Blood lipid and oxidative stress responses to soy protein with isoflavones and phytic acid in postmenopausal women¹–⁴

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ABSTRACT

Background: Postmenopausal women are at risk of cardiovascular disease (CVD) as a result of unfavorable blood lipid profiles and increased oxidative stress. Soy protein consumption may help protect against these risk factors.

Objective: Our objective was to ascertain the effect of the soy protein components isoflavones and phytate on CVD risk in postmenopausal women.

Design: In a double-blind 6-wk study, 55 postmenopausal women were randomly assigned to 1 of 4 treatments with soy protein (40 g/d) isolate (SPI): low phytate/low isoflavone (LP/LI); normal phytate/low isoflavone (NP/LI); or normal phytate/normal isoflavone (NP/NI). Blood lipids (total, LDL, and HDL cholesterol and triacylglycerol) and oxidative stress indexes (protein carbonyls, oxidized LDLs, and 8-iso-prostaglandin-F₂α) were measured at baseline and 6 wk.

Results: The oxidative stress indexes were not significantly affected by either phytate or isoflavones. Phytate treatment had a minimal but nonsignificant effect in reducing protein carbonyls and 8-iso-prostaglandin-F₂α; the reductions were 6–8% and 4–6% in the NP/LI and NP/NI groups and 1–4% and 3–4% in the LP/LI and LP/NI groups, respectively. Similarly, circulating lipids were not significantly affected by either phytate or isoflavones. The decline in total (6%–7% compared with 2%–4%) and LDL (10%–11% compared with 3%–7%) cholesterol did not differ significantly between the normal- and low-isoﬂavone groups, respectively.

Conclusion: In postmenopausal women, neither phytate nor isoflavones in SPI have a significant effect of reducing oxidative damage or favorably altering blood lipids. Am J Clin Nutr 2005;81:590–6.

KEY WORDS Postmenopausal women, oxidative stress, cardiovascular disease, soy protein, isoflavones, phytate, blood lipids

INTRODUCTION

Men are usually at higher risk than are women of developing cardiovascular disease (CVD). After menopause, the risk for women becomes similar to that for men. The postmenopausal lack of estrogen may be responsible for affecting antioxidant defenses, as well as lipid and lipoprotein concentrations (1), both of which are implicated in the pathogenesis of CVD (2, 3).

Soy protein consumption has been shown to significantly decrease serum concentrations of total and LDL cholesterol and triacylglycerols (4, 5). Many components associated with soy protein, eg, isoflavones (6), saponins (7), and β-conglycinin (7S globulin) protein fractions (8), are reported to have a lipid-lowering effect. Adding isoflavone-rich soy protein to a low-fat diet for 3 mo in hyperlipidemic men and postmenopausal women significantly reduced total and LDL-cholesterol concentrations (6). Conversely, a 6-mo study with perimenopausal women found that isoflavone-rich soy protein had no effect on serum lipid concentrations (9). Conflicting results may be due to subject selection, large interindividual variation, and varied doses of isoflavones. Hence, the effect of isoflavones on serum lipids in humans remains unclear. Soy isoflavones may also possess antioxidant properties that protect against LDL oxidation (5, 10) and improve total antioxidant status (11). The antioxidant effect of isoflavones may be due to their ability to donate hydrogen atoms to free radicals, which makes the radicals less reactive (12). Although it is unclear whether this free radical quenching happens in vivo, another possible mechanism of isoflavones may be the enhancement of antioxidant defenses by increasing antioxidant enzyme concentrations, as was shown in a mouse model (13).

Phytate, another component of soy, was originally considered an antinutrient, but it may be beneficial in some conditions. Phytate may have a stronger ability to quench free radicals than do isoflavones because of its metal-chelating ability, which renders the prooxidant metal iron unavailable to participate in the Fenton reaction and to catalyze hydroxyl radical formation in vitro (14). Thus, phytate may prevent oxidative damage, such as lipid peroxidation (15, 16) and may thereby decrease the formation of atherosclerotic lesions. Although phytate is absorbed in rats (17), its absorption in humans is very low (18); nevertheless, it is possible that even small amounts of phytate may protect against oxidative stress. In addition to its antioxidant activity, phytate has shown a lipid-lowering effect in rats (19). Reducing the ratio of zinc to copper (20) may be the mechanism by which

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phytate lowers lipid concentrations (21); however, human data in this area are limited. The overall hypothesis of the current study was that soy protein would reduce the risk of CVD—specifically, that soy isoflavones would favorably alter blood lipid concentrations and that phytate would decrease oxidative stress indexes.

