Blood pressure reduced by whole grain diet containing barley or whole wheat and brown rice in moderately hypercholesterolemic men

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Abstract

Whole grains have been reported to lower blood pressure, but results have been mixed. This report compares the effects of soluble and insoluble fibers on blood pressure in a whole grain diet. Twenty-one non-hypertensive men (28-62 yr) with elevated plasma cholesterol levels were selected for the study approved by the Institutional Review Board of the Johns Hopkins School of Public Health. Men consumed a Step 1 diet for 2 wk. and then consumed diets with brown rice/whole wheat, barley, or a combination for 5 wk in a Latin square. Systolic, diastolic, and mean arterial pressures did not change during the Step 1 diet, but were reduced by whole grains whether the fiber was predominantly soluble (barley) or insoluble (brown rice & whole wheat). Urinary excretion of phosphorus, and urea nitrogen were lower after consumption of the barley diet. Increasing whole grain foods in a healthy diet can reduce cardiovascular risk. Published by Elsevier Inc. All rights reserved.

Keywords: Barley; Wheat; Brown rice; Blood pressure; Fiber

1. Introduction

Consumption of diets high in whole grains have been reported to have a number of beneficial health effects including reduced risk of cancer [1], cardiovascular disease [2–4], and noninsulin-dependent diabetes mellitus [5–7]. These results have been attributed to the

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effects of the fiber content of whole grain foods on risk factors for these diseases including blood glucose [8], insulin [9], and cholesterol [10–12]. Other more general beneficial physiological effects of consumption of whole grains include reduced transit time which may reduce risk of colon cancer [13–14], reduced absorption of nutrients [15–17] which may reduce glucose and insulin responses and risk of obesity [18], and reductions in blood pressure [19] which may reduce risk of stroke [20]. The US Food and Drug Administration has allowed three health claims related to grain intakes [21]. One allows the claim that low-fat diets rich in fiber-containing grain products, fruits, and vegetables may reduce risk of some types of cancer. A second claim allows the statement that consumption of soluble fiber from oats or psyllium in a diet low in saturated fat and cholesterol may reduce the risk of heart disease. A specific claim for whole grain foods allows the statement that low-fat diets rich in whole-grain foods and other plant foods may reduce the risk of heart disease and certain cancers.

Numerous studies have demonstrated that whole grains that are high in soluble fiber such as oats are more effective in lowering blood cholesterol than those in which fibers are predominantly insoluble such as wheat or rice [22–26], but the effects on blood pressure have been mixed [27–35]. Epidemiological studies have combined sources of fiber (cereal, fruits, vegetables) making it difficult to determine the beneficial dietary component. Clinical studies testing the effects of soluble fibers have used oats or psyllium, but barley has as much or more soluble fiber [36]. Many of the studies in humans either have added fiber supplements or fiber-containing foods to self-selected diets. The purpose of this study was to examine the effects of consumption of varying levels of soluble fiber from barley in a controlled whole grain diet on risk factors for coronary heart disease in moderately hypercholesterolemic men. Blood pressure and urinary excretion are included in this report.

2. Materials and methods

2.1. Subjects

The study was approved by the Johns Hopkins School of Public Health Institutional Review Board. Written informed consent was obtained after an oral explanation of the study. Blood and urine were collected prior to the study for a general clinical screening to select men with moderately elevated cholesterol, but no other conditions which would affect lipid or glucose metabolism. Heights and weights were measured and duplicate blood pressure readings taken. Medical evaluations were conducted by Elizabeth Cristofalo or Benjamin Caballero of Johns Hopkins University School of Public Health who provided medical supervision throughout the study. Twenty-one men with moderately elevated plasma cholesterol levels were selected for the study. Two subjects withdrew during the first week. One man had an international business-related trip and one withdrew because he was not willing to comply with the regimen of the study. Another man withdrew during the adaptation period after an automobile accident made transportation to the center for meals difficult. Two of the men lost weight even though they were consuming 4000 kcal/d. Because they were overweight and did not feel that they could consume more calories due to the bulkiness of the
diets, we continued them on the study, but did not increase their energy intakes. We have not included them in these analyses. Data from 16 men are included in the analyses. Three of these men completed 2 or 3 of the 4 diet periods. (Table 1).

