A Comparison of the Influences of Soy- vs. Wheat-based Supplements on Weight Loss in Middle-aged Subjects

Yoko Suga¹, Kai Tanabe², Junghoon Kim², Hironori Sato³, Soh Iwashita⁴, Koichiro Hamada⁴ and Shinya Kuno²,³

¹Department of Health and Nutrition, Human and Environmental Studies, Kanto Gakuin University, 1-50-1 Mutsuura-higashi, Kanazawa-ku, Yokohama-shi, Kanagawa, 236-8503, Japan
²Graduate School of Comprehensive Human Sciences, Doctoral Program of Sports Medicine, University of Tsukuba, 1-1-1 Tennohdai, Tsukuba-shi, Ibaraki, 305-0006, Japan
³Tsukuba Wellness Research Co., Ltd, D6-8 Kenkyu-gakuen, Tsukuba-shi, Ibaraki, 305-0817, Japan
⁴Saga Nutraceuticals Research Institute, Otsuka Pharmaceutical Co., Ltd, 5006-5 Ohmagari-Higashiyama, Yoshinogari-cho, Kanzaki-gun, Saga, 842-0195, Japan

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The purpose of this study was to investigate the comparison and influence of soy-based foods and wheat-based foods on weight loss. Fifty healthy participants were randomly assigned to either the soy group (n = 24) or the wheat group (n = 26). The intervention program was performed for eight weeks. The nutritional supplement was taken before dinner every day, and aerobic exercise and weight training were performed twice a week. Body weight, waist circumference, lipids, glucose, and insulin were measured before and after the intervention. Thirty-eight subjects completed the study (soy group: n = 17, wheat group: n = 21). At the end of the eight-week intervention, the mean weight of the soy group decreased significantly from 73.4 ± 9.4 kg to 69.0 ± 9.8 kg, and the mean weight of the wheat group decreased significantly from 75.5 ± 10.7 kg to 72.7 ± 11.0 kg. There was a time and group interaction, and the relative decrease in weight from pre- to post-intervention was greater in the soy group than the wheat group. Our data suggested that each group significantly lost weight but that the weight loss was more significant in the soy group.

Keywords: weight loss, exercise, low glycemic index, middle-aged

1. Introduction

The increased incidence of obesity and diabetes is becoming a major problem in many developed countries. The World Health Organization has estimated that by 2030, more than 360,000,000 people around the world will have diabetes. In Japan, diabetes and pre-diabetes affect approximately 22,100,000 people (approximately 20% of the total population), and this number is increasing. Both improved control of caloric consumption and increased physical activity are important factors for weight loss.

The American College of Sports Medicine and the American Heart Association recommend that all healthy adults should engage in aerobic physical activity of moderate intensity for a minimum of 30 min/d for 5 d/wk or vigorous aerobic activity for a minimum of 20 min/d for 3 d/wk. (Haskell et al., 2007). However, according to the National Nutrition Survey in Japan, only approximately 30% of Japanese adults reportedly engaged in an appropriate amount of weekly exercise (Ministry of Health, Labour and Welfare, 2010).

Many studies have addressed the effectiveness of changing one meal to a “meal replacement” supplement as a part of weight loss programs that control caloric intake (Allison et al., 2003; Cheskin et al., 2008; Davis et al., 2010). In nutrition intervention programs, caloric intake limitations enhance weight loss, although dietary adherence is strongly associated with rates of weight loss and is adversely affected by the severity of caloric restrictions (Del Corral et al., 2009).

According to the National Nutrition Survey
Comparison and Influence of Soy- vs. Wheat-based Supplementation

(Ministry of Health, Labour and Welfare, 2007), compared with other age groups, a higher proportion of working adults in their 30s and 40s eat dinner at a later hour. As a result, it is possible for these adults to overeat at dinner because of the long duration of time that has elapsed since their lunch. Therefore, we must investigate a weight-loss method in which working adults can control the quantities that they consume at dinner.

