# Risk of overweight and obesity among semivegetarian, lactovegetarian, and vegan women[1–4]

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## ABSTRACT

**Background:** Observational studies suggest that a plant-based diet is inversely related to body mass index (BMI), overweight, and obesity.

**Objective:** Our objective was to examine the BMI (kg/m$^2$) and risk of overweight and obesity of self-defined semivegetarian, lactovegetarian, and vegan women.

**Design:** Data analyzed in this cross-sectional study were from 55 459 healthy women participating in the Swedish Mammography Cohort. Women were asked whether they considered themselves to be omnivores ($n$ = 54 257), semivegetarians ($n$ = 960), lactovegetarians ($n$ = 159), or vegans ($n$ = 83), and this question was the main exposure variable in this study. In secondary analyses, we reclassified women as lactovegetarians on the basis of food intakes reported on the food-frequency questionnaire.

**Results:** The prevalence of overweight or obesity (BMI ≥ 25) was 40% among omnivores, 29% among both semivegetarians and vegans, and 25% among lactovegetarians. In multivariate, adjusted logistic regression analyses, self-identified vegans had a significantly lower risk of overweight or obesity [odds ratio (OR) = 0.35; 95% CI: 0.18, 0.69] than did omnivores, as did lactovegetarians (OR = 0.54; 95% CI: 0.35, 0.85) and semivegetarians (OR = 0.52; 95% CI: 0.43, 0.62). Risk of overweight or obesity remained significantly lower among lactovegetarians classified on the basis of the food-frequency questionnaire (OR = 0.48; 95% CI: 0.30, 0.78).

**Conclusions:** Even if vegetarians consume some animal products, our results suggest that self-identified semivegetarian, lactovegetarian, and vegan women have a lower risk of overweight and obesity than do omnivorous women. The advice to consume more plant foods and less animal products may help individuals control their weight. *Am J Clin Nutr* 2005;81:1267–74.


**KEY WORDS** Overweight, obesity, BMI, vegetarian, lactovegetarian, vegan

## INTRODUCTION

There is a critical need to control the obesity epidemic in light of the increasing prevalence of overweight and obesity around the world (1). Two extensive reviews of observational studies that used eating pattern methods suggest that a plant-based diet high in fiber-rich foods, such as vegetables, fruits, cereals, whole grains, and legumes, is inversely related to body mass index (BMI), overweight, and obesity (2, 3). Protective eating patterns may also include lean protein foods such as chicken, fish, soy products, and reduced-fat dairy products (2). The studies in these reviews, however, varied in their design and adjustment for potential confounders in the analyses. Additional, recent evidence supports a protective effect of dietary fiber and whole grains (4–7), as well as dairy products and calcium (8, 9), although more studies are needed.

Therefore, the scientific literature suggests that it may be useful to further examine whether plant-based diets are inversely related to obesity. Moreover, the question remains as to whether animal products such as lean protein and dairy foods are helpful for controlling weight. Studies examining different types of vegetarian eating patterns seem well poised to assess this relation. Although some studies have shown associations between vegetarianism and blood pressure (10, 11), blood lipids (12–17), cancer (18), heart disease (18), and all-cause mortality (18–20), surprisingly few studies have rigorously examined the relation between vegetarian eating patterns and obesity (21–25). Although 3 reviews suggest that vegetarians have a lower BMI on average (26–28), much of the data on vegetarian diets and BMI are baseline associations from studies whose primary outcome was not obesity (10, 15, 18, 29) or from analyses that were not adjusted for potential confounders (25). Although a few well-designed studies have directly examined the relation between vegetarian eating patterns and BMI (22, 24), additional studies are needed to confirm these findings. Furthermore, no studies that we are aware of have examined vegetarian eating patterns among older Swedish women. The aim of the present study was to examine the BMI and risk of overweight and obesity among self-defined semivegetarian, lactovegetarian, and vegan women.

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## SUBJECTS AND METHODS

### Study design and participants

Data analyzed in this cross-sectional study were from the first wave of the Swedish Mammography Cohort (SMC) in 1987–1990, a population-based mammography screening program introduced in Vastmanland and Uppsala counties in central Sweden. All women born between 1914 and 1948 living in these 2 counties were invited to the screening ($n = 90\,903$) and received a 6-page questionnaire that included items about anthropometric, reproductive, sociodemographic, and dietary factors. Among those contacted, 66 651 (74%) completed the questionnaire and agreed to participate; these methods are further described elsewhere (30). In brief, questionnaires with missing or incorrect ID numbers, questionnaires lacking a date, women who moved out of the study area, and women who died during the study period but were missing a date of death were excluded from the study. Women with a previous cancer diagnosis as reported in the Swedish Cancer Registry were also excluded. After these exclusions, 61 433 participants in the SMC study remained, from which we created our study sample.