### 2.2. Diets and procedures

Subjects consumed Step 1 American Heart Association diet [37] with a seven day rotating menu for 2 wk to allow them to adjust to the regimen and establish energy needs (Table 2). Monday through Friday breakfast and dinner were consumed in the Human Study facility. Subjects picked up lunch at breakfast, evening snack at dinner and weekend meals were frozen and/or packed in ice for home consumption. All foods were weighed to 0.5 g.

Men were weighed daily Monday through Fridays. These weights were verified by Human Study personnel. Energy levels were adjusted proportionately in 300 kcal increments to maintain initial body weights. Men agreed to consume only and all food presented to them. The only exceptions were water and non-caloric beverages and sweeteners which were recorded daily. No discretionary salt was allowed. At the end of the 2 wk adaptation period

### Table 1
Initial screening characteristics of men¹

<table>
<thead>
<tr>
<th></th>
<th>Included</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>16</td>
</tr>
<tr>
<td>Age (yr)</td>
<td>46.9 ± 10.2</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>86.1 ± 11.9</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>179.2 ± 6.5</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>26.7 ± 2.8</td>
</tr>
<tr>
<td>Systolic Blood Pressure (mm Hg)</td>
<td>120 ± 12</td>
</tr>
<tr>
<td>Diastolic Blood Pressure (mm Hg)</td>
<td>74 ± 8</td>
</tr>
<tr>
<td>Cholesterol (mg/dL)</td>
<td>235 ± 30</td>
</tr>
</tbody>
</table>

¹ Mean ± SD

### Table 2
Nutrient content of diets

<table>
<thead>
<tr>
<th></th>
<th>Step 1</th>
<th>Wheat/rice</th>
<th>½ &amp; ½</th>
<th>Barley</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kcal</td>
<td>2812</td>
<td>2839</td>
<td>2828</td>
<td>2817</td>
</tr>
<tr>
<td>Protein [g]</td>
<td>110</td>
<td>107</td>
<td>107</td>
<td>106</td>
</tr>
<tr>
<td>Fat [g]</td>
<td>96</td>
<td>98</td>
<td>98</td>
<td>98</td>
</tr>
<tr>
<td>Saturated [g]</td>
<td>25</td>
<td>24</td>
<td>24</td>
<td>24</td>
</tr>
<tr>
<td>Cholesterol [mg]</td>
<td>291</td>
<td>262</td>
<td>262</td>
<td>262</td>
</tr>
<tr>
<td>Carbohydrate [g]</td>
<td>388</td>
<td>400</td>
<td>401</td>
<td>402</td>
</tr>
<tr>
<td>Dietary Fiber [g]</td>
<td>27</td>
<td>27</td>
<td>30</td>
<td>33</td>
</tr>
<tr>
<td>Soluble [barley] [g]</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>Sodium [mg]</td>
<td>3714</td>
<td>3366</td>
<td>3366</td>
<td>3366</td>
</tr>
<tr>
<td>Potassium [mg]</td>
<td>3199</td>
<td>3298</td>
<td>3317</td>
<td>3336</td>
</tr>
<tr>
<td>Calcium [mg]</td>
<td>819</td>
<td>925</td>
<td>913</td>
<td>899</td>
</tr>
<tr>
<td>Magnesium [mg]</td>
<td>326</td>
<td>446</td>
<td>379</td>
<td>312</td>
</tr>
</tbody>
</table>
subjects consumed an American Heart Association Step 1 diet containing no barley, or 3 g or 6 g/day of soluble fiber from barley/2800 kcal for 5 wk each in a Latin square design. Test foods were pancakes, spice cake, no bake cookies, hot cereal, toasted flakes, steamed pilaf. For menus containing no barley, whole wheat flour, wheat flakes and brown rice were used. For menus containing 6 g soluble fiber, barley flakes, barley flour, or pearled barley replaced the wheat or rice. For menus containing 3 g soluble fiber from barley/2800 kcal, these grain sources were half brown rice/whole wheat flour or flakes and half barley. Whole wheat flour and brown rice were purchased from a local grocery store. Wheat flakes were purchased in one lot from Barry Farm Enterprises, Ohio. Barley flakes, flour, and pearled barley were produced from one lot of barley and donated by the Barley Foods Council (Table 3). For experimental menus a test food was substituted into the Step 1 menu at breakfast, lunch, dinner, and the evening snack (Table 4).