SUBJECTS AND METHODS

Study design

In this 6-wk double-blind study, 55 free-living postmenopausal women were randomly assigned to 1 of 4 soy protein isolate (SPI) treatments provided by The Solae Company (St Louis, MO): low-phytate/low-isoﬂavone (LP/LI; n = 14), normal-phytate/low-isoﬂavone (NP/LI; n = 13), low-phytate/normal-isoﬂavone (LP/NI; n = 14), or normal-phytate/normal-isoﬂavone (NP/NI; n = 14) treatment. The 2 treatments containing isoﬂavone concentrations that are referred to as “normal” are in fact rich in isoﬂavones because their isoﬂavone content per gram protein is twice that found in typical S.P. The Solae Company prepared the low-isoﬂavone and low-phytate S.P. by using alcohol extraction and phytase hydrolysis, respectively. The phytate and isoﬂavone (aglycone) contents, respectively, of each treatment per 40 g soy protein were as follows: LP/LI treatment, 0.22 g and 1.2 mg; NP/LI treatment, 0.64 g and 1.2 mg; LP/NI treatment, 0.22 g and 85.8 mg; and NP/NI treatment, 0.78 g and 84.6 mg. All subjects were white except one Asian woman. The women were supplied with protein in a powder form in two 20-gram packets/d (84 total packets), and they were given recipes for incorporating the powder into fruit smoothies or other foodstuffs. Beginning 2 wk before and continuing throughout the intervention, subjects were required to avoid all supplements, including vitamins, minerals, and herbal remedies. Subjects were also provided with a list of foods that are phytate rich (ie, cereals, legumes, and nuts; 22, 23) or isoﬂavone rich (ie, primarily legumes; 24) and were instructed to avoid these foods during the intervention.

The study protocol, consent form, and subject-related materials were approved by Human Subjects Review Committee of Iowa State University (Institutional Review Board ID #002–351). Written informed consent was obtained from all subjects.

Subject selection

Postmenopausal women were recruited throughout central Iowa from April through November 2002 by means of campus and local newspaper advertisements and a television feature story. Approximately 300 women responded, and the potential participants were screened by telephone interviews to ensure that they met the inclusion and exclusion criteria. Health status with respect to chronic diseases (ie, arthritis, cancer, CVD, diabetes, or gastrointestinal, kidney, liver, parathyroid, and pulmonary disease) and menopausal state was assessed before a woman’s inclusion in the study with the use of a health and medical history questionnaire. Women were included in the study if they were postmenopausal (last menses ≥12 mo before intervention) and healthy (no chronic disease or medication use) and if they had a body mass index (BMI; in kg/m²) of 19–34. Women were excluded if they had a chronic disease, had undergone a hysterectomy, had taken hormone therapy ≤12 mo before the intervention, or had used cigarettes or hormone creams ≤6 mo before the intervention. On the basis of these criteria, 57 women were qualified to participate. Two of these women withdrew because of intolerable gastrointestinal side effects. The remaining 55 women completed the 6-wk intervention with minimal or no gastrointestinal side effects.

Data collection

Health and medical history, nutrition history, and soy food intake data (25) were obtained at baseline by using interviewer-administered questionnaires. Usual dietary intake was also assessed at baseline with the use of a food-frequency questionnaire from Block Dietary Data Systems (Berkeley, CA). Overnight-fasted blood samples were collected at baseline and week 6 and were frozen at -80 °C until they were used. A standard reference laboratory (Quest Diagnostics, St Louis, MO) analyzed serum and plasma for the blood lipid profile (total, LDL-, and HDL-cholesterol and triacylglycerol concentrations) and other blood chemistry analytes. Indexes of oxidative stress (ie, protein carbonyls, oxidized LDL (oxLDL), and 8-isoprostaglandin-F₂α (PGF₂α)) were measured in our laboratory at Iowa State University. Protein carbonyls were measured by using a slight modification of the procedure described in Reznick et al (26). Briefly, plasma was mixed with dinitrophenylhydrazine dissolved in hydrochloric acid, accompanied by blanks in hydrochloric acid alone. Protein was then precipitated with 20% (wt:vol) trichloroacetic acid and washed once with 10% trichloroacetic acid and 3 times with 5 mL of a 1:1 mixture of ethanol and ethyl acetate. Finally, precipitates were dissolved in a solution of 6 mmol guanidine-hydrochloric acid/L. The absorbance was measured spectrophotometrically at 380 nm. Plasma oxLDL concentrations were determined by using an enzyme-linked immunosorbent assay kit from ALPCO Diagnostics (Windham, NH), and serum PGF₂α (free + esterified) concentrations were determined by using an enzyme-linked immunosorbent assay kit from Stressgen Biotechnologies (Victoria, Canada). The overall CVs for protein carbonyls, PGF₂α, and oxLDL were <1%, 8%, and 6%, respectively.

