No consistent association between consumption of energy-dense snack foods and annual weight and waist circumference changes in Dutch adults

Marieke AH Hendriksen, Jolanda MA Boer, Huaidong Du, Edith JM Feskens, and Daphne L van der A

ABSTRACT
Background: There is conflicting evidence regarding an association between the consumption of energy-dense snack (EDS) foods and the development of overweight.

Objective: In the current study, we examined whether there was an association between the intake of EDS foods and annual weight and waist circumference changes in normal-weight and overweight Dutch adults.

Design: The study population included 9383 men and women from the MORGEN-EPIC (Monitoring Project on Risk Factors for Chronic Diseases in the Netherlands–European Prospective Investigation into Cancer and Nutrition) study, which is a population-based cohort study in 3 towns in the Netherlands (Amsterdam, Maastricht, and Doetinchem), who had a body mass index (in kg/m²) <30 and who were not dieting. Participants were enrolled between 1993 and 1997 and followed for an average of 8.1 y (Amsterdam and Maastricht: 9.9 y; Doetinchem: 4.9 y). Intake of EDS foods (sweets, cakes and pastries, and savory snacks) was assessed at baseline by using a validated food-frequency questionnaire. Multivariate linear and multinomial logistic regression models were applied and stratified by center to examine the association between energy from EDS foods (kcal) and annual weight and waist circumference changes.

Results: The mean (±SD) daily energy intake from EDS foods was 294 ± 192 kcal. In Amsterdam and Maastricht, the annual weight change was 168 ± 572 g/y, whereas in Doetinchem, the annual weight change was 444 ± 816 g/y. In the multivariate regression analysis adjusted for follow-up duration and anthropometric, dietary, and lifestyle factors, there was some, but inconsistent, evidence of an association of EDS-food consumption with annual weight change.

Conclusion: Our study provides some, but inconsistent, evidence that consumption of EDS foods is positively associated with an increase in annual weight in normal- to overweight Dutch adults. Am J Clin Nutr 2011;94:19–25.

INTRODUCTION
Worldwide, the prevalence of overweight and obesity is rapidly increasing. Overweight and obesity are major risk factors for chronic diseases such as cancer, type 2 diabetes, and coronary heart disease (1). Consequently, the prevention and treatment of overweight and obesity are of crucial importance to reduce the burden of disease.

Overweight is thought to result from an imbalance between energy intake and energy expenditure. An excess energy intake, which is when the energy intake exceeds the energy expenditure, may lead to a positive energy balance and, thus, to weight gain. It is not fully understood which specific dietary factors are main contributors to overweight.

Randomized controlled trials have yielded convincing evidence that a high intake of energy-dense, nutrient-low foods leads to excess weight gain (2). Snacks form one category of energy-dense, nutrient-low foods. Over the past decades, the consumption of energy-dense snack (EDS) foods has increased, as has the contribution of the energy intake from snack foods to the total daily energy intake (3). Studies have shown that EDS foods consumed between meals increase the total daily energy intake (4, 5). As a result, it may be argued that the consumption of EDS foods contributes to an excess energy intake, which leads to subsequent weight gain.

However, results from observational studies are conflicting (4, 6–10). It has been shown that dietary patterns characterized by high intakes of sweets and desserts may contribute to long-term weight gain (10). A cross-sectional study from Sweden showed that obese subjects were more frequent snackers than were their normal-weight counterparts, and snacking contributed to a higher total energy intake (4). In addition, a study performed in the United States showed that the total amount of snacks in grams was positively associated with the overweight status in children (8). In contrast, another US study in adolescents did not show an increased consumption of snack foods in obese adolescents compared with in adolescents with normal weights (6). Similarly, 2 longitudinal studies in children and adolescents failed to demonstrate any association between snack food intakes and weight gain (7, 10). Energy-dense snack foods are a category of nutrient-poor foods, which may lead to excess energy intake (5). It is hoped that this study will provide more information to understand this association.

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gains (7, 9). Selective underreporting may have been a major limitation in the examination of this association (6).

To our knowledge, no prospective studies have examined the relation between EDS foods and weight change in adults. Because overweight and obesity develop gradually over a period of time, it is important to understand whether snack consumption is related to weight gain. Therefore, the aim of the current study was to examine the association between the consumption of EDS foods and weight and waist circumference changes in the MORGEN-EPIC (Monitoring Project on Risk Factors and Chronic Diseases in the Netherlands–European Prospective Investigation into Cancer and Nutrition) cohort.

