Objective and Subjective Eating Speeds Are Related to Body Composition and Shape in Female College Students

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Summary  Eating speed reportedly relates to body composition and shape. Little is known about the relationship between the objectively assessed eating speed and the body composition and shape. This study examined relationships between eating speed as assessed both objectively and subjectively, and body composition and shape. The following variables of body composition and shape were measured in 84 female college students: body mass, relative body fat mass (%Fat), body mass index (BMI), and circumferences of the waist, abdomen and hip. After measuring the body composition and shape, subjects consumed a 174-kcal salmon rice ball. The following chewing variables were measured by observing videotape recordings of the subjects’ faces: number of chews per bite, total number of chews, total meal duration, number of bites, and chewing rate. The subjects were categorized into three groups (fast, moderate and slow) according to their own subjective assessments of the actual eating speed. In objective assessments of the eating speed, the total number of chews and the total meal duration were significantly negatively correlated with the body mass, %Fat, BMI, and circumferences of the waist, abdomen and hip. In subjective eating-speed assessments, the body mass, %Fat, BMI, and circumferences of the waist, abdomen and hip were greater in the fast eating group than in the slow eating group. Both the objectively and subjectively assessed eating speeds are related to the body composition and shape. The present study supports that fast eating may relate to gains in body mass and/or fat mass.

Key Words  body composition, eating speed, mastication, meal duration

Overweight and obesity have become one of the public health issues disseminating worldwide: the global obesity pandemic (1). The presence of overweight and obesity increases the incidence rates of many health problems, including cardiovascular diseases, diabetes, musculoskeletal disorders, and some cancers (2). Strategies for effectively preventing the spread of overweight and obesity are therefore urgently needed.

Slow eating, which involves chewing food slowly and thoroughly, is an effective strategy for preventing overweight and obesity, with many previous studies having found eating speed to be related to the body composition and shape (3–18). However, these studies were limited by their use of questionnaires to assess the eating speed. While questionnaires make it easy to survey eating speeds in large samples, it is unclear whether such subjective assessments of eating speed actually reflect actual eating speeds. Objective assessments of the eating speed are therefore necessary for reliably investigating the relationships between the eating speed and the body composition and shape.

To the best of our knowledge, only one study has objectively assessed the eating speed (19); those authors found that the total numbers of chews and the total meal duration were significantly correlated with the body mass index (BMI). Both males and females were included in that study, whereas Hill and McCutcheon found that chewing variables are affected by sex, with the eating duration being shorter and the number of bites for consuming two doughnuts being smaller in males than in females (20). Thus, elucidating the relationships between the eating speed and the body composition and shape requires the influence of sex to be controlled.

The purpose of the present study was to elucidate the relationships between the eating speed—as assessed both objectively and subjectively—and the body composition and shape while eliminating the influence of sex. In addition, an effect of the number of chews per
Materials and Methods

Subjects. Eighty-four healthy female college students participated in this study. The inclusion criteria were being a non-smoker and free from food allergies. Subjects were not informed about the exact purpose of the study until the experiments were finished in order to avoid possible attitude-driven changes in their eating behaviours. Instead, the subjects were simply told that the study was designed to monitor eating behaviours. This study was conducted according to the guidelines laid down in the Declaration of Helsinki and approved by the Ethics Committee of the Institute of Health Science, Kyushu University, Japan (IHS-2012-11). Each subject provided written informed consent to participate prior to the commencement of the study.

Study protocol. The body composition and shape were first measured, and then each subject was seated on a chair against a wall by herself to avoid any interference with the usual eating behaviours, where she consumed the test food, which comprised a commercially prepared salmon rice ball with an energy content of 174 kcal (energy proportions: 10% protein, 7% fat, and 83% carbohydrate). Each subject was instructed to consume the test food as she normally would, while not drinking, consuming food other than the test food or talking. The face of each subject was videotaped while consuming the test food to allow the chewing variables to be analysed later. After consuming the test food, the subjects self-rated their eating speed into three groups (fast, moderate and slow) based on their own subjective assessment of eating speed.

Measurements of body composition and shape. The following variables of body composition and shape were measured before the subjects consumed the test food: body mass, relative body fat mass (%Fat) (HBF-306, Omron Healthcare, Japan), and circumferences of the waist, abdomen and hip (measured using a tape measure in the expiratory phase in the upright position). The waist, abdomen and hip circumferences were measured at the smallest part of abdomen, around the abdomen at the level of the navel and around the widest part of the hip, respectively. The height was obtained from data measured in a college physical examination, and the BMI was then calculated as the body mass in kilograms divided by the square of the height in metres.