Statistical analysis

Statistical analysis was performed with SAS software (version 8.0; SAS Institute, Cary, NC) with significance set at P ≤ 0.05. The sample size per group was based on a pooled SD of 22 mg/dL and 80% power (P < 0.05) to detect a reduction in LDL cholesterol of 15 mg/dL, which is biologically significant enough to reduce CVD risk. Analysis of variance with Tukey’s multiple comparison was used to test the differences in baseline values among the treatments. To ascertain whether baseline-adjusted differences (6 wk — baseline) between isoﬂavone and phytate treatments differed significantly, we used two-way analysis of covariance with the respective baseline values as covariates. Pearson’s product-moment correlation analysis was used to determine the relation among the risk factors at baseline.

RESULTS

Compliance

Compliance was based on the number of packets returned at the week 6 visit. Most of the women consumed 100% of their packets. However, 4 subjects returned 2, 3, 4, and 8 packets, respectively, and 2 subjects requested 3 and 4 extra packets, respectively.
respectively. These subjects were evenly distributed across the treatment groups. Compliance was also checked by randomly analyzing isoflavone excretion in urine before and after intervention (n = 4 per treatment). The subjects in the LP/NI and NP/NI treatment groups excreted 23 and 29 nmol isoflavone/L, and the subjects in the LP/LI and NP/LI treatment groups excreted 1.6 and 2.8 nmol isoflavone/L, respectively. The graduate research assistant was in contact with these women on a regular basis. Fifteen of the 55 subjects reported intermittent constipation; we provided guidelines to increase fluid intake, which corrected the problem and apparently did not affect compliance.

Subject characteristics

The subjects ranged in age from 47 to 72 y. The time since menopause ranged from 1 to 20 y (median: 6.4 y). Thirteen subjects had smoked in earlier years, 6 subjects had experienced cancer (skin, n = 4; breast, n = 1; and cervical, n = 1), but all 6 were in remission, and 1 subject had 2 previous minor strokes that were not related to atherosclerotic CVD. There were no other reported cardiovascular events and no diagnoses of CVD. Twenty-eight and 26 of the subjects reported their health to be good and excellent, respectively, whereas 1 subject reported her health to be fair. Education levels were high school (n = 16), college (n = 29), and graduate school (n = 10). Thirteen of the participants stated they had experienced iron deficiency at least once in the past as a result of malnutrition, pregnancy, menopause, or the onset of menopause; however, only one woman had a baseline hemoglobin concentration < 12 g/dL. Thirty-six subjects (8–10/treatment) reported regular use of a multivitamin, and 2 subjects (LP/LI, n = 1; LP/NI, n = 1) reported regular use of iron supplements. Thirty-five subjects (7–11/treatment) reported they were consuming soy or soy products before the intervention, although most indicated that this consumption was irregular.

The subjects’ descriptive characteristics and daily nutrient intakes are reported in Table 1. None of the descriptive characteristics at baseline differed significantly between the treatment groups. Neither body weight nor BMI differed significantly among the treatment groups even at 6 wk (data not shown). The dietary intakes of macronutrients were within normal ranges and did not differ significantly among the treatment groups. Overall, intakes of selected antioxidants (vitamins A, C, and E) were within the recommended allowances in each treatment group. Although vitamin C intakes were higher in 2 treatments (NP/LI and LP/NI), the differences were not significant.