Soy-based supplements, which use unrefined whole soybeans as a raw material, are available in popular marketplaces and contain a comparatively high quantity of protein, dietary fiber, and fat. In addition, these supplements have low glycemic index (GI) values. It has been reported that soy-based foods are effective in suppressing increases in blood glucose (Ercan et al., 1994; Iwashita et al., 2008; Oku et al., 2009) and have a “second-meal effect” that suppresses increases in blood glucose from the subsequent meal (Iwashita et al., 2008; Liljeberg and Bjorck, 2000). These effects suggest that soy-based foods might be effective tools for weight loss and blood glucose control in diabetic patients. Although many studies report the benefits of low-GI diets, none have established that low-GI foods cause weight loss.

Although soy-based foods, which have low GI values in comparison to other types of between-meal snacks (in this paper, the term snack indicates cake and other sweet foods that are eaten either during a meal or between meals), have potential as supplements for controlling the amount of food that is consumed at dinner, no studies have examined their influence on weight loss in a middle-aged group of subjects in combination with a weight loss program featuring exercise and dietary controls. Middle-aged individuals tend to have inappropriate eating habits and metabolic syndromes. It is possible to achieve weight loss by controlling intake at dinner and by inducing the second-meal effect through the ingestion of soy-based foods before dinner.

The purpose of this investigation was to compare the influence of soy- and wheat-based foods on weight loss.

2. Methods

2.1. Subjects

This study included 50 overweight or obese men (n = 11) and women (n = 39) [mean body mass index (BMI) = 28.8 ± 2.8 kg/m²]. These individuals were aged 30-60 years (mean age = 47.2 ± 8.2 years) and were volunteers who had been recruited through advertisements. The recruitment of participants began in November 2009 and ended in December 2009. Subjects were excluded if they either performed vigorous exercise regularly or had a serious cardiovascular disease, metabolic disease, or walking disability. All of the subjects were informed of the details of the study and the possible risks and discomforts associated with the experimental procedures before they gave their written consent for participation. This study was approved by the Ethical Committee of the Institute of Health and Sport Sciences at the University of Tsukuba.

2.2. Experimental design

The subjects were randomly assigned to either the soy-based food group (soy group, 6 men and 18 women, n = 24) or the wheat-based food group (control group, 5 men and 21 women, n = 26). The intervention program lasted for eight weeks, beginning in January 2010 and ending in March 2010. During the program, the soy- or wheat-based foods involved in the experiment were consumed every day. The exercise aspects of the program were performed twice a week in classes and three times a week at home. This study was controlled by the double-blind method, and the group key was opened only after all of the analyses were completed.

2.3. Supplementary foods

The nutrient compositions of the test materials are provided in Table 1. The test food was a bar-type baked cake made from whole soy powder (SOYJOY®, 30 g/portion, 136 kcal/portion, Otsuka Pharmaceutical Co., Ltd., Tokyo, Japan).

<table>
<thead>
<tr>
<th>Nutrients</th>
<th>Soybean test food</th>
<th>Wheat test food</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy</td>
<td>136.4 kcal</td>
<td>129.0 kcal</td>
</tr>
<tr>
<td>Protein</td>
<td>4.4 g</td>
<td>2.0 g</td>
</tr>
<tr>
<td>Fat</td>
<td>7.2 g</td>
<td>4.8 g</td>
</tr>
<tr>
<td>Carbohydrate</td>
<td>11.8 g</td>
<td>18.9 g</td>
</tr>
<tr>
<td>Fiber</td>
<td>3.2 g</td>
<td>1.1 g</td>
</tr>
</tbody>
</table>

※ Amounts are per 30 g.
Wheat was used for the control group, and thus the test food for the wheat group consisted of a cake that had the same formulation except for the fact that the soy portion was changed to wheat (30 g/portion, 129 kcal/portion). The size of the sample was the same for the two groups. The subjects consumed one portion of the test food 1-2 h before dinner each day for eight weeks. To confirm their consumption of the test food, the subjects then returned the empty packages of supplements.