SUBJECTS AND METHODS

Subjects

Subjects included in this study were participants in the MORGEN-EPIC cohort. The MORGEN-EPIC cohort is a prospective cohort study in 3 geographical areas in the Netherlands, which is part of the European Prospective Investigation into Cancer and Nutrition study. A detailed description of the study design is available elsewhere (11). Briefly, a random sample was taken from the general population of individuals who were aged 20–64 y and resided in 3 Dutch towns (Amsterdam, Maastricht, and Doetinchem). A baseline data collection took place in 1993–1997. Follow-up measurements were collected between 1998 and 2002 in Doetinchem and in 2005 in Amsterdam and Maastricht.

A total number of 22,715 participants took part in the baseline examination. Subjects who emigrated, actively withdrew from the study, or died were not invited for follow-up examinations (n = 797; 3.5%). Response rates for the follow-up measurements in 1998–2002 (visit) and 2005 (self-report) were 76% and 50%, respectively. In total, the population lost to follow-up (including nonrespondents and subjects who emigrated, were deceased, or actively withdrew from the study) comprised 10,335 individuals (46%). Furthermore, subjects who ranked in the top or bottom 1% of the ratio of total energy intake:predicted energy expenditure (n = 153; 0.7%), women who were pregnant at baseline or follow-up (n = 129; 0.6%), subjects with missing data on diet or anthropometric measurements at baseline (n = 39; 0.2%), subjects with unrealistic anthropometric measures (including height <130 cm, body mass index (BMI) in kg/m²) <16, waist circumference <40 or >160 cm, weight change >5 kg/y, waist circumference change >7 cm/y, or the combination of waist circumference <60 cm and BMI >25; n = 33; 0.1%), and participants with prevalent chronic disease at baseline (diabetes, cancer, or cardiovascular disease; n = 915; 4%) were excluded. In total, after applying the exclusion criteria, 11,111 subjects were eligible for the study.

Literature reported that obese subjects tended to underreport their total energy intakes and weights (12). Therefore, we restricted the study population to normal-weight and overweight individuals and excluded subjects who were obese (BMI ≥30) at baseline (n = 1028) from the analyses. Moreover, because subjects who reported to be on a diet may have changed their habitual food intakes, particularly that of EDS foods, they were also excluded from the analyses (n = 700). The current analysis included 3938 individuals (41% of the initial sample) of whom 4391 subjects (46.8%) were men, and 4992 subjects (53.2%) were women.

Dietary assessment

Dietary intakes were assessed at baseline by means of a self-administered semiquantitative food-frequency questionnaire (FFQ) that was developed to estimate the total energy intake and usual frequency of consumption of 79 main food items over the preceding 12 mo (13, 14). The FFQ was administered during the baseline data collection (1993–1997). In the FFQ, subjects reported the frequency and portion sizes of their average food consumption. In the current study, EDS foods were defined as foods that are typically consumed as high-calorie, in-between-meal snacks in the Dutch diet. These EDS foods were classified into 3 subcategories as follows: 1) sweets (chocolates, licorice, and candy), 2) cakes and pastry (Dutch gingerbread, cakes, sweet pastries, and biscuits), and 3) savory snacks (small Russian salad, typical Dutch fried fast foods, spring rolls, cheese cubes, party sausages, nuts, and crisps). The sum of the 3 subcategories formed the total intake of EDS foods in grams. A previous validation study showed a relative validity of the categories sweets and cakes and pastry of 0.78 and 0.56, respectively, in men and of 0.69 and 0.45, respectively, in women (13).

The total energy intake from all EDS foods and the energy intake from sweets, cake and pastry, and savory snacks as well as the consumption of other food groups and the total energy intake were calculated in kilocalories per day by using an extensive version of the Dutch food composition table (15). Basal metabolic rate (BMR) was estimated by using Schofield equations, and participants with an energy intake compared with BMR <1.14 were defined as energy underreporters according to Goldberg cutoffs (16).