### Oxidative stress indexes

Oxidative stress indexes before and after intervention and the mean changes for each treatment are shown in Table 2. The mean protein carbonyl concentration at baseline was very low (0.2 nmol/mg protein), and there were no significant differences among the treatment groups. Phytate treatment had a very modest (P = 0.15) and nonsignificant effect on protein carbonyl concentrations, which decreased by 6%–8% and 1%–4%, respectively, in the normal-phytate and low-phytate groups. At baseline, the PGF₂α concentration in the NP/LI group was significantly (P = 0.05) different from that in the LP/LI group but not from that in the other 2 groups. Neither the phytate nor the isoflavone treatment had a significant effect on PGF₂α concentrations. The reduction in PGF₂α in the NP/LI group was 6%, and in the other 3 groups was 3%–4%. The mean oxLDL concentration at baseline ranged from 66 to 81 U/L across the treatments. As was seen with PGF₂α, there was a 5%–13% decline in oxLDL across the groups, but this reduction was not significantly affected by either phytate or isoflavone treatment. The reduction in oxLDL in the normal-isoflavone groups was 6–10 U/L, and that in the low-isoflavone groups was 4 U/L. No significant phytate × isoflavone interaction was found for any of the above 3 oxidative stress indicators.

### Blood lipid concentrations

Blood lipid values at baseline and 6 wk and the mean changes are shown in Table 2. Mean total cholesterol did not differ across

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**Table 1**

Baseline characteristics of subjects

<table>
<thead>
<tr>
<th>Treatment group</th>
<th>LP/LI (n = 14)</th>
<th>NP/LI (n = 13)</th>
<th>LP/NI (n = 14)</th>
<th>NP/NI (n = 14)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (y)</td>
<td>56 (49–70)</td>
<td>59 (53–69)</td>
<td>58 (47–72)</td>
<td>60 (50–70)</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>71 (58.2–93.6)</td>
<td>72.7 (59.0–96.8)</td>
<td>72.7 (55.2–92.5)</td>
<td>69.2 (52.3–92.4)</td>
</tr>
<tr>
<td>Height (m)</td>
<td>1.7 (1.5–1.8)</td>
<td>1.6 (1.5–1.7)</td>
<td>1.7 (1.6–1.7)</td>
<td>1.7 (1.6–1.7)</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>25.9 (18.6–32.9)</td>
<td>27.9 (21.2–33.9)</td>
<td>26.5 (19.9–32.0)</td>
<td>25.3 (21.3–33.6)</td>
</tr>
<tr>
<td>Dietary intake/d</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Energy (kcal)</td>
<td>1702 (515–2559)</td>
<td>1766 (763–2708)</td>
<td>1769 (877–2827)</td>
<td>1647 (1144–2595)</td>
</tr>
<tr>
<td>Protein (g)</td>
<td>65 (22–104)</td>
<td>68 (30–108)</td>
<td>71 (31–122)</td>
<td>63 (39–103)</td>
</tr>
<tr>
<td>Carbohydrate (g)</td>
<td>217 (53–412)</td>
<td>239 (119–405)</td>
<td>213 (85–339)</td>
<td>204 (146–328)</td>
</tr>
<tr>
<td>Fat (g)</td>
<td>66 (25–96)</td>
<td>64 (22–113)</td>
<td>75 (36–139)</td>
<td>67 (30–105)</td>
</tr>
<tr>
<td>Saturated fat (g)</td>
<td>21 (7–37)</td>
<td>18 (6–30)</td>
<td>21 (12–38)</td>
<td>18 (9–26)</td>
</tr>
<tr>
<td>Vitamin C (mg)</td>
<td>103 (42–192)</td>
<td>155 (99–312)</td>
<td>130 (43–211)</td>
<td>116 (50–170)</td>
</tr>
<tr>
<td>Vitamin E (α-TE)</td>
<td>9 (3–15)</td>
<td>11 (5–19)</td>
<td>11 (6–19)</td>
<td>10 (5–21)</td>
</tr>
<tr>
<td>Vitamin A (RE)</td>
<td>1753 (305–3934)</td>
<td>1734 (565–3065)</td>
<td>1570 (698–5107)</td>
<td>1161 (656–2238)</td>
</tr>
</tbody>
</table>

1. All values are median; range in parentheses. LP/LI, low phytate/low isoflavone; NP/LI, normal phytate/low isoflavone; LP/NI, low phytate/normal isoflavone; NP/NI, normal phytate/normal isoflavone; α-TE, α-tocopherol equivalents; RE, retinol equivalents. There were no significant differences between the treatment groups (ANOVA).

