Dietary conditions and corresponding facial characteristics in young women

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Background
Obesity is considered to be associated with not only an unbalanced status between energy intake and energy consumption (i.e., overeating and lack of exercise) but also with genetic conditions and abnormal eating behavior. In particular, abnormal eating behavior is assumed to affect food intake; hence, combinations of parameters derived from food intake and eating behavior would comprise some patterns of “dietary condition.” Meanwhile, obesity is generally considered to be related to a “round and large” facial shape, but no studies have demonstrated this relationship.

Aim
1) To objectively classify the dietary conditions of young women
2) To examine whether any physical characteristics of body composition, including facial morphology, are specific to each dietary condition.

Material and Methods
Participants
We included 115 female students from the School of Nutritional Sciences whose mean age was 20.6 years.

Data Recording
Daily food intake was recorded using the food frequency questionnaire based on food groups, which is composed of items on 29 food groups and 10 kinds of cookery, and elicits information on the average intake per week of each food or food group in commonly used units or portion sizes. After the participants completed the questionnaire, a dietician reviewed the completed questionnaires with the participants also. Nutrient content (63 items) was analyzed by using the Eiyu-kun ver. 6.0 software (Kensaku Inc, Tokyo, Japan). Eating behavior was recorded by using the questionnaire on the guidelines for obesity issued by the Japan Society for the Study of Obesity. The questionnaire consists of 55 questions on seven major scales as shown in Table 1. All of the items were rated on a 4-point scale ranging from 1 (seldom) to 4 (very often).

For physical characteristics, three-dimensional (3-D) facial images were obtained at rest by using a 3-D image-capturing device (3dMDcranial Systems, 3dMD Llc, Atlanta, US). The body composition parameters (body weight, body mass index [BMI], total body fat mass, and body fat percentage) were measured by using a multifrequency bioelectrical impedance analysis device (Inbody 720, Biospace Inc, Tokyo, Japan). From each 3-D facial image, 28 inter-landmark distances were measured by using the 3D-Rugle software (Medic Inc, Kyoto, Japan). Because of the poor data quality, 6 facial images were excluded from the analysis.

Feature extraction and clustering
As a preprocessing for the clustering, principal component analyses were conducted for parameters derived from the nutrient content and eating behavior to reduce dimensionality of variables. For each participant, the principal component scores that satisfied the condition where the accumulation contribution rate was set to 70% were used as feature elements and combined to comprise a feature vector. Feature vectors extracted from the all the participants were used for mathematical clustering (i.e., patternning) of the dietary conditions by using the vector quantization technique.

Statistical analysis
An analysis of variance (ANOVA) and Tukey-Kramer post-hoc test were conducted to examine whether 1) any nutrient content parameter was specific to each code (i.e., pattern); 2) any eating behavior parameter was specific to each code; 3) any body composition parameter was specific to each code; and 4) any inter-landmark distance of the face was specific to each code (all, P<.05).

Furthermore, to facilitate an understanding of the differences in facial topography between the codes, 3-D-averaged faces and accentuated averaged faces for each code were calculated using the 3D-Rugle computer software and qualitatively evaluated.

Conclusion
Dietary conditions were found to be classified into three representative codes. Physical characteristics (percentage body fat, BMI, total body fat mass, and facial morphology) were found to be associated with dietary conditions.

Results
Three dietary patterns were observed, and differences between the patterns were identified by maximizing 24 variables for nutritional content and 7 major scales for eating behavior as follows (Fig. 1; P<0.05):

Code 1 (n=42) was characterized by a greater fish oil ratio, a greater polyunsaturated fatty acid content, and a smaller n-3 fatty acid ratio when compared with Code 3.
Eating behavior showed lower scores (i.e., better scores) for recognition, emotional eating behavior, food preference when compared with Codes 2 and 3.

Code 2 (n=41) was characterized by greater energy, lipid, saturated fatty acid, and total amount of fatty acid when compared with Code 3. Eating behavior scores for recognition, external eating behavior, emotional eating behavior, hunger, eating style, and food preference were greater (i.e., worse) in Code 2 than in Code 1.

Code 3 (n=32) was characterized by smaller carbohydrates, sodium, vitamin B12, protein energy ratio, and n-3 polyunsaturated fatty acid when compared with Codes 1 and 2. Energy was smaller in Code 3 than in Code 2. Eating behavior scores for recognition, emotional eating behavior, eating style, food preference, and regularity of eating habits were greater (i.e., worse) in Code 3 than in Code 1.

Table 1. Eating behavior questionnaire that consists of 55 questions on seven major scales.

<table>
<thead>
<tr>
<th>Code 1</th>
<th>Code 2</th>
<th>Code 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scale 1 Recognition for weight and constitution</td>
<td>3.8</td>
<td>2.9</td>
</tr>
<tr>
<td>Scale 2 Recognition for constitution</td>
<td>3.5</td>
<td>2.8</td>
</tr>
<tr>
<td>Scale 3 Recognition for hunger</td>
<td>3.3</td>
<td>2.7</td>
</tr>
<tr>
<td>Scale 4 Recognition for eating style</td>
<td>3.1</td>
<td>2.6</td>
</tr>
<tr>
<td>Scale 5 Recognition for emotional eating behavior</td>
<td>3.0</td>
<td>2.5</td>
</tr>
<tr>
<td>Scale 6 Recognition for food preference</td>
<td>2.9</td>
<td>2.4</td>
</tr>
<tr>
<td>Scale 7 Recognition for regularity of eating habits</td>
<td>2.8</td>
<td>2.3</td>
</tr>
</tbody>
</table>

Fig. 1. ANOVA results for nutrient content parameters and eating behavior parameters (P<0.05).

Fig. 2. ANOVA results for the body composition parameters (P<0.05).

Fig. 3. 3-D-averaged faces and accentuated averaged faces for each code. For details, please see Tsakiris, D. et al. (European Orthodontics Society, Reykjavik, 2015).

Physical characteristics
Although no differences in body weight were found, Code 2 had a higher body fat percentage and BMI than Code 1, and the total body fat mass in Codes 2 and 3 was greater than that in Code 1 (Fig. 2).
Qualitative evaluation of 3-D-averaged faces and accentuated averaged faces for each code indicated that Code 2 had a tendency toward protruded lips and puffy cheeks, and that Code 3 had a tendency toward a long face (Fig. 3). Statistical analysis showed that facial height and lower facial height were greater in Code 3 than in Code 1. Nasal width was greater in Code 2 than in Code 1 (P<0.05).

Table 1. ANOVA results for the inter-landmark distances.

<table>
<thead>
<tr>
<th>Codon</th>
<th>Eye to eyebrow</th>
<th>Nose to chin</th>
<th>Mouth to chin</th>
<th>Lower face</th>
<th>Nose width</th>
</tr>
</thead>
<tbody>
<tr>
<td>Code 1</td>
<td>1.2</td>
<td>1.4</td>
<td>1.6</td>
<td>1.8</td>
<td>2.0</td>
</tr>
<tr>
<td>Code 2</td>
<td>1.3</td>
<td>1.5</td>
<td>1.7</td>
<td>1.9</td>
<td>2.1</td>
</tr>
<tr>
<td>Code 3</td>
<td>1.4</td>
<td>1.6</td>
<td>1.8</td>
<td>2.0</td>
<td>2.2</td>
</tr>
</tbody>
</table>