Anthropometric measurements

Baseline weights, waist circumferences, and heights were measured at the Municipal Health Service by trained research assistants. Follow-up measurements of weights and waist circumferences were self-reported in Amsterdam and Maastricht and measured in Doetinchem. Subjects were measured in light indoor clothing, and BMI was defined as weight (kg) divided by height squared (m²). The outcome in the current analysis was the annual body weight change (g/y) or annual waist circumference change (cm/y). The outcome was calculated for each subject by subtracting the baseline weight or waist circumference from the follow-up weight or waist circumference and dividing the difference in grams or centimeters by the follow-up duration in years. Weight-change categories were defined to assess the role of the intake of EDS foods in weight gain and weight loss, separately. Individuals were classified according to their weight-change status as being weight stable (≥−0.5 to <0.5 kg/y) or having minor annual weight gain (≥0.5 to 1.0 kg/y) or major annual weight gain (≥1.0 kg/y) or annual weight loss (≥−0.5 kg/y).

Other measurements

Information concerning lifestyles and health situations was assessed by means of a self-administered questionnaires at baseline. The questionnaires included questions on age, sex, educational level, physical activity, smoking, and health status, including the prevalence of cardiovascular disease, cancer, and diabetes. Physical activity was defined by using a validated physical activity index on the basis of occupational, recreational, and household activities, including walking and biking to work, as inactive,
moderately inactive, moderately active, and active (17). Educational level was defined as the highest school level successfully completed (primary school, technical or professional education, secondary school, and university degree). Stable smokers subjects who reported smoking at baseline and follow-up, quitters who stopped smoking during follow-up, starters who started smoking during follow-up, and nonsmokers who never smoked and who stopped smoking before baseline.

**Statistical analysis**

The difference between several factors among tertiles of EDS-food consumption was calculated by using analysis of variance. A chi-square test was used to calculate the distribution of categorical variables among tertiles. The association of EDS-food consumption per 100 kcal with the annual weight or waist circumference change was examined by using linear regression models (PROC GLM procedure in SAS version 9.1 software, 2004; SAS Institute). The association between EDS-food intake and weight change categories was calculated by using multinomial logistic regression analysis (PROC LOGISTIC procedure in SAS version 9.1 software, 2004; SAS Institute). Odds ratios and their 95% CIs were calculated by using weight stable as a reference category for each 100-kcal/d increase in the consumption of EDS foods. As the follow-up weight was self-reported in Amsterdam and Maastricht and measured in Doetinchem, it was decided to stratify all analyses according to centers (Doetinchem compared with Amsterdam and Maastricht). Models were adjusted for baseline age (y). Further adjustments were made for potential confounders including sex, weight (kg), height (m), follow-up duration, physical activity (inactive, moderately inactive, moderately active, active, or missing), education (primary school and below, technical-professional school, secondary school, or university degree), smoking (stable, quitter, start smokers, or nonsmokers), and consumption of sugar-sweetened soft drinks, fruit, and vegetables. In an effort to explore explanations for an association between EDS-food consumption and weight and waist changes, we conducted a secondary analysis by using a model that further controlled for the total energy intake, excluding the energy intake from EDS foods. Sensitivity analyses were performed by excluding subjects who were underreporters of energy intake (energy intake divided by BMR <1.14) and subjects with incident chronic diseases. Analyses were subsequently performed for EDS-food subcategories (sweets, cakes and pastries, and savory snacks). These models were adjusted for the same potential confounders, including the remaining subcategories of EDS foods.

For all analyses, statistical significance was set 2-sided with \( P < 0.05 \). All analyses were performed with SAS version 9.1 software (2004; SAS Institute).

**RESULTS**

The mean (±SD) total energy intake from EDS foods was 294 ± 192 kcal/d and contributed to 12% of the daily total energy intake. Savory snacks made the largest contribution (43%) to the energy intake from EDS foods (Figure 1). The average (±SD) age at baseline was 43.1 ± 10.4 y. Forty-seven percent of subjects were males, 6% of subjects had incident chronic diseases, and 59% of subjects had normal weights. Excluded subjects (obese subject and subjects who reported to be on a diet at baseline) were more likely to be women and older and reported a significantly lower intake of EDS foods and total energy intake (data not shown). The mean (±SD) follow-up duration in Doetinchem was 4.9 ± 0.16 y and in Amsterdam/Maastricht 9.9 ± 1.43 y (Table 1).

Mean (±SD) annual weight and waist circumference changes differed between Amsterdam and Maastricht and Doetinchem with an annual weight change of 168 ± 572 g/y in Amsterdam and Maastricht and 444 ± 816 g/y in Doetinchem.