2. Selected nutrients were assessed by using a food-frequency questionnaire.
treatments at baseline, ranging from 223 to 235 mg/dL. Although both the normal- and low-isoflavone treatment groups experienced a modest decline in total cholesterol (6%–7% and 2%–4%, respectively) after 6 wk, the reductions did not differ significantly between the groups. Similarly, LDL cholesterol decreased with treatment in all groups, but the differences between low and normal treatments (phytate or isoflavones) were too small to detect significance. The reduction in LDL cholesterol was 10%–11% (14–16 mg/dL) in the normal-isoflavone and 3%–7% (4–9 mg/dL) in the low-isoflavone group. The mean baseline triacylglycerol concentration in the NP/LI group was significantly higher than that in the other treatment groups, but we found no significant effect of treatment. Similarly, HDL cholesterol did not respond to treatment. As we have noted with oxidative stress, phytate and isoflavones had no significant interactive effect on blood lipids.

**Correlation of CVD risk factors**

Correlations among baseline BMI, oxidative stress indexes, and blood lipid measures are shown in Table 3. The highest positive correlations ($P < 0.0001$) were observed between triacylglycerol and PGF$_{2\alpha}$, as well as between LDL cholesterol and oxLDL and between total cholesterol and oxLDL. In addition, BMI was highly correlated with triacylglycerol ($P < 0.001$), PGF$_{2\alpha}$ ($P < 0.05$), and oxLDL ($P < 0.05$). HDL cholesterol was negatively correlated with triacylglycerol ($P < 0.0001$), BMI ($P < 0.0001$), PGF$_{2\alpha}$ ($P < 0.001$), and oxLDL ($P < 0.05$).

**DISCUSSION**

The Food and Drug Administration approved the health claim that a daily intake of 25 g soy protein (27) reduces heart disease risk. In the current study, we chose to use 40 g soy protein/d to ascertain whether a higher intake would elicit beneficial effects on blood lipid profiles, as well as on oxidative stress indexes, in postmenopausal women, who are at high risk for CVD. This amount was also chosen on the basis of previous human studies that investigated health benefits of soy protein (9, 28–30). Moreover, because of phytate’s low absorption in humans, the subjects needed to consume 40 g soy protein/d to obtain enough dietary
TABLE 3
Intercorrelations of baseline values

<table>
<thead>
<tr>
<th></th>
<th>PGF&lt;sub&gt;2α&lt;/sub&gt;</th>
<th>oxLDL</th>
<th>Total</th>
<th>LDL</th>
<th>HDL</th>
<th>Triacylglycerol</th>
<th>BMI</th>
</tr>
</thead>
<tbody>
<tr>
<td>PC</td>
<td>0.15</td>
<td>0.12</td>
<td>0.03</td>
<td>−0.05</td>
<td>−0.01</td>
<td>0.18</td>
<td>0.10</td>
</tr>
<tr>
<td>PGF&lt;sub&gt;2α&lt;/sub&gt;</td>
<td>—</td>
<td>0.25</td>
<td>0.17</td>
<td>0.04</td>
<td>−0.44&lt;sup&gt;2&lt;/sup&gt;</td>
<td>0.74&lt;sup&gt;2&lt;/sup&gt;</td>
<td>0.33&lt;sup&gt;2&lt;/sup&gt;</td>
</tr>
<tr>
<td>oxLDL</td>
<td>—</td>
<td>—</td>
<td>0.61&lt;sup&gt;3&lt;/sup&gt;</td>
<td>0.62&lt;sup&gt;3&lt;/sup&gt;</td>
<td>−0.32&lt;sup&gt;3&lt;/sup&gt;</td>
<td>0.39&lt;sup&gt;3&lt;/sup&gt;</td>
<td>0.34&lt;sup&gt;3&lt;/sup&gt;</td>
</tr>
<tr>
<td>Cholesterol</td>
<td></td>
<td></td>
<td>0.94&lt;sup&gt;4&lt;/sup&gt;</td>
<td></td>
<td>0.07</td>
<td>0.20</td>
<td>0.14</td>
</tr>
<tr>
<td>Total LDL</td>
<td></td>
<td></td>
<td></td>
<td>−0.06</td>
<td></td>
<td>0.05</td>
<td>0.17</td>
</tr>
<tr>
<td>HDL</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>−0.65&lt;sup&gt;2&lt;/sup&gt;</td>
<td>−0.52&lt;sup&gt;2&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>Triacylglycerol</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.45</td>
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</tr>
</tbody>
</table>