To obtain a healthy cohort, we first excluded women with a cardiovascular condition of angina, diabetes, coronary disease, or stroke ($n = 1834$); cardiovascular conditions were based on hospital diagnoses. We next excluded subjects whose energy intake appeared implausible (<2510 or >16 736 kJ; $n = 747$). Of the remaining study participants, subjects with missing height or weight data or with implausible values for weight (<40 or >225 kg), height (>2.25 or <1.4 m), or BMI (in kg/m$^2$: <14 or >50) were excluded ($n = 2197$). Last, women were excluded if they did not answer the question describing their overall dietary pattern, which was our main exposure variable ($n = 1196$), as described below. After all exclusions, 55 459 women were available for the analysis.

### Dietary assessment

Dietary intakes were assessed with a food-frequency questionnaire (FFQ). On the FFQ, the women were asked whether they considered themselves to be omnivorous (consume all foods), semivegetarian (mostly lactovegetarian, sometime consume fish or eggs), lactovegetarian (consume no meat, poultry, fish, or eggs), or vegan (consume no meat, poultry, fish, eggs, or dairy products). From this question, the women were grouped into 4 mutually exclusive categories of omnivore, semivegetarian, lactovegetarian, and vegan (the last 3 patterns are referred to as vegetarian eating patterns herein).

The FFQ contained 67 food questions, of which 60 were semiquantitative food items in which the subjects were asked how often, on average, they had consumed the foods in the past 6 mo, ranging from "never/seldom" to "4 or more times/d." (The remaining items on the questionnaire queried eating behaviors and were not used in the present study.) Standard portion sizes were used on the FFQ (eg, 1 slice of bread = 1 serving). Frequency intakes were converted to daily intakes (eg, 1–3 times/mo = 0.07 servings/d on the basis of the midpoint of 2 times/mo). Nutrients were derived from reported food intakes by using the database from the Swedish Food Administration. Foods were also categorized into several major food groups (ie, fruit, vegetables, potatoes, legumes, cereals, whole grains, refined grains, dairy products, meat, poultry, and fish) to examine food group intakes across the different eating patterns.

### Anthropometric assessment

Subjects self-reported their weight (kg) and height (m) on the questionnaire; high validity has been observed for self-reported height ($r = 1.0$) and weight ($r = 0.9$) compared with actual measurements among Swedish women (31). From height and weight, BMI (kg/m$^2$) was calculated. On the basis of their BMI, the women were classified as overweight (BMI 25–29.99) or obese (BMI $\geq$ 30) according to international cutoffs (32).

### Covariate assessment

On the 1987 questionnaire, the women reported their age, education, and marital status. Education was originally measured in 6 categories (compulsory school, vocational or girls' school, junior secondary school, secondary school, university or college, and other training) and was collapsed into 4 mutually exclusive categories of less than high school, high school, university, and other training. Marital status was reported as single, cohabitating but not married, married, divorced, or widowed.

Because only a limited set of covariates was assessed in 1987–1990, we used data from the second wave of the SMC study in 1997 to further adjust our regression analyses, including only those variables that could not have changed between 1987 and 1997. Specifically, the questionnaire in 1997 included questions on the age at birth of the first child, parity, and body shape at 10 y of age. Subjects were asked to recall their childhood body shape ("How was your figure at 10 y of age?") by choosing among 7 figures of increasing body size, ranging from smallest (figure 1) to largest (figure 7). The women were also asked to recall their age at the birth of their first child and to report how many children they had. Smoking habit (current, previous, or never) was also assessed. We re-categorized smokers as never smokers and ever smokers, because a never smoker in 1997 would also be a never smoker in 1987 but it could not be determined whether a current or previous smoker in 1997 would have had the same smoking status in 1987.

### Statistical analyses

Sample characteristics were described by using means and SDs for continuous variables and frequencies (number and percent) for categorical variables. We used Tukey's honestly significant differences test for continuous covariates and the chi-square test for categorical covariates to examine differences in sample characteristics across groups. Mean (±SE) intakes of macronutrients and food groups among each eating pattern group were calculated by using a generalized linear model and were adjusted for multiple comparisons by using Tukey's honestly significant differences test.

Linear and logistic regression analyses were performed, and each analysis included an indicator variable for each vegetarian eating pattern (eg, semivegetarian, lactovegetarian, or vegan) in the same model; omnivores were treated as the reference group. Two sets of linear regression analyses were performed, and alpha was set at 0.05. In the first analysis, the outcome was BMI, and in the second, the outcome was weight. For each outcome, the first model was adjusted for age and energy intake and the second model was multivariate adjusted for age, energy intake, alcohol intake, education, marital status, smoking status, parity, age at first birth, and childhood body shape for a subset of women for whom these data were available. A final model was tested with additional adjustment for intakes of total fat (% of energy/d) and

fiber (g/d). Last, we added a quadratic term for age to see if model fit improved. We also tested all models without baseline energy intake, because energy may be in the causal pathway of the association between eating patterns and weight. Models predicting weight were also adjusted for height.