Data analysis. The following chewing variables were measured by observing the videotape recordings of the subjects’ faces: number of chews per bite, total number of chews, total meal duration, number of bites and chewing rate. The number of chews per bite was counted using a hand tally counter. The total number of chews was calculated from the number of chews per bite summation. The total meal duration was assessed as the duration from the first bite to swallowing after the last bite of the test food. The chewing rate was calculated from the total number of chews and the total meal duration. Each chewing variable was measured twice; the difference between the first and second measurements was 0.5 ± 0.4% (mean ± SD) for the total number of chews and 0.1 ± 0.1% for the total meal duration. The closeness of these measurements meant that only the first measurements were used for further analyses.

The subjects were categorized into three groups (fast, moderate and slow) based on their own subjective assessments of the actual eating speed. The subjects were also categorized into below and above the number of chews per bite of 30 times (<30-CB and ≥30-CB groups).

Statistical analysis. The data are expressed as mean ± SD values. Pearson’s correlation analyses were conducted between the body composition and shape and the chewing variables. One-way analysis of variance was used to examine the effects of the subjectively assessed eating speed on the body composition and shape and the chewing variables. When a significant F value was detected, this was analysed using the Games-Howell post-hoc test for comparisons among groups. Unpaired trend tests were used to examine trends in the body composition and shape and the chewing variables among the three eating-speed groups adjusting for the number of subjects at each group. An unpaired t-test was used to examine the effect of 30-CB on the body composition and shape and the chewing variables. Statistical significance was accepted as being present.

Table 1. Relationships between the body composition and shape and the chewing variables.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Body mass</th>
<th>%Fat</th>
<th>BMI</th>
<th>Waist</th>
<th>Abdomen</th>
<th>Hip</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of chews per bite</td>
<td>0.05</td>
<td>-0.11</td>
<td>-0.06</td>
<td>-0.03</td>
<td>0.03</td>
<td>-0.07</td>
</tr>
<tr>
<td>Total number of chews</td>
<td>-0.22*</td>
<td>-0.25*</td>
<td>-0.24*</td>
<td>-0.26*</td>
<td>-0.25*</td>
<td>-0.24*</td>
</tr>
<tr>
<td>Total meal duration</td>
<td>-0.24*</td>
<td>-0.23*</td>
<td>-0.27*</td>
<td>-0.24*</td>
<td>-0.27*</td>
<td>-0.22*</td>
</tr>
<tr>
<td>Number of bites</td>
<td>-0.25*</td>
<td>-0.13</td>
<td>-0.17</td>
<td>-0.20</td>
<td>-0.25*</td>
<td>-0.14</td>
</tr>
<tr>
<td>Chewing rate</td>
<td>-0.06</td>
<td>-0.11</td>
<td>0</td>
<td>-0.11</td>
<td>-0.03</td>
<td>-0.12</td>
</tr>
</tbody>
</table>

Data are Pearson’s correlation coefficients. *p<0.05, significant correlation by Pearson’s correlation analysis. %Fat, relative body fat mass; BMI, body mass index.
when \( p<0.05 \). All statistical analyses were performed with SPSS (IBM SPSS Statistics 21.0 for Windows, IBM, Japan).

**RESULTS**

**Objective assessments of eating speed and body composition and shape**

The total number of chews and the total meal duration were significantly negatively correlated with the body mass, %Fat, BMI, and circumferences of the waist, abdomen and hip (Table 1). The number of bites was significantly negatively correlated with the body mass and the abdominal circumference.

The relationships between the %Fat, BMI and total number of chews and the total meal duration are shown in Fig. 1. The correlation coefficients ranged from \(-0.23\) to \(-0.27\).

**Subjective assessments of eating speed and body composition and shape**

In their own subjective assessments of eating speeds, 28, 47 and 9 subjects rated themselves as fast, moderate and slow eaters, respectively. The body composition and shape in the groups categorized based on subjective assessments of eating speed are listed in Table 2. The body mass, %Fat, BMI, and circumferences of the waist, abdomen and hip were significantly greater in the fast eating group than in the slow eating group. The BMI and the waist and hip circumferences were significantly...
Relationship between Eating Speed and Body Composition

The number of bites ($6.6$ times/bite) and the chews per bite ($11.6$ times) were lower and the total meal duration was significantly longer in subjectively slow eaters. The number of chews per bite of $30$ (30-CB) group was significantly lower and the total meal duration was significantly longer in the slow eating group. The total number of chews and the total meal duration were significantly negatively correlated with the body mass, %Fat, BMI, and circumferences of the waist, abdomen, and hip. When subjects were categorized based on their subjectively assessed eating speeds, with the total number of bites being lower and the total meal duration being shorter in fast eating than slow eating subjects (19). That previous study also found that the number of bites was smaller in fast eating than slow eating subjects, while the bite size (amount per bite) was larger in the fast eating subjects (19). The present and previous studies (19) together demonstrate the presence of relationships between both the objectively and subjectively assessed eating speeds and the body composition and shape.