The association of the total EDS-food consumption and consumption of its subcategories, respectively, with annual weight change stratified for centers is presented in Tables 2 and 3. A 100-kcal higher intake of the total EDS-food consumption was significantly associated with an annual weight change of 9.9 g/y (95% CI: 2.2, 17.5 g/y) in Amsterdam and Maastricht but not in Doetinchem. The additional adjustment for the total energy intake with the exclusion of EDS foods slightly weakened the association but remained significant.

The association of sweets, cakes and pastries, and savory snack intake with annual weight change was examined separately. In the multivariate-adjusted model, a 100-kcal higher intake of savory snack consumption was positively associated with an annual weight change of 22.9 g/y (95% CI: 9.4, 36.4 g/y) in Amsterdam and Maastricht. The additional adjustment for the total energy intake essentially changed the association. For the other EDS-food subcategories, no association was seen with the annual weight change.

In this cohort, 1664 subjects were classified as underreporters. Underreporters had higher BMI at baseline and follow-up, were more likely to be physical inactive, nonsmokers, and lower educated than were normal reporters. The sensitivity analysis showed that the exclusion of underreporters yielded slightly stronger associations; however, the associations did not change significantly (data not shown). In addition, the sensitivity analysis

![FIGURE 1. Contributions from energy-dense snack-food consumption (kcal) to total energy intake.](https://academic.oup.com/ajcn/article-abstract/94/1/19/4597815/21)
TABLE 1
General characteristics of the overall study population (n = 9383) and according to tertiles of energy from total energy-dense snack (EDS)-food consumption.†