Two sets of logistic regression analyses were also performed. In the first analysis, overweight or obesity (BMI $\geq$ 25) was the outcome variable; in the second, obesity (BMI $\geq$ 30) was the outcome variable. Models were built in the same way as described above, and odds ratios (ORs) and 95% CIs were calculated for each vegetarian group.

In a secondary analysis to check the associations between vegetarian eating pattern and BMI, overweight, and obesity, we reclassified women as actual lactovegetarians or actual vegans on the basis of reported dietary intakes on the FFQ, which we defined as zero consumption of meat, fish, and eggs or zero consumption of meat, fish, eggs, and dairy products, respectively. All regression analyses were repeated in the group of actual lactovegetarians.

We last performed a final set of regression analyses following the above modeling procedure among never smokers in which we excluded current or former smokers to prevent confounding by smoking status. Although our primary regression models above were adjusted for smoking, residual confounding may have affected our estimates. We could not discern whether ever smokers were current or former smokers in 1987, because smoking habit may have changed during the 10-y follow-up period when smoking status was measured. All analyses were performed by using SAS for WINDOWS, version 8.2 (SAS Institute Inc, Cary, NC).

## RESULTS

A small percentage of women were semivegetarian (1.73%), lactovegetarian (0.29%), or vegan (0.15%). The vegan women were significantly older than the omnivorous, semivegetarian, and lactovegetarian women ($P < 0.05$; **Table 1**). The omnivorous women were significantly heavier (66.6 $\pm$ 10.9 kg) than any of the 3 vegetarian groups and also had a significantly higher BMI (24.7 $\pm$ 3.9). The prevalence of overweight or obesity (BMI $\geq$ 25) was 40% among omnivores, 29% among both semivegetarians and vegans, and 25% among lactovegetarians. A higher percentage of semivegetarians (9%) and lactovegetarians (10%) attended university compared with omnivores (5%) and vegans (6%). Vegans had the highest percentage of never smokers (72%).

As shown in **Table 2**, intakes of all macronutrients differed significantly across eating patterns. Omnivores had significantly higher energy ($P < 0.005$) and protein ($P < 0.0003$) intakes, and significantly lower carbohydrate intake ($P < 0.001$), than did any of the 3 vegetarian groups. Omnivores also consumed a greater percentage of energy from saturated fat and monounsaturated fat than did all 3 vegetarian groups and had the lowest intake of fiber. Omnivores had the highest intakes of refined grains and animal foods and the lowest intakes of fruit and vegetables (**Table 3**). Few significant differences in food group intakes were noted among the 3 vegetarian eating groups: vegans consumed more vegetables and less dairy products than did lacto- or semivegetarians, whereas semivegetarians consumed the most fish.

In multivariate, adjusted linear regression analyses (**Table 4**), women who were semivegetarian (b = $-1.13$; 95% CI: $-1.42$, $-0.84$; $P < 0.005$), lactovegetarian (b = $-1.07$; 95% CI: $-1.81$, $-0.33$; $P < 0.005$), or vegan (b = $-1.29$; 95% CI: $-2.33$, $-0.25$; $P < 0.005$) had a significantly lower BMI than did omnivores. Among the 3 vegetarian groups, vegans had the lowest weight (b = $-5.31$; 95% CI: $-7.82$, $-2.80$; $P < 0.005$) compared with omnivores.

In multivariate, adjusted logistic regression analyses (**Table 5**), vegans had a significantly lower risk of overweight or obesity (OR = 0.35; 95% CI: 0.18, 0.69) than did omnivores, as did lactovegetarians (OR = 0.54; 95% CI: 0.35, 0.85) and semivegetarians (OR = 0.52; 95% CI: 0.43, 0.62). Semivegetarians also had a lower risk of obesity (OR = 0.46; 95% CI: 0.31, 0.66) than did omnivores. When lactovegetarians and vegans were collapsed into one group, there was a similar reduction in risk for obesity (OR = 0.46; 95% CI: 0.26, 0.83), although the odds ratio was no longer significant when further adjusted for covariates.