Table 3
Nutrient content of barley, whole wheat flour, and brown rice [100 g]

<table>
<thead>
<tr>
<th></th>
<th>Barley</th>
<th>Whole wheat flour</th>
<th>Brown rice</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kcal</td>
<td>352</td>
<td>339</td>
<td>370</td>
</tr>
<tr>
<td>Protein [g]</td>
<td>9.9</td>
<td>13.7</td>
<td>7.94</td>
</tr>
<tr>
<td>Fat [g]</td>
<td>1.2</td>
<td>1.9</td>
<td>2.9</td>
</tr>
<tr>
<td>Saturated [g]</td>
<td>0.2</td>
<td>0.3</td>
<td>0.6</td>
</tr>
<tr>
<td>Carbohydrate [g]</td>
<td>77.7</td>
<td>72.6</td>
<td>77.2</td>
</tr>
<tr>
<td>Dietary fiber [g]</td>
<td>15.6</td>
<td>12.2</td>
<td>3.5</td>
</tr>
<tr>
<td>Soluble [g]</td>
<td>5.0</td>
<td>1.1</td>
<td>0.3</td>
</tr>
<tr>
<td>Sodium [mg]</td>
<td>9</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td>Potassium [mg]</td>
<td>280</td>
<td>405</td>
<td>143</td>
</tr>
<tr>
<td>Calcium [mg]</td>
<td>29</td>
<td>34</td>
<td>23</td>
</tr>
<tr>
<td>Magnesium [mg]</td>
<td>79</td>
<td>138</td>
<td>143</td>
</tr>
<tr>
<td>Phosphorus [mg]</td>
<td>221</td>
<td>346</td>
<td>333</td>
</tr>
</tbody>
</table>

Table 4
Sample menus for day before blood pressure measurements

<table>
<thead>
<tr>
<th>Breakfast</th>
<th>Control Lunch</th>
<th>Control Dinner</th>
<th>Evening Snack</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grapefruit juice</td>
<td>Tuna salad</td>
<td>Chicken/gravy</td>
<td>apple</td>
</tr>
<tr>
<td>English muffin</td>
<td>Pita bread</td>
<td>green beans</td>
<td>peanut butter</td>
</tr>
<tr>
<td>Scrambled eggs</td>
<td>carrots</td>
<td>rice pilaf</td>
<td>rice cakes</td>
</tr>
<tr>
<td>Margarine/jelly</td>
<td>cookies</td>
<td>tossed salad</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lemonade</td>
<td>strawberries/cake</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Test</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grapefruit juice</td>
<td>tuna salad</td>
<td>chicken/gravy</td>
<td>test cookies</td>
</tr>
<tr>
<td>Test hot cereal</td>
<td>pita bread</td>
<td>green beans</td>
<td>lemonade</td>
</tr>
<tr>
<td>Lactose-free milk</td>
<td>carrots</td>
<td>tossed salad</td>
<td></td>
</tr>
<tr>
<td>English muffin</td>
<td>test cake</td>
<td>test pilaf</td>
<td></td>
</tr>
<tr>
<td>Margarine/jelly</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
2.3. Measurements

Subjects were instructed to take the elevator, not stairs, to the third floor Human Study Facility. After approximately a 5 minute rest, duplicate blood pressure readings were taken with a 5 minute interval Thursday of each week before breakfast using a Dinamap Pro Series 100, Critikon, L.L.C., Tampa, FL. Stressful occurrences such as car trouble, accidents, family illnesses or crises were recorded and these readings excluded.

The last three days of each diet period, 24-hr complete urine samples were collected. Coolers containing ice packs, funnels and pre-weighed 4 liter urine containers were distributed the day before collection began. After the first morning void, subjects collected all urine up to and including the next day’s first morning void each of the three days. Men turned in collections and ice packs, urine containers, and funnels were replaced daily. Urine samples were mixed, weighed, aliquoted and frozen daily.

Daily urine samples were analyzed for Na, K, Ca, P, Mg, uric acid, and glucose. (Dimension Xpand, Dade Behring Inc, Newark, DE).

Data were analyzed using mixed procedure analysis of variance (SAS 8.2, Cary, NC). For significant factors, least squares means were used to detect treatment differences.

3. Results

Body weights did not significantly change, though there was a slight decrease in weight of the 16 subjects included in the analysis (Table 5). Energy intakes did not differ among diets. Systolic blood pressure did not change significantly during the initial 2 week Step 1 control diet period. At the end of each of the 5-wk whole grain periods, systolic blood pressure was significantly lower than during the initial period. Diastolic and mean arterial pressures followed this same pattern. There was no significant change during the Step 1 control diet, but diastolic and mean arterial blood pressures were lower after all three whole grain diets than after the Step 1 diet.