2.4. Diet instruction program

All of the subjects received instructions from a dietitian before starting the intervention. The subjects were informed of their limit for total daily energy intake, which was 2,000 kcal for men and 1,800 kcal for women. The daily energy intake was calculated as follows. [Standard weight (using a BMI of 22) × The basal metabolic rate according to age × Physical activity rate (multiplied by 1.5)]

The subjects were also asked to reduce their dinner intake to 130 kcal, which was equal to the energy that was contained in the test food. The dietitian ensured that the participants recognized the quantities of 1800 kcal, 2000 kcal, and 130 kcal by showing them meal and food photographs.

2.5. Exercise program

All of the subjects participated in the classroom exercise twice a week during the intervention. They performed aerobic training with a bicycle ergometer and weight-bearing training, which consisted of seven items: sit-ups, squats, back extensions, leg extensions, hip extensions, leg curls, and push-ups (10 repetitions × two or three sets). Using a bicycle ergometer, the aerobic power was calculated to be the physical work capacity (PWC) that was 75% of the maximum heart rate (HR max; watt/kg × correction factor). The mean target heart rate for both groups was 107 beats/min. Each subject was instructed to perform weight-bearing training at home for three days a week and to increase the amount that he/she walked by 3,000 steps each day.

2.6. Measurement parameters

2.6.1. Anthropometric measurements

We measured each subject’s height, body weight, body fat percentage, and waist circumference in the morning after the subject in question had fasted for 10 h or more. The same person performed the measurements before and after the intervention. Body weight was measured to the nearest 0.1 kg using a digital scale, and height was measured to the nearest 0.1 cm using a wall-mounted stadiometer. The BMI was calculated as body weight/height² (kg/m²). The waist circumference was measured three times to the nearest 0.1 cm at the mid-point between the lower costal margin and the iliac crest using a calibrated measuring tape. A bioelectrical impedance measurement instrument (Karada Scan HBF354, 50 kHz, 500 μA; Omron Healthcare Co., Ltd., Kyoto, Japan) was used to measure body fat and muscle (Oshima et al., 2010).

2.6.2. Physical fitness test

The physical fitness test was based on the Japan Fitness Test, which was approved by the Ministry of Education, Culture, Sports, Science, and Technology. The subjects performed the following five tests: grip strength, sit-ups, sit-and-reach, standing on one foot and balancing with the eyes open, and a 10 m hurdle walk. Each test was scored and then used to make decisions about the weight training program of each subject.

2.6.3. Physical activity measurements

Each subject’s daily physical activity was measured using a pedometer with a triaxial accelerometer (Active Style Pro®, Omron Healthcare Co., Ltd., Kyoto, Japan, Ohkawara et al., 2011) for seven days before and after the intervention. The participants were instructed to wear the accelerometer on an elastic waist band on their right hip throughout the day. In particular, the accelerometer was supposed to be worn from the time that the participants woke up in the morning until the time that they went to bed at night, except during showers and baths. Synthetic activity counts were recorded every 1 min by the accelerometer, and METs (metabolic equivalents) and the EX (Exercise; METs/hours/week) for locomotive and non-locomotive activities were estimated. Physical activity of 3 or more METs was recorded as a parameter of moderate-to-vigorous activity. We had the subjects wear the pedometers (Walking Style® HJ-730IT, Omron Healthcare Co., Ltd., Kyoto, Japan) during the intervention.
2.6.4. Sampling and blood analysis

Blood sampling and oral glucose tolerance tests (OGTTs) were executed before and after the intervention. Blood samples were collected in the morning after fasting for 10 h or more. The blood was analyzed for its levels of fasting blood glucose, fasting insulin, glycohemoglobin A1c (HbA1c), triglycerides, HDL cholesterol, LDL cholesterol, and total cholesterol.