In secondary analyses, we counted 158 actual lactovegetarians and 14 actual vegans in the sample when defined on the basis of intakes reported in the FFQ; we only analyzed lactovegetarians because of the small number of vegans available for analysis. In a multivariate adjusted model, actual lactovegetarians had a significantly lower BMI (b = $-1.68$; 95% CI: $-2.46$, $-0.90$; $P = 0.0013$) and lower weight (b = $-4.17$; 95% CI: $-6.01$, $-2.33$; $P = 0.0062$) than did omnivores. The risk of overweight or obesity remained significantly lower among actual lactovegetarians (OR = 0.48; 95% CI: 0.30, 0.78; data not shown).

The quadratic term for age was significant, so it was retained in the final multivariate adjusted models above. Our results for all the regression analyses were similar and remained significant when fat and fiber were added to the model, when we omitted energy from the model, and when all analyses were repeated among never smokers (data not shown).

## DISCUSSION

In the present study, the mean weight, BMI, and prevalence of overweight and obesity were highest among omnivores compared with semivegetarians, lactovegetarians, and vegans. In a multivariate, adjusted logistic regression model, vegans had a significantly lower risk of overweight or obesity than did omnivores, as did lactovegetarians and semivegetarians. A reduced risk of overweight or obesity was also observed when we recategorized women as actual lactovegetarians on the basis of reported dietary intake on the FFQ rather than on the basis of whether they identified themselves as a vegetarian.

Although the number of vegetarians in this population was small, the large sample size of the study allowed us to examine dietary associations between BMI and overweight or obesity among subgroups of vegetarians and to detect significant effects. We were also able to adjust for many potential confounders and additional risk factors, including education, smoking, marital status, parity, age at first birth, and childhood body shape. Our results were similar and remained significant in an analysis limited to never smokers. All 3 vegetarian groups had BMIs $\approx$1 unit lower than that of the omnivores, which is of a similar magnitude to the difference reported in other studies (26, 27). Our logistic regression results suggest that vegans may be at an even lower risk of overweight or obesity than semi- and lactovegetarians (65% risk reduction compared with 48% and 46%, respectively), although the CIs between the groups overlapped. Three other studies observed a lower mean BMI among vegans than in other types of vegetarians (14, 22, 23). Differences in plasma lipids

**TABLE 1**
Sample characteristics of 55 459 self-identified omnivorous, semivegetarian, lactovegetarian, and vegan women participating in the Swedish Mammography Cohort

| Characteristic | Sample size | Omnivores ($n$ = 54 257) | Semivegetarians ($n$ = 960) | Lactovegetarians ($n$ = 159) | Vegans ($n$ = 83) | $P^1$ |
|---|---|---|---|---|---|---|
| Age (y) | 55 459 | 52.5 ± 9.7[2,a,b] | 53.6 ± 9.8[a] | 51.1 ± 9.5[b] | 54.8 ± 9.5[c] | < 0.05 |
| Weight (kg) | 55 459 | 66.6 ± 10.9[a] | 63.6 ± 10.0[b] | 64.0 ± 10.9[b] | 62.4 ± 10.7[b] | < 0.05 |
| Height (m) | 55 459 | 1.64 ± 0.1 | 1.64 ± 0.1 | 1.65 ± 0.1 | 1.64 ± 0.1 | 0.14 |
| BMI (kg/m$^2$) | 55 459 | 24.7 ± 3.9[a] | 23.6 ± 3.5[b] | 23.4 ± 3.5[b] | 23.3 ± 3.8[b] | < 0.005 |
| Overweight [$n$ (%)] | 55 459 | 16 285 (30) | 228 (24) | 33 (21) | 19 (23) | < 0.0001 |
| Obese [$n$ (%)] | 55 459 | 5220 (10) | 49 (5) | 7 (4) | 5 (6) | < 0.0001 |
| Education [$n$ (%)] | 54 570 | | | | | <0.0001 |
| Less than high school | | 42 725 (80) | 655 (70) | 110 (70) | 59 (74) | |
| High school | | 3738 (7) | 81 (9) | 14 (9) | 9 (11) | |
| University | | 2522 (5) | 87 (9) | 16 (10) | 5 (6) | |
| Other training | | 4404 (8) | 120 (12) | 17 (11) | 8 (9) | |
| Marital status [$n$ (%)] | 54 957 | | | | | < 0.0001 |
| Single | | 3156 (6) | 89 (9) | 15 (9) | 7 (9) | |
| Married | | 38 163 (71) | 564 (59) | 86 (54) | 51 (63) | |
| Cohabitating | | 3458 (6) | 51 (5) | 14 (9) | 2 (3) | |
| Divorced | | 4623 (9) | 149 (17) | 31 (20) | 14 (16) | |
| Widowed | | 4369 (8) | 96 (10) | 12 (8) | 7 (9) | |
| Smoking status [$n$ (%)][3] | 31 473 | | | | | < 0.0001 |
| Never | | 18 479 (60) | 409 (68) | 61 (66) | 33 (72) | |
| Past | | 7619 (25) | 153 (24) | 26 (28) | 11 (24) | |
| Current | | 4628 (15) | 46 (8) | 6 (6) | 2 (4) | |
| Age at birth of first child [$n$ (%)][3] | 31 351 | | | | | 0.004 |
| ≤ 24 y | | 18 102 (59) | 309 (54) | 48 (58) | 25 (55) | |
| 25–30 y | | 10 168 (33) | 215 (38) | 26 (32) | 19 (41) | |
| > 30 y | | 2382 (8) | 47 (8) | 8 (10) | 2 (4) | |
| Parity [$n$ (%)][3] | 34 825 | | | | | 0.18 |
| 0 | | 2521 (7) | 65 (10) | 10 (10) | 1 (2) | |
| 1–2 | | 19 805 (58) | 374 (58) | 54 (54) | 28 (56) | |
| 3–4 | | 10 196 (30) | 179 (28) | 31 (31) | 16 (32) | |
| > 4 | | 1502 (4) | 33 (5) | 5 (5) | 5 (10) | |
| Body shape at age 10 y [$n$ (%)][3,4] | 35 024 | | | | | 0.14 |
| 1–2 | | 18 365 (54) | 341 (52) | 52 (50) | 24 (48) | |
| 3–4 | | 12 796 (37) | 268 (41) | 47 (45) | 19 (38) | |
| ≥ 4 | | 3052 (9) | 48 (7) | 5 (5) | 7 (14) | |