Table 5

<table>
<thead>
<tr>
<th></th>
<th>Day 1</th>
<th>Control</th>
<th>wheat/rice</th>
<th>½ &amp; ½</th>
<th>barley</th>
</tr>
</thead>
</table>
| Body weight [kg]       | 86.1
|                        |          | 86.1
|                        |          | 85.7
|                        |          | 85.5
|                        |          | 85.6 |
| Energy intake [Kcal]   | —         | 2969
|                        |          | 3063
|                        |          | 3034
|                        |          | 3025 |
| Energy intake [MJ]     | —         | 12.4
|                        |          | 12.8
|                        |          | 12.7
|                        |          | 12.6 |
| Energy intake [kJ/kg]  | —         | 145
|                        |          | 151
|                        |          | 150
|                        |          | 149 |
| Systolic               | 120
|                        | 120
|                        | 112
|                        | 114
|                        | 114 |
| Diastolic              | 74
|                        | 76
|                        | 71
|                        | 72
|                        | 72 |
| Mean arterial          | 88
|                        | 92
|                        | 86
|                        | 86
|                        | 86 |

1 Mixed procedure analyses of variance for 16 subjects completing at least 2 periods. Body weight for each diet period p = 0.49, SEM 0.7. Energy intake p = 0.27, SEM 84 kcal, 0.4 Mj. Energy intake kJ/kg p = 0.14, SEM 4.3 kJ/kg. Six readings for control period, 10 readings for other 3 diet periods. Systolic: p = 0.0004, SEM = 2.6; diastolic: p = 0.015, SEM = 1.7; Mean arterial: p = 0.0009, SEM = 2.0. Values within a row not sharing a common superscript are different p < 0.05 according to least squares means.
There was a significant difference among weeks during the study. Fig. 1. The greatest changes in blood pressure tended to occur at the ends of the last two diet periods, but the Latin square design accounts for this period effect in the statistical analysis.

Total daily urinary excretion of glucose was minimal and did not vary according to diet. Sodium, potassium, calcium, magnesium, uric acid, and creatinine excretions were similar for all diet periods. Potassium, magnesium, and uric acid excretion tended to be lower after barley consumption than after consumption of diets containing whole wheat and brown rice. Phosphorus and urea nitrogen excretion were lower after consumption of the barley diet than after the other 3 diets (Table 6).

4. Discussion

Other reports on the effects on blood pressure of diets containing grains or fibers from grain have been inconsistent, but study populations, sources and amounts of grains, length of consumption, and especially dietary control have been very heterogeneous [27–35]. Many of these studies supplemented self-selected diets with added fiber supplements without control of other factors which may have affected blood pressure. Most did not use whole-grain foods, but instead used extracts or isolated fiber component and few have used barley [36]. In the present study diet was completely controlled including sodium intake. All diets corresponded to American Heart Association Recommendations for a step 1 diet [37].
Results of some of the previous studies indicate the heterogeneity of effects of various grains on blood pressure. Rossner et al. [38] reported a decline in blood pressure for women consuming a high fiber supplement, but the purpose of the study was weight reduction. Sixty-two moderately obese women lost an average of 4 kg in a parallel study in which half consumed a 6.5 g fiber supplement (vegetable, citrus and grain) and half consumed a placebo (lactose/sucrose); however, systolic blood pressure declined only in those consuming the fiber even though weight loss was equivalent, suggesting an effect of fiber independent of weight loss. Twenty-one lean hypertensive patients were given a similar mixed supplement (7 g/day) for 3 months and compared to 25 patients receiving placebo [39]. Without weight change, the patients receiving the fiber experienced a significant decline in both systolic and diastolic blood pressure. It is not possible, however, to determine which source of fiber (grain, citrus, vegetable) is responsible for the change in blood pressure. Several studies reporting blood pressure changes have compared grain sources high in soluble and insoluble fibers, but often the amounts of dietary fiber are not comparable [27–35]. Swain et al [27] compared oat bran [87 g/day] and a low fiber wheat supplement in a 6 wk crossover design. The remainder of the diet was self-selected. Systolic blood pressure was initially 112/68 mm Hg and did not change significantly. Fiber intake during the oat period was 38.9 g/day and 18.4 g/day during the wheat period. Sixteen of the 20 subjects in this study were women and dietitians (mean age 30 yr). It is possible that the youth, dietary knowledge, and low blood pressures of these subjects made it unlikely that dietary change could affect them. Another study [28] used oats in a controlled diet study of 43 normal and moderately obese men and women. Subjects were assigned to either a control or oat diet after a two week period during which a weight maintenance control diet containing 5 g soluble fiber was consumed. After this period a hypocaloric diet (4.2 Mj < maintenance) either the control diet or a diet containing 45 g oats/4.2 Mj was consumed for 6 wk. Systolic blood pressure declined in the oat group compared to the control group. There was no change in diastolic blood pressure. Both groups lost comparable amounts of weight. The control group consumed substantially less dietary fiber (12.5 g vs. 16.3 g/day) as well as soluble fiber (3.5

