Stability of Blood Pressure in Vegetarians Receiving Dietary Protein Supplements

FRANK M. SACKS, M.D., PAMELA G. WOOD, AND EDWARD H. KASS, M.D., PH.D.

SUMMARY Vegetarians have relatively low blood pressure (BP) levels and consume less protein than do nonvegetarians, and there have been suggestions that certain proteins may raise BP. To determine whether dietary protein supplements raise the BP of vegetarians, 58 g per day of a 60:40 mixture of soy and wheat proteins and an isocaloric low protein supplement supplying 7 g/day of rice protein were added for 6-week periods to the diet of 18 vegetarians in a 2-group crossover design. Mean daily protein intake during consumption of the low and high protein supplements was 63 and 119 g, respectively. Mean BP was 109/72 mm Hg after the high protein and 108/71 mm Hg after the low protein diet. Consumption of other major nutrients, mean body weight, and sodium and potassium excretion did not change significantly. Thus, protein supplementation of a vegetarian diet that contained a below average but nutritionally adequate amount of protein did not significantly affect BP over 6 weeks. (Hypertension 6: 199-201, 1984)

KEY WORDS • dietary protein • blood pressure • vegetarians

EPIDEMIOLOGIC data show that vegetarians in the United States have lower blood pressure levels1 and consume less protein than the general population (authors' unpublished observations).2 Consumption of animal byproducts and eggs, sources of protein in the vegetarian diet, were predictive of BP levels in vegetarian groups.1, 3 However, removal of animal protein from the diet of nonvegetarians produced no significant changes in mean BP,4 whereas the addition of meat to the vegetarian diet significantly increased systolic BP by 3%, but not diastolic BP.5 In these population studies, and in clinical trials, the effect of protein on BP could not be determined apart from the potential effects of fats and other nutrients contained in the animal products. Thus, the present study compared the effects of high and low-protein supplements on BP without significantly altering the consumption of other nutrients.

Subjects and Methods

The protocol tested the effect of a mean daily supplement of 58 g of a 60:40 soy protein/wheat protein mixture added to the vegetarian diet. Strict vegetarians (vegan) subjects were recruited for this study; their mean age was 32 years, with a range of 22 to 41 years. They received a baseline assessment, and then were randomly divided by use of a table of random numbers into two groups that received, respectively, a high protein supplement and a low protein control supplement in opposite sequence for 6-week periods. Initially, 23 subjects began the protocol. Five subjects left the study, three for personal reasons and two because they reported consuming less than half of the supplements. Seven men and 11 women completed the protocol. Eight persons were in the sequence of low protein followed by high protein, and 10 persons were in the opposite sequence.

The high protein supplement was a patty containing 21 g of soy protein, 13 g of wheat protein, and 17 g of carbohydrate. The men consumed two patties per day, and the women consumed 1.5 per day. The low protein supplement was a rice patty that contained 2 g protein, 18 g carbohydrate, and 0.5 g fat. Both types of supplements were supplied by the Vegetable Protein Company, Cambridge, Massachusetts. The men consumed four of the rice patties per day, and the women consumed three per day. Nine of the subjects cooked for themselves the designated amount of rice per day since they did not like the texture of the rice patties.

Blood pressure, body weight, and 24-hour urine specimens were collected at the end of the baseline period and after the high and low protein supplementation periods. The BP was measured using a semiautomated device.6 A microphone beneath a standard inflatable cuff transmitted the Korotkoff tones, which were printed as spikes superimposed on a calibration curve produced by the falling level of mercury in a
manometer. The participants were sitting quietly for 5 minutes prior to the measurements. Three BP were taken in succession from the right arm on each of six visits at the end of each dietary period. For each subject, a schedule of visits for BP readings was devised according to his/her activities so that the times (morning or afternoon) and places (home, laboratory, or work) were the same for each dietary period. Body weight was measured on one portable scale, and urine was collected over a 24-hour period at the end of the three dietary periods. Urinary sodium, potassium, and creatinine were measured with automated procedures at the Core Laboratory, Clinical Research Center, Brigham and Women's Hospital.

