Effect of eating speed on obesity and diabetes mellitus

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Diet therapy is important for treating obese subjects and patients with type 2 diabetes to prevent complications. Doctors instruct patients to reduce calorie or carbohydrate intake. It is commonly recognized that eating slowly is important to reduce obesity and control diabetes. Indeed, eating fast is associated with obesity, fatty liver, and metabolic syndrome. We analyze the effect of eating speed on obesity, metabolic syndrome, fatty liver, and diabetes mellitus.

Introduction

Diet therapy is important for treating obese subjects and patients with type 2 diabetes to prevent complications. Doctors instruct patients to reduce calorie or carbohydrate intake. It is commonly recognized that eating slowly is important to reduce obesity and control diabetes. Indeed, eating fast is associated with obesity, fatty liver, and metabolic syndrome. We analyze the effect of eating speed on obesity, metabolic syndrome, fatty liver, and diabetes mellitus.

Eating speed and obesity

Regarding the relationship between eating speed and obesity, there were two meta-analysis reports. Eating slowly was associated with lower energy intake and there was no significant relationship between eating speed and hunger at the end of the meal or up to 3.5 hours later [1]. Eating fast is positively associated with excess body weight [2]. In a cross-sectional study, the rate of eating was positively associated with energy intake and body mass index (BMI) in middle aged Japanese men and women [3]. Andrade et al. reported that eating slowly decreased energy intake and resulted in more satiety after meal completion in 30 healthy...
women. Shah et al. reported that eating slowly decreased energy intake in subjects with normal weight but not overweight and obese patients. Thus, eating fast increases the body weight and eating slowly decreases the energy intake.

Regarding children and adolescents, eating fast was also positively associated with an increased risk of being overweight or waist to height ratio in cross-sectional studies. In a prospective study, a faster rate of eating in early childhood was associated with current and later BMI in young Japanese children. Similarly, in Japanese school girls, eating quickly was associated with excess gains of BMI, percent body fat, waist circumference, and waist to height ratio. Thus, eating fast is associated with overweight in children and adolescents.

Eating speed and metabolic syndrome including fatty liver

Regarding eating speed and metabolic syndrome, self-reported eating speed was associated with the presence of metabolic syndrome in Japanese men and women in a cross-sectional study. Regarding eating speed and fatty liver disease, eating fast was associated with non-alcoholic fatty liver disease (NAFLD) in Korean adults. In a retrospective cohort study, Japanese subjects who habitually ate before bedtime, and those who ate fast and before bedtime, tended to have an increased risk of NAFLD.

The relation between eating speed and diabetes mellitus

As meta-analyses that describe the relationship between eating speed and diabetes have not yet been reported, we have discussed four cross-sectional studies below. In a total of 7275 Japanese patients with diabetes or impaired fasting glucose, eating fast was associated with obesity and cardiovascular risk factors. In addition, the eating speed and HbA1c level were associated only in insulin-treated patients. Takayama et al. evaluated the relationship between eating speed and BMI in Japanese patients with type 2 diabetes or hyperlipidemia. The BMI of male patients who ate fast was higher than that of male patients with at a normal or slower pace. In female patients, no significant differences between eating speed and body weights were noted. Saito et al. investigated the relationship between eating speed and BMI or glycemic control in Japanese patients with type 2 diabetes. The BMI of the patients who ate fast was higher than that of the patients who ate at medium speed; however, eating speed was not associated with the HbA1c level (the present study included patients on medication). Regarding mastication, an inverse dose-dependent association was found between masticatory performance and diabetes.

In a case control study, it was reported that compared to those who ate slowly, the subjects who ate fast were associated with a higher risk of diabetes. Thus, eating fast contributes to obesity in patients with diabetes and increases the risk of diabetes.

Eating speed and postprandial levels of glucose or gastrointestinal hormones

Healthy subjects

Gastrointestinal hormones, such as glucagon-like peptide-1 (GLP-1) and peptide YY (PYY), are secreted from the small intestine and are reported to decrease the appetite. Ghrelin is secreted from the stomach and is reported to increase the appetite. The effects of eating slowly on postprandial levels of glucose, insulin, and gastrointestinal hormones are shown in Table 1. In a cross-over study, Kokkinos et al. reported that in a healthy adult male with BMI 26, compared to eating ice cream fast (5 min), eating ice cream slowly (30 min) increased postprandial GLP-1 and PYY levels, but did not change postprandial glucose, insulin, and ghrelin levels. This change in hormonal levels may indicate an anorexigenic effect. Rigamonti et al. reported that compared with eating ice cream fast, eating it slowly increased postprandial GLP-1 levels in obese adolescents; but, eating ice cream slowly did not increase GLP-1 levels in

