroxides (by initiating oxidant stress; 2, 8, 9) and promote breakdown of peroxides, possibly in part by altering enzyme activities related to glutathione metabolism (6, 7, 10, 14, 23). Possibly, at 5 min and 3 h post-exercise, soy antioxidant intake shifted the net effect on serum values for lipid peroxides downward by reducing the production of lipid peroxides. This contention is reasonable, since most antioxidant actions tend to reduce lipid peroxide production (11). At 24 h post-exercise, the formation of peroxides may have fallen back to a slow, pre-exercise rate, which would mean that any short term soy effects would be minimal.

Our laboratory has conducted an additional study (5), with similarities and differences to the presently reported work. This other study also involves soy versus whey, and moderate intensity weight resistance exercise, but focuses on women and employs multiple exercise sessions. In this female study, post-exercise values for lipid peroxides showed either increases, decreases, or no changes for different scenarios. Two key factors in producing the decreases seem to be soy intake and adaptation to the exercise. Decreased values for peroxides are only seen for the last exercise session and only with soy intake.

In summary, the present study showed that moderate intensity weight resistance exercise could depress concentrations of serum lipid peroxides, but the effect was influenced by time after exercise and dietary intake of soy.

References


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