The diets of the individual subjects during the baseline period before the study began and after 6 weeks of high- and low-protein supplementation were assessed with a self-administered food frequency questionnaire designed for use in the macrobiotic vegetarian community. This approach to dietary assessment was found to give values that correlated closely with 7-day diet records. Quantitative dietary information was available for 15/18 subjects for all periods, and 16/18 persons for both the prestudy and high-protein phases. Although 2/18 subjects returned a diet questionnaire for both the prestudy and high-protein phases, the subjects reported a higher caloric intake during the high-protein period; caloric intake was probably similar throughout the protocol. Mean caloric intake was lower than expected for the mean weight of the subjects. Underreporting of overall intake of foods probably occurred. The polyunsaturated-to-saturated fatty acid ratio of the diet was 1.5 (16.1 g/day polyunsaturates, 10.6/day saturates).

The blood pressure tapes were coded and read blindly by one person (PGW) according to standard criteria that approximated the auscultatory method. Differences in mean BP, nutrients, and urinary biochemicals of the group between the dietary periods were assessed using a two-tailed paired t test. The average BP at each dietary period was based on all readings collected during six visits, with three measurements per visit. The power of detecting a 3 mm Hg mean difference in BP between the high- and low-protein periods with a 2-tailed p value of 0.05 was 82% for systolic and 83% for diastolic BP. The calculation was based on the intrapersonal standard deviation of the difference in mean BP for the high- and low-protein periods, where the average BP at each period was based on all readings.

**Results**

The high- and low-protein diets contained a mean of 119 and 63 g protein per day, respectively, as calculated from diet histories and separate records of consumption of the supplements. Thus, mean protein consumption for the group during the study was within the range of nutritional adequacy. Mean fat and carbohydrate consumption did not change significantly during the study. The subjects reported a higher caloric intake of borderline significance (p = 0.06) during the high-protein diet than during the low-protein supplemented diet. Since the subjects did not gain weight during the high-protein period, caloric intake was probably similar throughout the protocol. Mean caloric intake was lower than expected for the mean weight of the subjects. Underreporting of overall intake of foods probably occurred. The polyunsaturated-to-saturated fatty acid ratio of the diet was 1.5 (16.1 g/day polyunsaturates, 10.6/day saturates).

Mean BP was 112/74 mm Hg during the prestudy period, 108/71 mm Hg during the low-protein period, and 109/72 mm Hg during the high-protein period; p ≤ 0.05 for prestudy/low-protein systolic and diastolic BP differences; p = 0.02 for prestudy/high-protein systolic BP differences (Table 1). There were no significant differences in mean systolic or diastolic BP

### Table 1: Blood Pressure, Nutrient Intake, and Related Measurements during High- and Low-Protein Diets

<table>
<thead>
<tr>
<th></th>
<th>No.</th>
<th>Prestudy</th>
<th>Low protein (6 wks)</th>
<th>High protein (6 wks)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blood pressure</td>
<td>18</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Systolic (mm Hg)</td>
<td>111.8 ± 13.4*</td>
<td>107.9 ± 13.7'</td>
<td>108.8 ± 13.5'''</td>
<td></td>
</tr>
<tr>
<td>Diastolic (mm Hg)</td>
<td>73.6 ± 7.9*</td>
<td>71.3 ± 8.6''</td>
<td>71.9 ± 9.3''</td>
<td></td>
</tr>
<tr>
<td>Nutrient intake</td>
<td>15</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Protein (g/day)</td>
<td>70 ± 30</td>
<td>63 ± 23</td>
<td>119 ± 31</td>
<td></td>
</tr>
<tr>
<td>Carbohydrate (g/day)</td>
<td>264 ± 120</td>
<td>237 ± 73</td>
<td>262 ± 103</td>
<td></td>
</tr>
<tr>
<td>Fat (g/day)</td>
<td>45 ± 33</td>
<td>43 ± 28</td>
<td>39 ± 26</td>
<td></td>
</tr>
<tr>
<td>Kcal/day</td>
<td>1735 ± 785</td>
<td>1589 ± 561''</td>
<td>1879 ± 678''</td>
<td></td>
</tr>
<tr>
<td>Body weight (kg)</td>
<td>18</td>
<td>62.7 ± 10.4</td>
<td>62.6 ± 9.9</td>
<td>63.0 ± 10.2</td>
</tr>
<tr>
<td>Urinary excretion</td>
<td>14</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sodium (g/24 hr)</td>
<td>2.41 ± 1.24</td>
<td>2.67 ± 1.51</td>
<td>2.64 ± 0.81</td>
<td></td>
</tr>
<tr>
<td>Potassium (g/24 hr)</td>
<td>1.93 ± 0.72</td>
<td>1.63 ± 0.97</td>
<td>1.72 ± 0.65</td>
<td></td>
</tr>
<tr>
<td>Creatinine (g/24 hr)</td>
<td>0.91 ± 0.32</td>
<td>0.95 ± 0.33</td>
<td>1.14 ± 0.44</td>
<td></td>
</tr>
</tbody>
</table>