[1] $P$ values were obtained by using Tukey's honestly significant differences test for continuous variables (age, weight, height, and BMI) and the chi-square test for categorical variables (overweight, obesity, education, marital status, smoking status, parity, age at first birth, and body shape at age 10 y). For continuous variables, groups with different superscript letters are significantly different, $P < 0.05$.
[2] $\bar{x}$ ± SD (all such values).
[3] Data were available only for women who participated in the follow-up study in 1997 ($n$ = 38 984); missing data are not included in the calculations.
[4] Body shape was assessed by use of a pictogram, which asked subjects to rank their body size on a scale ranging from 1 (smallest) to 7 (largest).

among different types of vegetarians have also been reported (14–16). More research is needed to further examine whether different types of vegetarian eating patterns have different effects on weight and health.

Our study raises interesting questions about how individuals define themselves and whether this information is useful in research even if it does not completely reflect "truth." In this case, our questionnaire asked participants to self-identify themselves as *omnivorous*, *semivegetarian*, *lactovegetarian*, or *vegan*, and these terms were specifically defined for them. When we looked at intakes of major food groups across the 3 vegetarian groups on the basis of the FFQ, however, we found that in none of the self-defined vegetarian groups, including vegans, was mean animal product intake actually zero. We were able to analyze actual lactovegetarians, and these individuals showed a similar relation with BMI and risk of overweight or obesity as did self-reported lactovegetarians and vegans. Therefore, that self-reported vegetarians consumed some animal foods may not be biologically meaningful with regard to obesity and weight, because the food and nutrient intakes of vegetarians differed significantly from those of omnivores despite some animal product consumption, and a significant protective effect was still observed.

Our finding that self-identified vegetarians consume meat is not unusual (25, 33). A study of 13 313 Americans aged ≥6 y found that only 36% of self-defined vegetarians reported consuming no meat (33). In that study, the investigators further stratified the self-defined vegetarians and nonvegetarians into those who did and did not report consuming meat on their diet recalls. They found that self-defined vegetarians aged ≥20 y had a lower BMI than did self-defined nonvegetarians, regardless of whether they ate meat (33); this result supports our finding.

**TABLE 2**
Energy and macronutrient intakes among 55 459 self-identified omnivorous, semivegetarian, lactovegetarian, and vegan women participating in the Swedish Mammography Cohort[1]