The present study included only female subjects so as to eliminate the influence of sex. A previous study found that chewing variables were influenced by sex: the number of bites was significantly lower and the total meal duration was significantly shorter in male subjects than female subjects, while eating speed was faster and the bite size was larger in the male subjects (20). Another study showed relationships between the body composition and shape and various chewing variables, while it did not examine the effect of sex on chewing variables; however, it is likely that the total number of chews and the number of bites were lower and the total meal dura-

**Table 3. Chewing variables for all subjects and in the three subjective-eating-speed groups.**

<table>
<thead>
<tr>
<th></th>
<th>All ($n=84$)</th>
<th>Fast ($n=28$)</th>
<th>Moderate ($n=47$)</th>
<th>Slow ($n=9$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of chews per bite</td>
<td>$24\pm8$</td>
<td>$24\pm6$</td>
<td>$24\pm8$</td>
<td>$28\pm12$</td>
</tr>
<tr>
<td>Total number of chews</td>
<td>$250\pm67$</td>
<td>$221\pm63$</td>
<td>$254\pm63$</td>
<td>$315\pm45$</td>
</tr>
<tr>
<td>Total meal duration (s)</td>
<td>$206\pm48$</td>
<td>$182\pm43$</td>
<td>$211\pm44$</td>
<td>$260\pm39$</td>
</tr>
<tr>
<td>Number of bites</td>
<td>$11\pm3$</td>
<td>$10\pm3$</td>
<td>$11\pm3$</td>
<td>$13\pm5$</td>
</tr>
<tr>
<td>Chewing rate (times/s)</td>
<td>$1.2\pm0.1$</td>
<td>$1.2\pm0.2$</td>
<td>$1.2\pm0.2$</td>
<td>$1.2\pm0.1$</td>
</tr>
</tbody>
</table>

Data are mean±SD values. *p<0.05, fast vs. slow eating group by one-way analysis of variance among the three eating-speed groups. †p<0.05, moderate vs. slow eating group by one-way analysis of variance among the three eating-speed groups. ‡p<0.05, fast vs. moderate eating group by one-way analysis of variance among the three eating-speed groups. §p<0.05, significant trend by unpaired trend test among the three eating-speed groups.

**DISCUSSION**

The present cross-sectional study examined relationships between the eating speed as assessed both objectively and subjectively and the body composition and shape solely in female subjects so as to eliminate the influence of sex. The objective and subjective eating speeds were related to the body composition and shape in 84 healthy female college students, with faster eating being related to overweight or greater relative fat mass. Together with previous cross-sectional studies (e.g., Ref. 19), these results demonstrate that fast eating is related to being overweight.

The eating-speed variables were related to body composition and shape, with faster eating being associated with overweight. The present study assessed eating speed both objectively and subjectively because it was unclear whether the subjective eating speed, as used in previous studies (3–18), actually reflects a subject’s actual eating speed. The objectively assessed variables of eating speed, total number of chews and total meal duration were significantly negatively correlated with the body mass, %Fat, BMI, and circumferences of the waist, abdomen, and hip. When subjects were categorized based on their subjectively assessed eating speeds, the body mass, %Fat, BMI, and circumferences of the waist, abdomen, and hip were greater in the fast eating group than in the slow eating group. These results are consistent with the study of Ekuni et al., finding relationships between the BMI and the objectively and subjectively assessed eating speeds, with the total number of bites being lower and the total meal duration being shorter in fast eating than slow eating subjects (19). That previous study also found that the number of bites was smaller in fast eating than slow eating subjects, while the bite size (amount per bite) was larger in the fast eating subjects (19). The present and previous studies (19) together demonstrate the presence of relationships between both the objectively and subjectively assessed eating speeds and the body composition and shape.

