ABSTRACT

I determined whether water consumption reduces energy intake and affects satiety in non-obese young adults. The final subjects consisted of 15 individuals (8 women and 7 men) with average ages of 26.4 and 23.5 years for women and men, respectively. When subjects drank water before eating a test meal, they ate a lower amount of the test meal compared to eating test meals under waterless and postload water conditions (preload water: 123.3 g vs. waterless: 161.7 g or postload water: 163.3 g, p < 0.05). Water consumption after eating a test meal did not affect energy intake. When the subjects drank water before eating a test meal, despite consuming a lower amount, the subjects did not feel significantly less satiety than eating meals under waterless or postload water conditions. The finding that pre-meal water consumption led to a significant reduction in meal energy intake in young adults suggests that pre-meal water consumption may be an effective weight control strategy, although the mechanism of action is unknown.

Keywords: Water; Obesity; Energy intake; Satiation

INTRODUCTION

Obesity is a medical condition in which excess body fat has accumulated to the extent that it may bring negative effects on health. Obesity increases the risk of many physical and mental conditions [1]. These comorbidities are most commonly shown in metabolic syndrome, a combination of medical disorders which includes: diabetes mellitus type 2, high blood pressure, high blood cholesterol, and high triglyceride levels. Obesity is one of the leading preventable causes of death worldwide [2,3].

Increasing daily water consumption is widely recognized by the general public as a weight loss strategy [4]. Previous studies typically showed a reduction in energy intake when water was added to the diet [5,6]. Popkin and colleagues [7] reported that daily energy intake among habitual water drinkers in the general adult population was approximately 9% (194 kcal/day) less than those who did not drink water. There is a common belief among the public that water consumption suppresses hunger and reduce energy intake, and therefore water consumption is frequently recommended to facilitate weight control [8]. Recently, it was reported that water consumption has been found to reduce energy intake among non-obese...
older adults, but not in younger adults [8,9]. These differences may be caused by age-related changes in gastrointestinal physiology and perceptions of satiety. The specific mechanism that is responsible for reduced energy intake after water consumption among older adults remains unknown, but it is suspected that delayed gastric emptying may contribute to promoting fullness and reducing hunger [8,10,11]. In this study, I determined whether water consumption reduces energy intake and affects satiety in non-obese young adults. I also observed whether water postload and preload had any effects on energy intake and satiety.

**MATERIALS AND METHODS**

Subjects were recruited via advertisement in a local newspaper. Recruited individuals were interviewed to ensure they met the following criteria: healthy, 20–30 years of age; body mass index (BMI) of 18–30 kg/m²; not taking medication known to influence energy intake or appetite; not athletes in training; not pregnant or lactating; non-smokers; free from food allergies; stable in weight in the past 6 months; and not on a diet to gain or lose weight. The Eating Attitudes Test [12], which measures attitudes towards foods and eating, and the Zung Self-Rating Questionnaire [13], which assess symptoms of depression were also included in the criteria. Volunteers who scored less than 20 on the Eating Attitudes Test and less than 42 on the Zung Self-Rating Questionnaire were selected for participation. The study was approved by the Ethical Committee for Human Experimentation, Jeonju University, and was conducted in accordance with the Committee’s rules and regulations (jjIRB-160919-HR-2016-0904).

Before commencing study, subjects’ height was measured using the DS-102 (Jenix Co., Seoul, Korea); their weight and body composition (body fat and lean body mass) were measured using the InBody 770 (Biospace Co., Seoul, Korea) while wearing light clothing. BMI (kg/m²) was calculated as body weight (kg)/[height (m)]². Blood pressure was measured in a standardized fashion using a BP203RV blood pressure monitor (Colin, Komaki, Japan).

The experiment was a randomized cross-over design. Subjects came to the laboratory on three separate days and were asked to keep their evening meals and activity levels as similar as possible on the days prior to each test day. They were also instructed to refrain from consuming any foods or energy-containing beverages before a test meal. Subjects reported to the laboratory for three test meals (Jeolpyeon, 500 g) in random order as follows: 1) without water, 2) with water (300 mL) before a test meal (water preload), and 3) with water (300 mL) after a test meal (water postload). Jeolpyeon is a type of Korean steamed rice cake made of non-glutinous rice flour. One piece of Jeolpyeon (20 g) contained 44 kcal, 9.56 g of carbohydrates, 0.16 g of fat, and 0.86 g of protein. Large servings (20 pieces or 400 g) were provided to ensure that the amount of food served does not limit food intake. Subjects were instructed to eat as much or as little of a meal as they desired. The test meal was provided between 9:00 am and 10:00 am as breakfast. Each test meal was weighed after serving to determine the amount consumed to within 0.1 g. Subjective satiety and thirst were measured by a conventional 100 mm visual analogue scale (VAS) rating. Subjects completed this rating 6 times: immediately before and after the meal, then every half-hour for 2 hours after the meal. Subjects rated how hungry or thirsty they felt by marking a cross on a scale of 0 to 100 mm. On the scale, 0 represented ‘not at all’ whilst 100 represented ‘very much.’ The pleasantness was also assessed using an additional 100 mm VAS prior to consumption. All statistical analyses were conducted using a repeated measure analysis of variance with one within subject factor and Bonferroni-adjusted pairwise comparisons entered into the SPSS program (ver. 12.0; SPSS Inc., Chicago, IL, USA). The results are reported as means ± standard error of the mean. Differences in means were considered significant at p < 0.05.
RESULTS

The subjects’ characteristics are provided in Table 1. Sixteen adults were selected for participation in the study. One subject failed to complete the study. Thus, the final subjects consisted of 15 individuals (8 women and 7 men) with average ages of 26.4 and 23.5 years for women and men, respectively. The women had average heights and weights of 160.4 cm and 53.2 kg, respectively, whilst the men had average heights and weights of 172.3 cm and 65.4 kg, respectively. In addition, the mean scores for eating attitudes were 12.4 and 9.8 points for women and men, respectively, whilst the depression scores were 39.4 and 38.7 points for women and men, respectively. When subjects were asked to rate the pleasantness of the meal’s taste, they indicated no significant differences among the 3 test meals (data not shown).