<table>
<thead>
<tr>
<th>Reports (Reference number)</th>
<th>Subjects</th>
<th>BMI</th>
<th>Glucose</th>
<th>Insulin</th>
<th>GLP-1</th>
<th>GIP</th>
<th>PYY</th>
<th>Ghrelin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kokkinos et al. (21)</td>
<td>Healthy</td>
<td>26.1</td>
<td>n.s.</td>
<td>n.s.</td>
<td>Increased</td>
<td>-</td>
<td>Increased</td>
<td>n.s</td>
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<tr>
<td>Karl et al. (23)</td>
<td>Healthy</td>
<td>27.3</td>
<td>n.s.</td>
<td>n.s.</td>
<td>-</td>
<td>n.s</td>
<td>-</td>
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<tr>
<td>Shah (24)</td>
<td>Healthy</td>
<td>25.0</td>
<td>-</td>
<td>-</td>
<td>n.s.</td>
<td>-</td>
<td>n.s</td>
<td>n.s</td>
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<tr>
<td>Rigamonti et al. (22)</td>
<td>Healthy adolescents</td>
<td>37.2</td>
<td>n.s.</td>
<td>n.s.</td>
<td>Increased</td>
<td>-</td>
<td>n.s</td>
<td>-</td>
</tr>
<tr>
<td>Healthy adults</td>
<td>Healthy adolescents</td>
<td>44.1</td>
<td>n.s.</td>
<td>n.s.</td>
<td>-</td>
<td>n.s</td>
<td>-</td>
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</tr>
<tr>
<td>Angelopoulos et al. (25)</td>
<td>With diabetes</td>
<td>30.6</td>
<td>n.s.</td>
<td>n.s.</td>
<td>-</td>
<td>n.s</td>
<td>n.s</td>
<td>n.s</td>
</tr>
<tr>
<td>Kamiko et al. (27)</td>
<td>With diabetes</td>
<td>25.6</td>
<td>n.s.</td>
<td>n.s.</td>
<td>-</td>
<td>n.s</td>
<td>n.s</td>
<td>n.s</td>
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</table>

BMI: body mass index, GLP-1: glucagon-like peptide-1, PYY: peptide YY, GIP: glucose-dependent insulinotropic polypeptide, n.s.: not significant vs. eating fast.
obese adults [22]. However, Karl et al. reported that eating speed does not affect postprandial glucose, insulin, PYY, cholecystokinin (CCK), pancreatic polypeptide (PP), leptin, and neuropeptide Y levels when a fixed portion meal is given to healthy adult men [23]. In another report, 25 subjects ate the same food for breakfast slowly (30 min) and fast (10 min), on 2 separate days, in a randomized crossover design [24]. The eating speed at breakfast did not change the postprandial levels of GLP-1, PYY, ghrelin, hunger, and fullness. Thus, the effect of eating speed on the gastrointestinal hormones in healthy subjects is controversial.

Patients with diabetes (including our data)

It is important to investigate whether eating fast worsens diabetes directly. Angelopoulos and Kokkinos et al. also reported the effects of eating speed on the postprandial glucose and gastrointestinal hormone levels in overweight and obese patients with diabetes compared to obese subjects without diabetes [25]. In overweight and obese patients with type 2 diabetes, compared to eating ice-cream fast (5 min), eating ice-cream slowly (30 min) did not change postprandial glucose, insulin, GLP-1, PYY, and ghrelin levels, and increased the feeling of fullness and decreased that of hunger. These results differed from those of their previous report on obese subjects without diabetes [21]. As the incretin effects are reported to be blunted in overweight and obese patients with diabetes [22, 26], they suggested that postprandial GLP-1 and PYY levels were unchanged by eating speed in these patients.

As studies comparing glucose metabolism in Japanese patients with type 2 diabetes eating fast or slowly have not been reported, we evaluated the effects of slow or fast ingestion of enteral formula (liquid meal) on postprandial glucose and gastrointestinal hormone levels [25]. Ten Japanese patients with type 2 diabetes who had been admitted in our hospital were recruited for the study. All the patients received enteral formula for breakfast. This trial was performed for 2 days for each subject (Day 1: enteral formula drunk in 5 min, Day 2: enteral formula drunk over 20 min). The patients were fasted overnight, and blood samples were drawn before breakfast and at 30, 60, and 120 min since the commencement of breakfast. The area under the curve (AUC) of postprandial plasma glucose, serum insulin, plasma active GLP-1 and ghrelin, plasma total glucose-dependent insulinotropic polypeptide (GIP), and serum total PYY was not significantly altered by ingestion within 5 min or over 20 min. Our results were in accordance with those of a previous report [25]. Additionally, in another comparative study on chewing 30 times per bite and eating normally, there was no difference in postprandial glucose, insulin, and GLP-1 levels in patients with type 2 diabetes [28]. Thus, eating slowly per se does not affect postprandial glucose or gastrointestinal hormone levels directly in patients with type 2 diabetes. Indeed, the speed of eating was associated with the incidence of type 2 diabetes, but associations between eating speed and the incidence of diabetes were not significant in models with additional adjustment for BMI [29]. Therefore, eating slowly prevents excess energy intake and body weight gain over a long observation period and may improve insulin resistance and glycemic control in patients with type 2 diabetes.

Considering eating speed and hunger or energy intake, no significant relation between eating speed and hunger at the end of a meal or up to 3.5 hours later was noted in the meta-analysis data [11]. As eating slowly was associated with lower energy intake [1], a longer duration of observation of hunger or satiety, when eating slowly in patients with diabetes is needed.

Conclusion

Compared to eating fast, eating slowly did not directly affect the levels of postprandial glucose or gastrointestinal hormones (GLP-1, PYY, ghrelin) in patients with type 2 diabetes [25, 27]. We hypothesized that eating slowly prevents excess energy intake and body weight gain over a long observation period and this may improve insulin resistance and glycemic control in patients with type 2 diabetes. Therefore, obese patients with type 2 diabetes could be advised to eat slowly to decrease energy intake. Further studies on eating speed and diabetes are needed.

Conflicting interests

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23. Karl JP, Young AJ, Montain SJ. Eating rate during a fixed-portion meal does not affect postprandial appetite and gut peptides or energy intake during a subsequent meal. Physiol Behav 2011; 102:524-531.