| Energy or macronutrient (intake/d) | Omnivores ($n$ = 54 257) | Semivegetarians ($n$ = 960) | Lactovegetarians ($n$ = 159) | Vegans ($n$ = 83) | $P$ |
|---|---|---|---|---|---|
| Energy (kJ)[2] | 5766 ± 8[a] | 5183 ± 50[b] | 5067 ± 117[b] | 4786 ± 167[b] | < 0.005 |
| Carbohydrate (% of energy)[3] | 50.9 ± 0.1[a] | 57.3 ± 0.2[b] | 59.8 ± 0.5[c] | 62.7 ± 0.6[d] | < 0.001 |
| Protein (% of energy)[3] | 16.3 ± 0.0[a] | 14.7 ± 0.1[b] | 13.5 ± 0.2[c] | 12.4 ± 0.2[d] | < 0.005 |
| Fat (% of energy)[3] | 30.7 ± 0.0[a] | 26.0 ± 0.2[b] | 25.2 ± 0.4[b] | 23.0 ± 0.6[c] | < 0.05 |
| Saturated fat (% of energy)[3] | 13.0 ± 0.0[a] | 11.4 ± 0.1[b] | 11.1 ± 0.2[b] | 9.0 ± 0.3[c] | < 0.0001 |
| Monounsaturated fat (% of energy)[3] | 11.2 ± 0.0[a] | 8.8 ± 0.1[b] | 8.4 ± 0.2[b,c] | 8.1 ± 0.2[c] | < 0.05 |
| Polyunsaturated fat (% of energy)[3] | 4.4 ± 0.0[a] | 3.9 ± 0.0[b] | 3.7 ± 0.1[b] | 4.1 ± 0.1[a,b] | < 0.0001 |
| Fiber (g)[3] | 17.0 ± 0.1[a] | 20.9 ± 0.1[b] | 22.4 ± 0.3[c] | 23.0 ± 0.5[c] | < 0.0001 |
| Alcohol (g)[3] | 3.2 ± 0.0[a] | 2.7 ± 0.1[b] | 1.8 ± 0.2[c] | 2.0 ± 0.3[b,c] | < 0.005 |

[1] All values are $\bar{x}$ ± SE. Values in a row with different superscript letters are significantly different, $P < 0.05$ (Tukey's honestly significant differences test).
[2] Adjusted for age.
[3] Adjusted for age and total energy intake.

We found that food and nutrient intakes across the 3 groups of vegetarians showed many significant differences. Notably, all the vegetarian groups had higher intakes of fruit, vegetables, and fiber and lower intakes of fat and protein. Studies of vegetarians in the United Kingdom (16), Israel (34), Canada (29), and the United States (33) also reported higher intakes of fiber and carbohydrate and lower intakes of protein and saturated fat by vegetarians than by omnivores. A higher intake of carbohydrates and fiber among vegetarians is expected, because plant-based foods are composed mainly of carbohydrates. That vegetarians are leaner and have a reduced risk of overweight or obesity despite higher total carbohydrate intake points to the importance of differentiating between types of carbohydrate when selecting diets, including weight-loss diets. Current fad diets that emphasize low carbohydrate intakes ignore the fact that whole and refined carbohydrate foods evoke different metabolic responses, thereby exerting different effects on appetite and energy intake. This study and others (5, 7) suggest that a high-carbohydrate diet may be protective against obesity if the carbohydrates come from fiber-rich foods such as fruit, vegetables, and whole grains.

Nutritional studies that examine eating patterns, rather than single nutrients, cannot determine the biological mechanisms responsible for observed effects. In fact, several different mechanisms involving both macro- and micronutrients are likely responsible for the lower risk of obesity and smaller BMI that we observed. In an elegant study of 38 000 participants in EPIC-Oxford, Spencer et al (22) found that

**TABLE 3**
Food group intakes for 55 459 self-identified omnivorous, semivegetarian, lactovegetarian, and vegan women participating in the Swedish Mammography Cohort[1]

| Food group (servings/d) | Omnivores ($n$ = 54 257) | Semivegetarians ($n$ = 960) | Lactovegetarians ($n$ = 159) | Vegans ($n$ = 83) | $P$ |
|---|---|---|---|---|---|
| Fruit[2] | 1.5 ± 0.0[a] | 2.0 ± 0.0[b] | 2.2 ± 0.1[b] | 2.2 ± 0.1[b] | <0.0001 |
| Vegetables[3] | 1.7 ± 0.0[a] | 2.5 ± 0.0[b] | 2.6 ± 0.1[b] | 3.2 ± 0.1[c] | <0.0001 |
| Potatoes[4] | 0.81 ± 0.00[a] | 0.66 ± 0.01[b] | 0.74 ± 0.03[a,b] | 0.86 ± 0.02[a] | <0.0005 |
| Legumes[5] | 0.05 ± 0.0[a] | 0.05 ± 0.0[a,b] | 0.06 ± 0.0[a,b,c] | 0.08 ± 0.1[c] | <0.05 |
| Cereal[6] | 0.27 ± 0.00[a] | 0.40 ± 0.03[b] | 0.40 ± 0.03[b] | 0.22 ± 0.04[a] | <0.005 |
| Whole grains[7] | 1.9 ± 0.1[a] | 2.2 ± 0.0[b] | 2.2 ± 0.1[b] | 2.0 ± 0.2[a,b] | <0.05 |
| Refined grains[8] | 0.88 ± 0.0[a] | 0.60 ± 0.0[b] | 0.58 ± 0.1[b] | 0.61 ± 0.1[b] | <0.01 |
| Eggs | 0.19 ± 0.0[a] | 0.16 ± 0.0[b] | 0.06 ± 0.02[c] | 0.04 ± 0.02[c] | <0.0001 |
| Dairy products[9] | 4.9 ± 0.0[a] | 4.3 ± 0.1[b] | 4.1 ± 0.2[b] | 2.7 ± 0.2[c] | <0.0003 |
| Meat[10] | 1.1 ± 0.0[a] | 0.1 ± 0.0[b] | 0.2 ± 0.0[b] | 0.3 ± 0.1[b] | <0.0001 |
| Poultry[11] | 0.06 ± 0.0[a] | 0.02 ± 0.0[b] | 0.01 ± 0.1[c] | 0.02 ± 0.1[b,c] | <0.05 |
| Fish[12] | 0.28 ± 0.00[a] | 0.34 ± 0.01[b] | 0.07 ± 0.01[c] | 0.15 ± 0.02[d] | <0.05 |