![Figure 1](https://doi.org/10.7762/cnr.2018.7.4.291)

**Figure 1.** Consumption volume on test meals served with and without water. Each box plot is composed of 5 horizontal lines that display the 10th, 25th, 50th, 75th, and 90th percentiles, respectively. All values above the 90th and below the 10th percentiles are plotted separately. The different marks indicate significant differences by a repeated measures analysis of variance followed by Bonferroni-adjusted pairwise comparisons.

| Characteristics                      | Subjects (n = 15) |          |          |
|--------------------------------------|-----------------|----------|----------|
|                                      | Women (n = 8)   | Men (n = 7) |          |
| Age, yr                              | 26.4 ± 2.2      | 23.5 ± 1.7 |          |
| Height, cm                           | 160.4 ± 2.7     | 172.3 ± 2.9 |          |
| Weight, kg                           | 53.2 ± 4.9      | 65.4 ± 4.2 |          |
| Body mass index                      | 20.4 ± 3.7      | 21.9 ± 3.4 |          |
| Systolic blood pressure, mmHg        | 117.8 ± 8.3     | 133.9 ± 5.6 |          |
| Diastolic blood pressure, mmHg       | 71.8 ± 3.8      | 75.6 ± 3.2 |          |
| Pulse, beats/min                     | 95.8 ± 5.9      | 92.2 ± 4.4 |          |
| Eating attitude score                | 12.4 ± 3.2      | 9.8 ± 1.6  |          |
| Depression score                     | 39.4 ± 4.3      | 38.7 ± 3.7 |          |

Values are mean ± standard error of the mean for 15 subjects. Eating attitude score was assessed by the Eating Attitude Test; Depression score was assessed by the Zung Self-Rating Questionnaire.
with and without water are presented in Figure 2. The initial ratings on satiety and thirst did not differ among the test meals served with or without water. As expected, satiety and thirst ratings changed significantly with time in response to meal ingestion. There was a significant difference in fullness between meal conditions. After eating a test meal, subjects reported significantly more fullness under the postload water condition than under the waterless condition (waterless: 66.5 mm vs. postload water: 86.4 mm, p < 0.05). There were no significant differences in satiety ratings between preload and postload water conditions for 2 hours after eating test meals. Even though subjects drank water before eating a test meal, despite consuming less, they did not feel significantly less satiety compared with waterless or postload water conditions. Water consumption had a significant effect on thirst ratings. When subjects ate a test meal with water (preload or postload), they felt significantly less thirst compared with the waterless condition (p < 0.05).

Figure 2. (A) Hunger and (B) thirst ratings on test meals served with and without water. Values are means ± standard error of the mean for 15 subjects. Data were analyzed with a repeated measure analysis of variance followed by Bonferroni-adjusted pairwise comparisons.
DISCUSSION

It was found that pre-meal water consumption, indeed, reduced energy intake among the non-obese young adults. An acute reduction in energy intake following water ingestion was observed. Low-energy, high-volume preloads, including specific formulations of soups and salads, reduce hunger before a meal and reduce overall energy intake compared to a condition without preloading [14,15]. The effect of beverage consumption on energy intake has been of interest, because it has been suggested that liquid foods are less satiating than solid foods [16]. Two small laboratory studies identified by a systemic review [17] had specifically investigated whether preload water would lead to a reduction in energy intake. Both laboratory studies compared a group of participants who were given preload of water before a test meal to a group of participants who were not given the preload and found that overall energy intake from the meal was lower in the preload group than in the other group [8,9]. More test meal studies have shown that consuming water prior to and during meals increases satiety and causes changes in the subjective sensations of satiety associated with reduced energy intake [4,6,8,9]. Water consumption after a meal, however, did not have an effect on energy intake. Whether the reduction in energy intake results in weight loss is unclear, although the recent study by Dennis et al. [4] suggests that this might be the case at least in the short term. The mechanism responsible for the observed effects of preloading is unclear, but one potential explanation was proposed, that consuming water before a meal reduces the energy density of stomach contents [18]. Previous cohort studies and controlled trials have shown that consumption of lower energy density foods could have an effect on body weight in the short term, but this effect may not be maintained in the longer term [19-21]. It is important to assess whether or not the short-term weight loss effect of preload water consumption will maintain its effect in a longer time frame. The results of this study are consistent with the expectation that water consumption may promote weight loss by lowering total energy intake. A present study also suggests that immediate pre-meal water ingestion might be a viable strategy that could help facilitate weight management among young adults [22].

My finding that pre-meal water consumption led to a significant reduction in meal energy intake in the young suggests that this may be an effective weight control strategy, even though the mechanism of action remains unknown. Future studies should involve investigation of the effects of immediate pre-meal water ingestion in overweight/obese young subjects, as well as long-term weight loss effects of this dietary strategy.

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