<sup>1</sup> Pearson’s correlation coefficient. PC, protein carbonyl; PGF<sub>2α</sub>, 8-iso-prostaglandin-F<sub>2α</sub>; oxLDL, oxidized LDL.
<sup>2</sup> P < 0.001.
<sup>3</sup> P < 0.0001.
<sup>4</sup> P < 0.05.
<sup>5</sup> P < 0.01.

phytate to show beneficial effects. However, the amount of phytate provided daily from 40 g soy protein (ie, 0.64–0.78 g) was considerably lower than the amount used in an earlier human study, in which 8.8 g phytate/d was given to patients at risk of kidney stones (31).

Our results showing no significant effect of soy isoflavones on oxLDL do not agree with the results of a study by others that showed a positive correlation between reductions in oxLDL and serum daidzein, genistein, and total isoflavone concentrations after a 12-wk intervention with soy foods in postmenopausal women (5). Perhaps differences in response to treatment may depend on the menopausal status of the person at baseline and whether baseline values are taken into account in the analyses, as we have done. Women in our study were considered to have normal antioxidant status because the oxLDL concentration in only 1 woman was greater (170 U/L) than the reference range (26–117 U/L) specified by the assay kit manufacturer. However, our data indicate a strong correlation between oxLDL and blood lipids, which suggests that a response to treatment may also depend on the interaction between blood lipids and oxidative stress. Jenkins et al (10) showed that the consumption of 33 g soy protein/d for 1 mo significantly decreased oxLDL concentrations (26–117 U/L) specified by the assay kit manufacturer. However, only 1 woman was greater (170 U/L) than the reference range.

Oxidative stress indicators and the circulating lipids (except HDL cholesterol) declined in all 4 groups (albeit not significantly), but this decline in turn made the differences between the phytate and isoflavone groups very small and, indeed, too small.
to detect significance. For example, we based our study on detec-
ting a 15 mg/dL difference in LDL, but the actual difference bet-ween the normal- and low-isoflavone groups was only 9.5
mg/dL (baseline-adjusted difference of 6.5 mg/dL). It is possible
that other components in SPI might have an additional effect on
the outcome variables. Beneficial effects on lipids and anti-
oxidant status have been shown by other components of soy protein,
such as saponins (7), 7S globulin (8), and arginine (36). Thus, a
single component in SPI may not necessarily be responsible for
protection against CVD, but rather multiple components of SPI
may be protective through different mechanisms.

Although subjects were recruited throughout the summer and
fall seasons, we could not document differences among the treat-
ments at baseline or intervention-related changes in BMI, which
suggests that seasonal variations in dietary intake had no effect
on BMI. Moreover, because all subjects consumed the same
amount of protein during the intervention, the differences in
dietary intakes between the treatment groups were not expected.
However, the positive correlation of BMI with the oxidative
stress markers oxLDL and PFG₂α (Table 3) is noteworthy. Va-
sankari et al (37) found a similar correlation between BMI and
oxLDL, whereas Suzuki et al (38) found no correlation between
these 2 markers. Baseline BMI was also negatively correlated
with HDL cholesterol, much as was reported in another study
(39). A negative correlation between HDL cholesterol and fat
mass (40) suggests unfavorable HDL-cholesterol concentrations
in overweight or obese persons. Thus, reducing BMI may help to
reduce oxidative stress and maintain HDL cholesterol. However,
confirmation of these results will require further study of the
relation between fat mass and oxidative stress.

In contrast to the studies that examined only total antioxidant
status (11, 30), our study included 3 oxidative stress indicators
to assess specific damage to proteins and lipids, which may be a
better indication of oxidative damage. Yet, we have not shown a
significant effect on these 3 indexes by SPI that contained either
phytate or isoflavones. Previous studies (6, 11) had led us to
believe that a 6-wk intervention was sufficiently long to note
changes in oxidative stress and lipids. We found no significant
beneficial effect of phytate or isoflavones in this study, but future
studies with higher doses of these components and a greater
number of subjects, perhaps including subjects with hyperlipid-
emia, may provide different results.

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DLA and MBR participated in the study design. HME and LNH collected
and analyzed the data. HME wrote the first draft of the manuscript, and DLA.
AGK, and MBR provided advice and consultation on the final draft. None of
the authors had any personal or financial conflicts of interest.

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