Comparisons between means = mean difference (d) ± 1 sd.

a and a' - d = 3.9 ± 6.6, p = 0.025
a and a'' - d = 2.9 ± 4.5, p = 0.02.
b and b' - d = 2.3 ± 4.6, p = 0.05.
c' and c'' - d = 289 ± 510, p = 0.06.
All other comparisons were not significant; p > 0.10 by paired t test.
between the high- and low-protein periods ($p > 0.3$). Evidence for a secular trend in mean BP during the study was obtained by analyzing the BP in chronological sequence over the 12-week protocol rather than by specific dietary period. Mean BP (mm Hg) was 112/74 at Week 0, 109/72 at Week 6, and 108/71 at Week 12; mean difference for Week 0–12 = 4.1 ± 5.9, $p < 0.01$ systolic, 2.3 ± 5.4, $p = 0.09$ diastolic. Differences between mean BP taken at Weeks 6 and 12 were not significant.

Mean body weight and urinary excretion of sodium and potassium did not change significantly during the study. There was a trend toward increased creatinine excretion during the high-protein period, $p = 0.1$.

**Discussion**

The present study was designed specifically to test the hypothesis that high-protein intake is hypertensive relative to moderate-to-low intake. Isoenergetic low-protein and high-protein test foods were given to each subject in a randomized two-group crossover design. The amount of protein added, 58 g, nearly doubled the basal protein consumption. Compared to the average U.S. diet, the range of protein intake (g/day) studied spanned the 25th to 85th percentiles. The intradividual variance of BP was minimized by obtaining 18 measurements of BP for each person during each dietary period, enabling any significant change of 3 mm Hg in either systolic or diastolic BP to be detected. Nonetheless, no difference in BP between high-protein and low-protein periods was observed.

In the present study, protein of vegetable origin was used as a supplement, since this form was more acceptable to the vegetarian subjects than animal protein. However, the 60:40 mixture of soy and wheat protein may be expected to produce an amino acid composition of high biologic value. The calculated amino acid score or biologic value of the protein supplement was 90%, using the amino acid content of gluten and soybeans and the 1974 National Academy of Science-National Research Council standard for protein quality. Thus, if animal protein has effects on BP that are different from vegetable protein mixtures, differences in amino acid content are not likely to be the cause. A recent study confirmed that an isocaloric exchange of soy protein and casein (dairy protein) produced no changes over 4 weeks in blood pressure of normotensives.

This study suggests that protein, when consumed in low-to-above-average amounts, has no short-term effects on blood pressure in adults. Since the vegetarians were consuming protein well above the minimum requirement, the effects of protein when added to a protein-deficient diet cannot be inferred from these data. There is suggestive evidence that high protein diets over many years can damage the kidney. Whether the pathogenesis of essential hypertension involves this mechanism is unknown. It is unlikely, however, that the low blood pressure of persons in the United States who have recently become vegetarians is the result of the relatively low protein intake. The basis for the relative hypotension in vegetarians remains to be defined.

**Acknowledgments**

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