An OGTT was performed after obtaining venous blood samples and measurements of blood pressure at the beginning and end of the study (which was 8 weeks in duration). A total of 50 g of glucose was ingested (Iwashita et al., 2008). During the OGTT, blood samples that were used to measure the glucose and insulin levels in the plasma were obtained at 0, 15, 30, 45, 60, 75, 90, 105, and 120 min. The glucose and insulin quantities that were obtained from the venous blood samples were analyzed at each time point. Changes in the incremental area under the curve (IAUC) between 0 and 120 min during the OGTT for plasma glucose (IAUC, Glucose 0-120) and plasma insulin (IAUC, Insulin 0-120) constituted the predefined primary endpoints. The baseline of the IAUC was set at 0 mg/dL for glucose and insulin. Stimulated secretion was represented by the areas under the glucose and insulin curves, using the levels recorded at 0 min as the baseline of the area. Seven subjects could not complete the oral glucose tolerance test. Therefore, the total number of subjects available for comparison through this test was 31 (soy group: 17; wheat group: 14).

2.6.5. Dietary evaluation

A three-day food record survey was conducted to investigate dietary nutritional intake. The subjects were asked to fill out a record sheet and to include all food and drink that they had consumed for three nonconsecutive days, including a holiday, for the analysis of nutritional intake. A pre-investigation was conducted before the start of the intervention and a post-investigation was conducted during the last week of the intervention.

The supplement was also included in the food that was recorded by the post-investigation. Computer software (Excel Eiyo-kun Ver. 2.3, Kenpaku Co., Ltd., Tokyo, Japan) was used to calculate the daily energy and nutrient intake of each subject. The subjects recorded the amount of food that they consumed at dinner and their hunger for each day. The hunger was evaluated using the following 5 categories: 1, very strong; 2, strong; 3, ordinary; 4, not strong; and 5, none at all.

The amount of food that was consumed at dinner was evaluated using the following 3 classifications: 1, much more than the previously determined amount; 2, a little more than the previously determined amount; and 3, the determined amount. The subjects rated their hunger immediately before dinner and rated the amount of food that they consumed after dinner.

2.7. Sample size

Power calculations were performed on the differential change in body weight using statistical software R (power = 0.80, significant level = 0.05, effect size = 0.85). Twenty-three participants per group were needed.

2.8. Statistical Processing

The results are expressed as the means ± standard deviation (SD). The two-way repeated measures analysis of variance approach was used to perform multiple comparisons. Comparisons of the hunger scale and the amount of food consumed at dinner in both groups were performed using unpaired t tests. For comparisons between the groups before the intervention, an unpaired t-test and a Mann-Whitney test were applied. All eight week outcomes were analysed on a PPB (Per Protocol Based), and additionally, ITT (Intention-to-Treat) analysis using baseline values carried forward if outcome date were missing were used. For all of the statistical analyses, SPSS version 12.0 J (SPSS Inc., Japan) was used. A value of p < 0.05 was considered to be statistically significant.

3. Results

3.1. Subjects

We excluded subjects if their adherence to the program (participation in the exercise classes and adherence to the test diet) was less than 70% or if they did not participate in the measurements before and after the intervention. In total, 12 individuals were excluded from the study due to these requirements. Three subjects in the wheat group were ex-
Table 2  Physical characteristics

<table>
<thead>
<tr>
<th></th>
<th>Total (N = 38)</th>
<th>Soy group (N = 17)</th>
<th>Wheat group (N = 21)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>47.2 ± 8.2</td>
<td>46.5 ± 8.7</td>
<td>47.8 ± 7.9</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>74.6 ± 10.1</td>
<td>73.4 ± 9.4</td>
<td>75.5 ± 10.7</td>
</tr>
<tr>
<td>Body Mass Index (kg/m²)</td>
<td>28.8 ± 2.8</td>
<td>28.6 ± 2.5</td>
<td>28.9 ± 3.0</td>
</tr>
<tr>
<td>Steps (steps/day)</td>
<td>5451 ± 2069</td>
<td>5521 ± 2106</td>
<td>5393 ± 2090</td>
</tr>
</tbody>
</table>