<table>
<thead>
<tr>
<th></th>
<th>Control</th>
<th>wheat/rice</th>
<th>½ &amp; ½ barley</th>
<th>barley</th>
<th>SEM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glucose [g]</td>
<td>0.14a</td>
<td>0.15a</td>
<td>0.16a</td>
<td>0.14a</td>
<td>0.02</td>
</tr>
<tr>
<td>Sodium [mmol]</td>
<td>108b</td>
<td>106b</td>
<td>113b</td>
<td>95b</td>
<td>8.0</td>
</tr>
<tr>
<td>Potassium [mmol]</td>
<td>55.7b</td>
<td>58.8b</td>
<td>60.4a</td>
<td>50.8a</td>
<td>3.9</td>
</tr>
<tr>
<td>Calcium [mg]</td>
<td>113a</td>
<td>119a</td>
<td>136a</td>
<td>117a</td>
<td>14</td>
</tr>
<tr>
<td>Magnesium [mg]</td>
<td>99a</td>
<td>91a</td>
<td>96a</td>
<td>79a</td>
<td>9.0</td>
</tr>
<tr>
<td>Phosphorus [mg]</td>
<td>974a</td>
<td>910a</td>
<td>908a</td>
<td>793b</td>
<td>55</td>
</tr>
<tr>
<td>Uric acid [mg]</td>
<td>356a</td>
<td>304a</td>
<td>335a</td>
<td>271a</td>
<td>44</td>
</tr>
<tr>
<td>Creatinine [g]</td>
<td>1.56a</td>
<td>1.49b</td>
<td>1.62a</td>
<td>1.48a</td>
<td>0.09</td>
</tr>
<tr>
<td>Urea nitrogen [g]</td>
<td>11.3a</td>
<td>10.3ab</td>
<td>10.3ab</td>
<td>9.3b</td>
<td>0.7</td>
</tr>
</tbody>
</table>

1 Three 24-hr urine collections at the end of each period. Least squares means. Mixed procedure analyses of variance for 16 subjects completing at least 2 periods: Glucose, sodium, potassium, calcium, magnesium, uric acid, creatinine—all NS; phosphorus: p = 0.035; urea nitrogen: p = 0.008. Values within a row not sharing a common superscript are different p < 0.05 according to least squares means.
g vs. 7.2 g/day) than the oat group. Kestin et al [40] compared the effects of wheat, rice, and oat brans to a low-fiber diet in 24 mildly hypercholesterolemic men in a 4 wk crossover design and found no differences in blood pressure. Fibers were provided and the rest of the diet was self-selected with weighed-inventory food records four days during each four week period.

Jenkins et al [23] supplemented self-selected diets of 68 moderately hypercholesterolemic men and women instructed on the principles of the National Cholesterol Education Program Step II diet [41] with high-fiber (1.8-2.5 g psyllium or 0.75 g soluble glucans/serving) and control foods. Subjects consumed 7.2 g psyllium and 0.75 g glucan/day during the one month high-fiber period in a cross-over design, with low-fiber foods consumed during the alternate month. Neither systolic nor diastolic blood pressure were affected by either diet.

Studies examining the effects of barley consumption on blood pressure are limited. Lupton et al [26] compared cellulose (20 g), barley bran flour (30 g) and barley oil (3 g) added to self-selected diets with dietary instruction for the National Cholesterol Lowering Diet Recommendations [41] in 79 men and women with hypercholesterolemia (men would be comparable to those in our study). Systolic blood pressure did not change, but diastolic blood pressure was reduced in all three groups. The greatest reduction (−11 mm Hg) occurred in the barley bran flour, though groups were not statistically compared. The barley bran flour used in this study was predominantly insoluble fiber, unlike the barley used in our study.