<table>
<thead>
<tr>
<th></th>
<th>Overall</th>
<th>Tertile 1, low (n = 3127)</th>
<th>Tertile 2 (n = 3128)</th>
<th>Tertile 3, high (n = 3128)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline age (y)</td>
<td>43.1 ± 10.4^2</td>
<td>44.4 ± 10.4</td>
<td>43.1 ± 10.3</td>
<td>41.9 ± 10.3</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Men [n (%)]</td>
<td>4391 (46.8)</td>
<td>1395 (44.6)</td>
<td>1413 (45.2)</td>
<td>1583 (50.6)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Participants in Amsterdam and Maastricht [n (%)]</td>
<td>5846 (62.2)</td>
<td>2032 (65.0)</td>
<td>1884 (60.2)</td>
<td>1930 (61.7)</td>
<td>0.0004</td>
</tr>
<tr>
<td>Baseline weight (kg)</td>
<td>72.5 ± 11.4</td>
<td>71.2 ± 11.1</td>
<td>72.6 ± 11.3</td>
<td>73.7 ± 11.6</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Baseline waist (cm)</td>
<td>84.2 ± 10.5</td>
<td>83.8 ± 10.8</td>
<td>84.3 ± 10.5</td>
<td>84.6 ± 10.3</td>
<td>0.008</td>
</tr>
<tr>
<td>Baseline BMI (kg/m²)</td>
<td>24.3 ± 2.68</td>
<td>24.3 ± 2.74</td>
<td>24.4 ± 2.65</td>
<td>24.3 ± 2.66</td>
<td>0.06</td>
</tr>
<tr>
<td>Follow-up time (y)</td>
<td>8.09 ± 2.67</td>
<td>8.20 ± 2.63</td>
<td>8.01 ± 2.69</td>
<td>8.07 ± 2.68</td>
<td>0.01</td>
</tr>
<tr>
<td>Energy intake from EDS foods (kcal)</td>
<td>294 ± 192</td>
<td>124 ± 44.5</td>
<td>256 ± 39.0</td>
<td>502 ± 182.0</td>
<td>—</td>
</tr>
<tr>
<td>Total energy intake (kcal)</td>
<td>2270 ± 619</td>
<td>1980 ± 516</td>
<td>2222 ± 541</td>
<td>2605 ± 627</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Energy intake from sweets (kcal)</td>
<td>62.1 ± 81.5</td>
<td>20.2 ± 21.5</td>
<td>48.0 ± 39.9</td>
<td>118.0 ± 113.2</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Energy intake from cakes and pastries (kcal)</td>
<td>104.5 ± 87.9</td>
<td>47.1 ± 32.9</td>
<td>97.7 ± 52.9</td>
<td>168.7 ± 108.7</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Energy intake from savory snacks (kcal)</td>
<td>127.4 ± 112.7</td>
<td>56.8 ± 34.8</td>
<td>110.0 ± 55.9</td>
<td>215.2 ± 144.0</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Energy intake &lt;1200 kcal/d [n (%)]</td>
<td>123 (1.31)</td>
<td>99 (3.17)</td>
<td>21 (0.67)</td>
<td>3 (0.10)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Fruit consumption (g/d)</td>
<td>185 ± 127</td>
<td>168 ± 128</td>
<td>184 ± 124</td>
<td>201 ± 126</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Vegetable consumption (g/d)</td>
<td>125 ± 48</td>
<td>126 ± 51</td>
<td>123 ± 47</td>
<td>125 ± 46</td>
<td>0.04</td>
</tr>
<tr>
<td>Soft drink consumption (g/d)</td>
<td>131 ± 157</td>
<td>114 ± 150</td>
<td>126 ± 146</td>
<td>155 ± 171</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Incident diseases [n (%)]</td>
<td>653 (7.0)</td>
<td>259 (8.3)</td>
<td>208 (6.7)</td>
<td>186 (6.0)</td>
<td>0.001</td>
</tr>
<tr>
<td>Overweight [n (%)]</td>
<td>3835 (40.9)</td>
<td>1256 (40.0)</td>
<td>1305 (41.7)</td>
<td>1274 (40.7)</td>
<td>0.44</td>
</tr>
<tr>
<td>Level of education [n (%)]^4</td>
<td>Overall</td>
<td>Tertile 1, low (n = 3127)</td>
<td>Tertile 2 (n = 3128)</td>
<td>Tertile 3, high (n = 3128)</td>
<td>P</td>
</tr>
<tr>
<td>Primary school</td>
<td>671 (7.2)</td>
<td>314 (10.1)</td>
<td>206 (6.6)</td>
<td>151 (4.8)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Technical/professional school</td>
<td>3414 (36.5)</td>
<td>1122 (36.0)</td>
<td>1175 (37.6)</td>
<td>1117 (35.8)</td>
<td>—</td>
</tr>
<tr>
<td>Secondary school</td>
<td>2457 (26.3)</td>
<td>817 (26.2)</td>
<td>807 (25.9)</td>
<td>833 (26.7)</td>
<td>0.01</td>
</tr>
<tr>
<td>University degree</td>
<td>2815 (30.1)</td>
<td>860 (27.6)</td>
<td>934 (29.9)</td>
<td>1021 (32.7)</td>
<td>0.07</td>
</tr>
<tr>
<td>Smoking status [n (%)]^5</td>
<td>Overall</td>
<td>Tertile 1, low (n = 3127)</td>
<td>Tertile 2 (n = 3128)</td>
<td>Tertile 3, high (n = 3128)</td>
<td>P</td>
</tr>
<tr>
<td>Non-smoker</td>
<td>5815 (64.5)</td>
<td>1818 (60.6)</td>
<td>1981 (65.8)</td>
<td>2016 (67.1)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Stable</td>
<td>2038 (22.6)</td>
<td>798 (26.6)</td>
<td>631 (21.0)</td>
<td>609 (20.3)</td>
<td>—</td>
</tr>
<tr>
<td>Starter</td>
<td>217 (2.4)</td>
<td>57 (1.9)</td>
<td>77 (2.6)</td>
<td>83 (2.8)</td>
<td>—</td>
</tr>
<tr>
<td>Quitter</td>
<td>948 (10.5)</td>
<td>328 (10.9)</td>
<td>322 (10.7)</td>
<td>298 (9.9)</td>
<td>—</td>
</tr>
<tr>
<td>Physical activity index [n (%)]</td>
<td>Overall</td>
<td>Tertile 1, low (n = 3127)</td>
<td>Tertile 2 (n = 3128)</td>
<td>Tertile 3, high (n = 3128)</td>
<td>P</td>
</tr>
<tr>
<td>Inactive</td>
<td>1101 (11.7)</td>
<td>371 (11.9)</td>
<td>385 (12.3)</td>
<td>345 (11.0)</td>
<td>0.07</td>
</tr>
<tr>
<td>Moderately inactive</td>
<td>1651 (17.6)</td>
<td>583 (18.6)</td>
<td>530 (16.9)</td>
<td>538 (17.2)</td>
<td>0.0001</td>
</tr>
<tr>
<td>Moderately active</td>
<td>3140 (33.5)</td>
<td>1056 (33.8)</td>
<td>1057 (33.8)</td>
<td>1027 (32.8)</td>
<td>0.0001</td>
</tr>
<tr>
<td>Active</td>
<td>1442 (15.4)</td>
<td>440 (14.1)</td>
<td>472 (15.1)</td>
<td>530 (16.9)</td>
<td>0.0001</td>
</tr>
<tr>
<td>Missing^6</td>
<td>2049 (21.8)</td>
<td>677 (21.7)</td>
<td>684 (21.9)</td>
<td>688 (22.0)</td>
<td>—</td>
</tr>
</tbody>
</table>