Mean ± SD

Table 3  Changes in physical composition

<table>
<thead>
<tr>
<th></th>
<th>Soy group</th>
<th>Wheat group</th>
<th>repeated ANOVA</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N  Pre Mean SD</td>
<td>Post 8 weeks Mean SD</td>
<td>N  Pre Mean SD</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>17 73.4 ± 9.4</td>
<td>69.0 ± 9.8</td>
<td>21 75.5 ± 10.7</td>
</tr>
<tr>
<td>Body Mass Index (kg/m²)</td>
<td>17 28.6 ± 2.5</td>
<td>26.8 ± 2.7</td>
<td>21 28.9 ± 3.0</td>
</tr>
<tr>
<td>Waist (cm)</td>
<td>17 95.9 ± 6.3</td>
<td>91.0 ± 7.9</td>
<td>21 98.8 ± 7.9</td>
</tr>
<tr>
<td>% muscle mass (%)</td>
<td>17 24.9 ± 2.7</td>
<td>25.9 ± 3.2</td>
<td>21 24.1 ± 3.1</td>
</tr>
<tr>
<td>% fat mass (%)</td>
<td>17 34.2 ± 4.7</td>
<td>31.7 ± 6.1</td>
<td>21 35.9 ± 4.8</td>
</tr>
</tbody>
</table>

Excluded due to insufficient supplement intake (less than 70%). One subject in the wheat group was excluded because of insufficient participation in the classroom exercises (less than 70%). One subject in the wheat group and seven subjects in the soy group were removed from the study because they could not participate in the classroom exercises for a specific reason, such as family care requirements or pregnancy, for instance.

The total number of subjects that remained in the study was 38; 17 subjects were in the soy group (23.5% of which were males) and 21 subjects were in the wheat group (19.0% of which were males). There was no significant difference in the gender compositions of the soy group and the wheat group.

The physical characteristics of the subjects before they began the program are provided in Table 2. There were no significant differences in the age, weight, BMI, and daily steps that were walked between the soy group and the wheat group.

3.2. Adherence to the program

The adherence to consuming the test food was 94.9% for the soy group and 92.2% for the wheat group. The adherence to participating in the exercise classes was 98.2% for the soy group and 97.9% for the wheat group. On average, the soy and wheat groups performed 5.0 and 4.4 of their intended weight-bearing training sessions per week, respectively, corresponding to adherences to the weight-bearing training regimen of 99% and 88%, respectively. There was no significant difference between the soy group and the wheat group with respect to the adherence to the weight-bearing training.

3.3. Body weight and composition

The physical characteristics of the subjects before and after the intervention are provided in Table 3. As a result of the 8-week intervention, the mean weight of the soy group significantly decreased from 73.4 ± 9.4 kg to 69.0 ± 9.8 kg, and the mean weight of the wheat group significantly decreased from 75.5 ± 10.7 kg to 72.7 ± 11.0 kg. There was an interaction between time and group (p<0.05), as the relative decrease in weight between pre- and post-intervention measurements was larger in the soy group than in the wheat group. Similarly, the reductions in BMI, waist circumference, and body fat percentage were more significant in the soy group than in the wheat group (p<0.05).

With respect to weight changes by gender, in the soy group, the mean weight of the women (n = 13) significantly decreased from 70.7 ± 7.0 kg to 66.8 ± 8.1 kg, and the mean weight of the men (n = 4) changed from 82.2 ± 11.9 kg to 76.3 ± 12.7 kg. In the wheat group, the mean weight of the women (n
-17) significantly decreased from 72.6 ± 9.0 kg to 69.5 ± 8.7 kg, and the mean weight of the men (n= 4) changed from 86.6 ± 9.5 kg to 81.4 ± 11.7 kg. The weight losses for the men during the course of the intervention were not significant.