We attempted to control other dietary factors which might affect blood pressure including protein, calcium, magnesium, sodium, and potassium [42–49]. The lack of difference in excretions of creatinine, calcium, magnesium, and sodium would indicate that we were fairly successful in this control. Phosphorus excretion, however, was somewhat lower when men consumed the barley diet. This may be due to the lower level of phosphorus in the barley as compared to the whole wheat. Numerous studies have found inverse relationships between blood pressure and intakes of potassium [29,33,44,48–49], but our diets were similar in content.

Weight loss was an unexpected and unwanted result in two subjects of our study. Since the 2 men who lost weight were overweight, we did not feel that it would be ethical to try to make them regain the weight loss. Consumption of the 4000 kcal was difficult for them because the high fiber content of the menus made the volume of food great. We therefore continued them on the study at 4000 kcal, but did not include them in the analysis. Predicting an individual’s energy expenditure is difficult because physical activity is so variable [50].

The study began in March and ended at the end of June. The non-significant weight loss in the remaining 16 subjects could easily be due to change in the weight of clothing worn in March vs June. The Latin square should eliminate this time effect in all but the step 1 period of the diet which was at the beginning of the study for all subjects. Our subjects did consume slightly more energy during the whole grain period, but this increase was not significant. However, Swain et al [27] reported increased energy intakes during both the wheat and oat periods compared to baseline without weight gain (140 kJ/kg/day for baseline vs. 157 and 164 kJ/kg/day for wheat and oat supplement periods, respectively). These values are somewhat higher than intakes of our population, but our subjects were older (and heavier).

Increased resistant starch [51] or the viscosity of the intestinal contents providing a physical barrier to absorption leading to reduced energy availability [52] could account for
this apparent decrease in food efficiency of the test diets. Fermentable fibers have been reported to increase short chain fatty acid production indicating metabolism in the large intestine and unavailability of energy through the small intestine [52]. Consumption of diets containing these components of grains may also reduce the availability of energy in the diet. Although this loss of available energy might not be considered desirable in most of the world, in Western societies where obesity and diseases of nutrient excess are major health problems, this characteristic of fibers is welcome.

One of the problems associated with sequential blood pressure measurements in individuals is that blood pressure tends to decline as subjects become more comfortable with their surroundings. Because all subjects consumed the Step 1 diet at the beginning of the study, diet and time are somewhat confounded by the design. We viewed this period as an adaptation period during which subjects would become accustomed to the regimen of the study and adapted to consumption of a high fiber lower fat menu. Blood pressure clearly did not decrease during this period, despite the fact that measurements were taken at screening and twice on the first day, and at the end of wk 1 and wk 2. It is possible that continuation on the Step 1 diet would also have resulted in reduction in blood pressure since the greatest reductions were seen during the last two periods, especially, during weeks 11 and 12, but the Latin square design should account for the period effect. Further examination of the results for weeks 11 and 12 indicate that there were declines in all groups and most subjects; however, values of individuals are within the range of readings from other weeks. The same equipment was used throughout the study and the same two technicians took measurements. There are many factors which affect blood pressure; however, there is no reason to suspect that the readings taken during these weeks are not valid. The mixed procedure takes into account differences in treatment and time. There was a significant week effect, but several weeks had blood pressure readings lower than the control period.

A number of mechanisms have been proposed to be responsible for the reduction in blood pressure which occurs with increased fiber intake including increased water and electrolyte excretion with insoluble fiber intake [53]; change in gastric emptying time with viscous fibers; or increased cation exchange leading to greater fecal mineral losses associated with acid polysaccharides [54]. Our urinary measurements indicate that though sodium excretion did not differ, potassium excretion did appear to be somewhat higher in diets containing more insoluble fiber; however blood pressures did not vary after consumption of the three whole grain diets. Since we have no measures of gastric emptying or fecal losses, we can only speculate on these effects.

In summary, when fed in a healthy diet, consumption of diets high in whole grain foods lowers systolic and diastolic blood pressure in moderately hypercholesterolemic men, whether sources are predominantly soluble fiber from barley, insoluble fiber from a combination of whole wheat and brown rice, or soluble and insoluble fiber from whole grain foods.

5. Conclusions

These results indicate that addition of whole grain foods to a healthy diet whether from soluble or insoluble sources can reduce risk of cardiovascular disease.
References

vegetable protein (soy) and soluble fiber added to a standard cholesterol-lowering diet. Metabolism 1999;48:809–16.