† All P values were significant at P < 0.05. P values for differences in characteristics across tertiles of EDS-food consumption were based on the chi-square test for categorical variables or the ANOVA test for continuous variables.

^2 Mean ± SD (all such values).

^4 Numbers do not add up to total number of participants due to 26 missing values.

^5 Numbers do not add up to total number of participants due to 365 missing values.

^6 Missing values were included in the multivariate analysis.

showed that the exclusion of subjects with incident disease did not affect the associations.

In Amsterdam and Maastricht, 16% of subjects had minor weight gain, 7% of subjects had major weight gain, and 9% of subjects had weight loss, whereas in Doetinchem, the percentages of subjects were 24%, 21% and 10%, respectively. With the use of multinomial logistic regression analyses that was adjusted for potential confounders, a 100-kcal higher intake of EDS foods was significantly associated with minor weight gain [OR (95% CI): 1.04 (1.01, 1.08) for 100 kcal/d] in Amsterdam and Maastricht and weight loss [OR (95% CI): 0.93 (0.88–0.98) for 100 kcal/d] (Table 4). These results implied that an increase of 100 kcal/d in energy from EDS foods resulted in a 7% lower chance to reduce weight than to stay weight stable. However, the adjustment for total energy intake made the association nonsignificant (Table 4).

For waist circumference change, the associations were very weak and mostly (except for sweets in Amsterdam and Maastricht) failed to show significance (data not shown). However, the associations were all in the same direction as for the annual weight change.

### DISCUSSION

In the current study, we examined the association between EDS foods and annual weight and waist circumference changes in a large cohort of normal-weight and overweight adults. We observed some significant, positive associations between the consumption of EDS foods and change of weight and weight-change categories in normal weight to overweight Dutch adults. These associations may possibly have been because of the consumption of savory snack foods. However, these associations were weak and not consistent across different subgroups.

To our knowledge, this was the first longitudinal study that examined the association of EDS foods and weight change in a large cohort of adults. A limitation of this study may have been...
the likely underreporting of EDS-food consumption and self-reported weight at follow-up in Amsterdam and Maastricht. In the literature, it is well known that overweight and obese subjects tend to underreport their total energy intakes (18, 19). Evidence exists that specific foods that are high in fat and sugars, such as EDS foods, are also subject to underreporting in overweight and obese subjects (20–22). Furthermore, in an attempt to lose weight, overweight and obese subjects may change their food intakes, and especially EDS foods may be eliminated from diets (23). Moreover, it is generally known that people tend to underreport their weight and the degree of underreporting is proportional to the degree of obesity (12, 24). To account for these issues as much as possible, we decided to exclude from the current analysis obese subjects and subjects who reported being on a diet. We observed no association between EDS foods and the annual weight or waist circumference change in Doetinchem (despite the measured data on weight and waist circumferences). Therefore, the association may not have been present in our data set. In addition, we performed a sensitivity analysis in which we excluded subjects who underreported their total energy intakes according to Goldberg cutoffs (16). Although we did not observe significant associations in these analyses, we could not exclude the possibility that the lack of an association between EDS foods and weight gain in this study may have been because of residual confounding of selective misreporting of specific foods that belong to the category EDS foods. Some significant associations were weakened when adjustments were made for the total energy intake, which meant that the association of EDS-food consumption and the annual weight or waist circumference change partly depended on the total energy intake.