To the result of the ITT analysis, the mean weight of the soy group significantly decreased from 74.9 ± 10.0, to 71.9 ± 10.9, and the mean weight of wheat group significantly decreased from 74.3 ± 10.3, to 72.1 ± 10.3. However, there were no significant differences between the two groups.

3.4. Daily food intakes

The dietary parameters before and after the intervention are shown in Table 4. During the eight-week intervention program, the total caloric intake, dinner caloric intake and carbohydrate consumption of the subjects decreased. However, no significant differences in any dietary parameter were observed between the soy and the wheat group before and after the intervention.

3.5. Physical activity

The total daily steps taken and physical activity before and after the intervention are indicated in Table 4. There were no significant differences between the two groups during the 8-week intervention.

3.6. Blood chemistry and blood pressure

The blood analysis and blood pressure of subjects before and after the intervention are provided in Table 5. Both groups experienced decreases in their blood pressure, LDL cholesterol, total cholesterol, and insulin levels over the course of the intervention period. However, there were no significant differences between the two groups.

3.7. Responses to oral glucose

The blood glucose IAUC values of the subjects are shown in Table 5. There was no significant

<table>
<thead>
<tr>
<th>Table 4</th>
<th>The changes in the energy intake, nutrient consumption, and physical activity of study subjects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soy group</td>
<td>Wheat group</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>Pre Mean SD</td>
</tr>
<tr>
<td>Total energy (kcal/day)</td>
<td>17</td>
</tr>
<tr>
<td>Energy of dinner (kcal/day)</td>
<td>17</td>
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<tr>
<td>Protein (g/day)</td>
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<tr>
<td>Fat (g/day)</td>
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<tr>
<td>Carbohydrate (g/day)</td>
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</tr>
<tr>
<td>Steps (steps/day)</td>
<td>17</td>
</tr>
<tr>
<td>Physical activity (METs·h/week)</td>
<td>17</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 5</th>
<th>Changes in blood pressure and blood data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soy group</td>
<td>Wheat group</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>Pre Mean SD</td>
</tr>
<tr>
<td>SBP (mmHg)</td>
<td>17</td>
</tr>
<tr>
<td>DBP (mmHg)</td>
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<tr>
<td>Fasting blood glucose (mg/dL)</td>
<td>17</td>
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<tr>
<td>Fasting insulin (µIU/mL)</td>
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<tr>
<td>Glu-IAUC* (mg·min/dL)</td>
<td>17</td>
</tr>
<tr>
<td>HbA1c (%)</td>
<td>17</td>
</tr>
<tr>
<td>Triglycerides (mg/dl)</td>
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</tr>
<tr>
<td>HDL cholesterol (mg/dL)</td>
<td>17</td>
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<tr>
<td>LDL cholesterol (mg/dL)</td>
<td>17</td>
</tr>
<tr>
<td>Total cholesterol (mg/dL)</td>
<td>17</td>
</tr>
</tbody>
</table>

*IAUC: The values indicate the incremental area under the curve of blood glucose
difference in IAUC after the intervention, and there was no significant interaction in IAUC between the soy group and the wheat group.

### 3.8. The control over dinner and the hunger scale

The amount of food consumption and the hunger scale of the subjects are shown in Table 6. No significant differences were observed in either parameter.

### 4. Discussion

The purpose of this study was to investigate and compare the influence of soy- and wheat-based foods on the weight loss of middle-aged individuals in a weight loss program involving exercise and dietary control. Each group lost significant amounts of weight, but the weight loss was more significant in the soy group than in the wheat group.

In a previous study, the soy-based food used in this study was determined to have a GI value of 6.2, which is markedly lower than the GI values of other foods that are used as between-meal snacks (Iwashita et al., 2008). This low GI value is thought to be partially due to the composition of the soy-based nutrient. In fact, 90% of the carbohydrates in the test food have the same composition as sucrose, which is a compound of glucose and fructose at a one-to-one ratio.