[1] All values are $\bar{x}$ ± SD. Values in a row with different superscript letters are significantly different, $P < 0.05$ (Tukey's honestly significant differences test).
[2] Includes apples, pears, bananas, and citrus fruit.
[3] Includes lettuce, root vegetables, spinach, tomatoes, and white cabbage.
[4] Includes boiled potatoes, French fries, and fried potatoes.
[5] Includes brown beans and pea soup.
[6] Includes ready-to-eat (cold) cereal and muesli.
[7] Includes hard (crisp) bread, porridge, and whole-meal bread.
[8] Includes white bread, rice, pancakes, and spaghetti.
[9] Includes milk, sour milk, butter, cheese, and margarine (both full-fat and reduced-fat products).
[10] Includes meat, stews, casseroles, minced meat, sandwich meats, bacon, sausage, black pudding, liver, and pâté.
[11] Includes chicken.
[12] Includes fatty fish (eg, salmon, mackerel, and herring), other fish, and shellfish.

**TABLE 4**
Linear regression coefficients ($\beta$) and SEs showing the association between self-identified vegetarian eating patterns and BMI and weight among 55 459 women participating in the Swedish Mammography Cohort

| Self-identified vegetarian eating pattern[1] | $\beta$ (SE) BMI (kg/m$^2$) | $\beta$ (SE) Weight (kg)[2] |
|---|---|---|
| Semivegetarian[3] | | |
| Adjusted for age and energy | −1.30 (0.12)[4] | −3.47 (0.33)[4] |
| Multivariate adjusted[5] | −1.13 (0.15)[4] | −3.29 (0.36)[6] |
| Lactovegetarian[7] | | |
| Adjusted for age and energy | −1.25 (0.30)[4] | −3.22 (0.80)[4] |
| Multivariate adjusted[5] | −1.07 (0.38)[4] | −2.74 (0.90)[4] |
| Vegan[8] | | |
| Adjusted for age and energy | −1.76 (0.41)[4] | −4.75 (1.06)[4] |
| Multivariate adjusted[5] | −1.29 (0.53)[6] | −5.31 (1.28)[4] |

[1] All 3 eating patterns were tested in the same model with omnivores as the reference group.
[2] Models were further adjusted for height.
[3] Semivegetarians were defined as women who considered themselves mostly lactovegetarian but who sometimes consumed fish or eggs.
[4] $P < 0.005$.
[5] Further adjusted for age squared, alcohol intake, education, marital status, smoking status, parity, age at first birth, and childhood body shape.
[6] $P < 0.05$.
[7] Lactovegetarians were defined as women who did not consume meat, fish, or eggs.
[8] Vegans were defined as women who did not consume meat, fish, eggs, or dairy products.

high protein (as a percentage of energy) and low fiber intakes were the dietary factors most strongly associated with increasing BMI and that differences in macronutrient intakes accounted for about one-half the difference in mean BMI between vegans and meat-eaters. Another study of 5292 vegetarians in the United Kingdom found that differences in BMI between meat-eaters and vegetarians were partly, but not wholly, explained by differences in animal fat, fiber, and alcohol intakes (24). Likewise, our results remained similar and significant when we adjusted our models for total fat and fiber intakes, which suggests that additional, significant dietary components of a vegetarian diet are protective.

Because differences in foods and nutrients essentially define the different vegetarian eating patterns, and may be in the causal pathway between diet and body weight, it is arguable whether some dietary variables should be adjusted for in the analysis. For example, it is likely that the high fiber consumption among vegetarians is partly responsible for the lower energy intakes observed in some studies (21, 22, 33) and ours, because fiber contributes to greater satiation and satiety and hence decreased energy intakes within and between meals (35). In the present study, energy intakes were higher and fiber intakes were lower as more animal products were included in the diet. Low energy intakes among vegetarian groups may also be because we used a short questionnaire designed for the general population that did not specifically include vegetarian foods (eg, soy products, meatless products, tofu, and hummus). However, estimated energy intakes among all groups were low in the present study, likely because of the underreporting that is common with the FFQ method. It is controversial as to whether underreporting is associated with dietary composition (36, 37), although there did not appear to be distortion in macronutrient intakes expressed as a percentage of total energy in our study. Omitting total energy from our models did not appreciably change our regression results. One review notes that the probability of underreporting increases as BMI increases (37), although we do not expect that underreporting would affect self-report of vegetarian status.