Over the past decades, studies have observed an increased intake of EDS foods and an increased energy intake from EDS foods (3, 25) and have speculated that these changes may have contributed to the increasing obesity epidemic. Longitudinal studies on food patterns supported this hypothesis by reporting that the consumption of a variety of energy-dense foods, including EDSs, were associated with weight gain (8, 10, 26, 27). However, longitudinal studies that examined the association of EDS foods themselves and weight gain failed to support these findings. In the study by Phillips et al (9), the consumption of EDS foods did not seem to affect the weight in nonobese girls. In addition, snack foods were not important determinants of weight gain over a 3-y period in children and adolescents (7). One cross-sectional study observed that obese subjects consumed more EDS foods and had a higher intake frequency of EDS foods (3, 25) and have speculated that these changes may have partly depended on the total energy intake.
the relation between the consumption of EDS foods and weight change, including additional investigations into the degree of bias caused by selective underreporting.

In conclusion, our results on the basis of a large cohort of normal- and overweight subjects (6). From these results, it can be concluded that the findings from observational studies are inconclusive.

In intervention studies, it has been shown that the energy density of foods can affect the total energy intake (29). Compared with subjects who consume a low energy-dense diet, subjects who consume a high energy-dense diet have a higher total energy intake (30). However, considerable less evidence is available that shows that the consumption of EDSs contributes to a higher energy intake. One-day intervention studies showed that subjects did not eat less calories during dinner after being exposed to high-energy preloads (31, 32). For example, in 8 young subjects, Marmonier et al (31) showed that the consumption of snack foods that were high in carbohydrates during an in-between-meal occasion contributed to higher total energy intakes. Poppitt et al (32) observed that the energy intake during lunch was not affected by high-carbohydrate and high-fat preloads consumed 90 min before lunch. However, medium-term intervention studies showed that a partial energy compensation took place after the consumption of EDS foods (33, 34). An intervention study of 9 d in 8 young men who consumed 3 types of ad libitum diets (high fat, high protein, high carbohydrates, and no snacking) showed that, when subjects were required to eat snacks as part of the 3 diets, their total energy intakes were not significantly higher compared with normal intakes (33). This was confirmed by a 14-d intervention study by Whybrow et al (34) in which partial energy compensation took place after the compulsory consumption of EDS foods. Furthermore, a recent Dutch, 8-wk intervention study in healthy, nonrestrained, normal-weight young adults showed that the consumption of EDS snacks did not increase body weight, which suggests that energy compensation took places when EDS snacks were consumed (35). However, this study (35) was executed in a selective study population and thus, made it difficult to generalize the results to a general population.

In conclusion, our results on the basis of a large cohort of normal-weight and overweight Dutch adults generally showed that there may have been some evidence that the consumption of EDS foods, in particular savory snacks, was significantly positively associated with an increase in the annual weight change in normal-weight to overweight Dutch adults. However, the associations were small and not consistent across different subgroups, and therefore, the results should be interpreted with caution. Long-term studies are needed to improve our understanding of the relation between the consumption of EDS foods and weight

<table>
<thead>
<tr>
<th>Annual weight-change categories</th>
<th>≥0.5 to −0.5 kg/y</th>
<th>&gt;−0.5 to ≤0.5 kg/y</th>
<th>≥0.5 to ≤1.0 kg/y</th>
<th>≥1.0 kg/y</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amsterdam and Maastricht</td>
<td>Model 1 0.93 (0.88, 0.98)</td>
<td>1.00</td>
<td>1.04 (1.01, 1.08)</td>
<td>1.00 (0.95, 1.06)</td>
</tr>
<tr>
<td></td>
<td>Model 2 0.94 (0.94, 1.00)</td>
<td>1.00</td>
<td>1.02 (0.98, 1.07)</td>
<td>1.01 (0.94, 1.07)</td>
</tr>
<tr>
<td>Doetinchem</td>
<td>Model 1 0.96 (0.89, 1.02)</td>
<td>1.00</td>
<td>0.96 (0.92, 1.01)</td>
<td>0.97 (0.92, 1.02)</td>
</tr>
<tr>
<td></td>
<td>Model 2 0.97 (0.90, 1.05)</td>
<td>1.00</td>
<td>0.98 (0.92, 1.04)</td>
<td>0.99 (0.94, 1.06)</td>
</tr>
</tbody>
</table>

1 All values are odds ratios; 95% CIs in parentheses. Model 1 adjusted for baseline age, sex, baseline weight, height, duration of follow-up, physical activity, education, smoking status, fruit consumption, vegetable consumption, and soda drink consumption. Model 2 adjusted as for model 1 plus total energy intake excluding energy-dense snack foods.

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