In addition, the protein, fat, and dietary fiber that are included in the test food decrease sugar digestion and absorption (Iwashita et al., 2008). Moreover, previous studies have indicated that the consumption of foods with low GI values suppresses the increase in blood glucose that occurs during meals; this phenomenon explains the second-meal effect (Iwashita et al., 2008; Liljeberg and Bjorck, 2000).

In a previous study, the second-meal effect has been shown to occur for the soy-based nutrients that were used in the present study (Iwashita et al., 2008). The wheat group’s test food contained the same elements that were used in a previous study, and it was determined in that study that the blood glucose and insulin levels increased 30-45 minutes after the ingestion of this test food; these levels were significantly higher in the wheat group than in the soy group (Iwashita et al., 2008). In the present study, the energy of controlled dinners was compared for the soy group and the wheat group, based on the hypothesis that the ingestion of soy-based food, which has a low GI value and produces the second-meal effect, would produce a positive effect on post-dinner blood glucose responses and thereby increase the effectiveness of weight loss efforts.

In this study, postprandial blood glucose should be suppressed with low-GI foods, such as the soy group’s test food, and we hypothesized that we would observe a suppressive effect on blood glucose and insulin levels from these foods both before and after the intervention. However, we could not demonstrate that after the ingestion of the low-GI food as a pre-dinner snack, the repeated control of subsequent eating-induced increases in blood glucose affected the suppression of blood glucose, as measured by the glucose tolerance test. In this study, individuals who clearly showed signs of being diabetic were excluded from the study. Prior to the start of the intervention, the study subjects had an average blood glucose level of 103 mg/dL, which was a normal level. This glucose level may have influenced the lack of a marked difference between the two groups before and after the intervention.

Although a significant reduction was observed in both total one-day energy intake and dinner energy intake after the intervention in both groups, no sig-
significant differences were observed between the groups. Furthermore, no significant differences were observed between the groups for the average rates of change in total energy consumption during eight weeks (soy group: $-20.7 \pm 28.8\%$; wheat group: $-19.8 \pm 23.8\%$) or the average rates of change in dinner energy consumption during eight weeks (soy group: $-41.0 \pm 59.2\%$; wheat group: $-31.0 \pm 64.7\%$). These results indicated that no significant differences were observed between the two groups with respect to either subjective feelings of hunger before dinner or the control of caloric intake during dinner. We hypothesized that the slow digestion and absorption of soy-based food would influence pre-dinner hunger suppression and change the quantity of food that was consumed at dinner; however, this effect was not observed in the present study. It is possible that the quantity of daily physical activity contributed to the weight losses that were observed during the intervention period. However, there was no significant difference in the daily steps between the two groups, and it is believed that the controls implemented to prevent differences from arising between the two groups regarding the implementation of the exercise program were successful. Therefore, it appears unlikely that the implementation of the exercise program or differences in consumed energy influenced the significantly greater weight loss in the soy group. We hypothesized that the low GI value of soy-based food would suppress hunger pangs before dinner and reduce the amount of dinner that was consumed. In addition, we thought that the soy-based food would contribute to post-dinner blood glucose suppression through the second-meal effect, which would result in a greater rate of weight loss in the soy group compared with the wheat group. Although the intake of soy foods for eight weeks did not change blood glucose responses, we thought that the accumulation of the temporary second-meal effect from consuming soy food before dinner was most likely a factor in the greater levels of weight loss that were observed in the soy group. However, we could not clarify the mechanism by which the intake of soy-based food influenced the weight loss that was observed during the weight loss program. A more detailed investigation is necessary to examine the possibility that the accumulation of the second-meal effect leads to weight loss. Because this study was conducted with non-diabetic middle-aged individuals who had a tendency toward obesity, further studies are necessary to determine if the present results apply to blood glucose control and weight loss in patients with diabetes.