The present study included only female subjects so as to eliminate the influence of sex. A previous study found that chewing variables were influenced by sex: the number of bites was significantly lower and the total meal duration was significantly shorter in male subjects than female subjects, while eating speed was faster and the bite size was larger in the male subjects (20). Another study showed relationships between the body composition and shape and various chewing variables, while it did not examine the effect of sex on chewing variables; however, it is likely that the total number of chews and the number of bites were lower and the total meal dura-
tion was shorter in male subjects than female subjects, while the eating speed was faster and the bite size was larger in the male subjects in that study (see Table 2 in Ref. 19). The present study excluded the influence of sex, and still found significant negative correlations between the body composition and shape and the objectively assessed eating speed.

Cross-sectional, longitudinal and experimental studies have provided strong evidence for fast eating inducing overweight (3–19). The subjects in the present study who assessed themselves as fast eaters tended to be overweight and obese, and indeed ate the test meal with a smaller total number of chews and shorter total meal duration than did the slow eaters. This is consistent with the findings of many previous studies of the relationships between the objectively and subjectively assessed eating speeds and the body composition and shape (3–19). Previous studies have also demonstrated that fast eating induces overeating, and that overeating is related to weight gain due to the ingestion of a larger volume of food before experiencing satiety (22–24). Longitudinal studies found that fast eating induced weight gain, with the odds ratio of being overweight during a 3-y follow-up being 4.4 times higher in fast eaters than in not-fast eaters (5), and the weight gain during an 8-y follow-up being 1.9 kg in a fast eating group compared to 0.7 kg in moderate and slow eating groups (15). In addition, our recent experimental studies showed that the postprandial energy expenditure was greater for slow eating than fast eating when consuming the same test meal, suggesting that fast eating is related to overweight even in the absence of overeating (25, 26). These observations together indicate that fast eating can lead to weight gain via multiple mechanisms.

The present study found that the objectively and subjectively assessed eating speed were similar. The total number of chews was lower and the total meal duration was shorter in the fast eating group than the slow eating group as assessed by the subjects themselves. In other words, the subjects who assessed themselves as being fast eaters did indeed eat rapidly. Nevertheless, the number of chews per bite, the number of bites and the chewing rate did not differ among the three eating-speed groups. The number of chews per bite and the number of bites tended to be smaller in the fast eating group than in the slow eating group. The total number of chews was calculated from the number of chews per bite and the number of bites, and so small differences in the number of chews per bite and the number of bites among three groups could have affected the calculated total number of chews. The chewing rate did not differ significantly among the three eating-speed groups, which is consistent with the findings of previous studies (e.g., Ref. 19).

The results did not necessarily support the number of chews per bite of 30 as being a suitable cut-off point for assessing the body composition and shape. The body mass, %Fat, BMI, and circumferences of the waist, abdomen and hip did not differ significantly between the <30-CB and ≥30-CB groups. The data were, however, obtained from only 17 subjects in the ≥30-CB group, and so a definitive conclusion cannot be drawn about any effect of the 30 chews per bite cut-off in the present study.

The present study did not exclude the possibility of influence from the menstrual cycle. Previous studies have shown possible effects of the menstrual cycle on appetite and food intake (27, 28), which could affect the eating speed. Nevertheless, the effect of the menstrual cycle is likely to be small given that Bryant et al. found that the food intake differed by 100 kcal/d between the premenstrual and postmenstrual phases (27). Moreover, we applied the same amount of test food in all groups in the present study, and so avoided any effect of food intake on eating speed. In a further study, we need to investigate the objective and subjective eating speed of male subjects.

The magnitude of the effect of eating speed on body composition and shape should be noted, since the correlation coefficients between chewing variables and body composition and shape were relatively low, ranging from $-0.22$ to $-0.27$. The slopes were also low, ranging from 0.01 to 0.02 for a given total meal duration and total number of chews. This means increasing chews for 100 s and 100 times decreases relative fat and BMI by $1-2\%$ and $1-2\;kg/m^2$. It is still unclear what extent a small change in chewing nature induces body shape.

The test food in the present study contained a small amount of energy (174 kcal). Humans typically consume 600–700 kcal at each daily meal, with variable macronutrient contents (29). Thus, further examinations using whole-day meal intakes are needed to fully elucidate the relationships between the eating speed and the body composition and shape.

In conclusion, this study examined the relationships between the eating speed as assessed both objectively and subjectively and the body composition and shape while eliminating the influence of sex. The objective and subjective eating speeds were found to be related to both the body composition and shape. Those subjects who assessed themselves as being fast eaters tended to be overweight and obese, and indeed exhibited a smaller number of chews and a shorter meal duration than did the slow eaters in the present study. The present study supports the notion that fast eating may therefore be related to gains in body mass and/or fat mass.

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REFERENCES