Although nutritional guidance was given just once prior to intervention in this study, a 5% weight loss was achieved after the short-term intervention of this study. Although there was a tendency towards a lower rate of weight loss in this study compared with previous studies that involved intervention periods ranging from 12 weeks to a year (Larson-Meyer et al., 2006; Racette et al., 2006; Ross et al., 2000; Ross et al., 2004), and published reports claim that the effects of weight loss are greater over longer periods of time (Wadden et al., 2004), we believe that we have obtained the same weight loss results over the short, eight-week period that are often observed in studies with longer intervention periods. We think that the increase in energy consumption that resulted from the increase in the number of steps taken by study subjects by approximately 3,000 steps each day contributed to the quantity of weight loss that was observed. In particular, although the energy consumption of the subjects increased, the quantity of energy that the subjects took in at meals was fixed, leading to approximately 3 kg of weight loss over the course of eight weeks. The weight loss is determined by the difference between energy intake and consumption. We believe that the intake of soy-based foods has produced an increase in the energy consumption of subjects. However, because the quantity of meals is only assumed but not known for three days out of the last week of the intervention, this difference could not be proven.

One study suggested that the initial rate of weight loss during the first month influenced the rate of later performance (Adachi and Tanaka, 2008); thus, for obese subjects, the ability to achieve weight loss in a short period of time was thought to be an important aspect of achieving weight loss goals. Although greater weight loss could be obtained with the enforcement of nutritional interventions that produce a larger daily energy deficit, it has been demonstrated that the program compliance of subjects is worse for programs involving greater energy deficits (Del Corral et al., 2009; Hammer et al., 1989). Therefore, in the early stage of weight loss, a simpler program is optimal. The weight loss method in this study was to consume snacks to suppress nighttime hunger pains and reduce dinner portions without limiting meals. We believe that subjects who
had eating habits that made them prone to obesity
would still be able to follow this program.

In the result of ITT which carried out additional-
ly, although weight of both groups decreased sig-
ificantly, there were no significant differences be-
tween the two groups. Because ITT analysis using
baseline values carried forward if outcome date were
missing, it is considered to have influenced the result
that there are more dropouts of soy group than
wheat group.

In conclusion, the weight-loss program that used
soy-based food produced a larger quantity of weight
loss compared with the control group, and therefore
the effectiveness of soy-based nutrients was demon-
strated. However, a change in the blood glucose
response, which was thought to be one of the factors
that would influence both the weight loss and other
positive effects, was not observed between groups.
Although the rate of weight loss was high in the soy
group, we could not definitively determine that the
results were due to the low-GI properties of the soy-
based food. Further studies are required to clarify
the mechanism by which soy-based foods produce
weight loss.

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Comparison and Influence of Soy- vs. Wheat-based Supplementation


List of abbreviations
BMI: Body Mass Index
Soy group: soy-based nutrients group
Wheat group: wheat-based nutrients group
GI: glycemic index
HbA1c: glycohemoglobin A1C
OGTT: oral glucose tolerance tests
IAUC: incremental area under the curve
PWC: physical work capacity
HRmax: heart rate max
MET: Metabolic equivalent

Name: Yoko Suga
Affiliation: Department of Health and Nutrition, Human and Environmental Studies, Kanto Gakuin University
Address: 1-50-1 Mutsuura-higashi, Kanazawa-ku, Yokohama-shi, Kanagawa, 236-8503, Japan

Brief Biographical History:
1994-1996 Master’s Program in Health and Sport Science, University of Tsukuba
1996-2004 Public office, Taiyo village
2004-2007 Doctoral Program in Sport Medicine, University of Tsukuba
2007-2012 Researcher of Tsukuba Wellness Research Co., Ltd

Main Works:
•Relationships between nutrition intake status, nutritional condition and physical fitness in elderly women. Int. J. Sport Health Sci., 4: 544-554, 2006

Membership in Learned Societies:
•The Japanese society of physical fitness and sports medicine
•The Japan society of physical education, health and sport sciences
•The Japan society of exercise and sports physiology
•The Japan dietetic association
•The Japanese society of nutrition and dietetics
•The Japanese society of public health
•The Japanese society of Clinical Sports Medicine