Our study has several limitations, including its cross sectional design. Although data on weight from the follow-up study of the

**TABLE 5**
Odds ratios (ORs) and 95% CIs showing the association between self-identified vegetarian eating patterns and overweight and obesity among 55 459 women participating in the Swedish Mammography Cohort

| Self-identified vegetarian eating pattern[1] | Overweight or obese (BMI ≥ 25) OR | Overweight or obese (BMI ≥ 25) 95% CI | Obese (BMI ≥ 30) OR | Obese (BMI ≥ 30) 95% CI |
|---|---|---|---|---|
| Semivegetarian[2] | | | | |
| Adjusted for age and energy | 0.55 | 0.48, 0.64 | 0.47 | 0.35, 0.62 |
| Multivariate adjusted[3] | 0.52 | 0.43, 0.62 | 0.46 | 0.31, 0.66 |
| Lactovegetarian[4] | | | | |
| Adjusted for age and energy | 0.51 | 0.35, 0.73 | 0.46 | 0.26, 0.83 |
| Multivariate adjusted[3] | 0.54 | 0.35, 0.85 | 0.64 | 0.34, 1.19 |
| Vegan[5] | | | | |
| Adjusted for age and energy | 0.51 | 0.31, 0.82 | 0.52 | 0.21, 1.28 |
| Multivariate adjusted[3] | 0.35 | 0.18, 0.69 | 0.64 | 0.29, 1.40 |
| Lactovegetarian + vegan[6] | | | | |
| Adjusted for age and energy | 0.50 | 0.38, 0.68 | 0.46 | 0.26, 0.83 |
| Multivariate adjusted[3] | 0.47 | 0.32, 0.68 | 0.64 | 0.29, 1.41 |

[1] All 3 eating patterns were tested in the same model with omnivores as the reference group.
[2] Semivegetarians were defined as women who considered themselves mostly lactovegetarian but who sometimes consumed fish or eggs.
[3] Multivariate models were further adjusted for age squared, alcohol intake, education, marital status, smoking status, parity, age at first birth, and childhood body shape.
[4] Lactovegetarians were defined as women who did not consume meat, fish, or eggs.
[5] Vegans were defined as women who did not consume meat, fish, eggs, or dairy products.
[6] Because of the small numbers of obese lactovegetarians ($n = 7$) and obese vegans ($n = 5$), the 2 groups were collapsed into 1 category.

Swedish Mammography Cohort are available, these measures are ≈10 y away from baseline and are available only for a smaller sample of women who participated in the second wave of the study (≈65% of our baseline study sample). In addition, the FFQ in 1997 was modified and excluded our primary exposure variable on how women defined their eating pattern. Furthermore, we had no data on changes in weight and changes in diet during the 10-y follow-up period.

Cross-sectional studies of obesity and body weight cannot determine causality, because it cannot be determined whether diet led to obesity or whether obesity led to changes in diet. In our study, reverse causality seems unlikely, because we would have observed positive associations between vegetarian patterns and BMI or overweight or obesity, which would most likely indicate that overweight women switched to a vegetarian diet in an attempt to lose weight. Also, individuals usually choose to become vegetarians earlier in life than the age of the women in this study (≈52 y on average), so it seems unlikely that the women in this study would have become vegetarians simply to lose weight. Because our study showed inverse relations between vegetarian eating patterns and overweight or obesity and our results are supported by other studies, our findings may reflect true associations; however, prospective research studies and intervention studies are needed to confirm our findings.

An additional limitation of our study is that it only included older women. One review, however, found that vegetarians of all ages and both sexes are leaner than omnivores (26), which suggests that our results may be generalizable to younger women and to men. Last, although we were able to adjust for some confounders, we were not able to adjust for physical activity. A large study, however, found that differences in BMI among vegetarian groups remained significant in models adjusted for physical activity and nondietary lifestyle factors (including smoking and physical activity) and accounted for <5% of the differences in BMI among these dietary groups (22).

In conclusion, even if vegetarians consume some animal products as part of their diet, our results suggest that self-identified semivegetarian, lactovegetarian, and vegan women have a lower risk of overweight and obesity than do omnivorous women. Additional studies focusing on single nutrients are needed to elucidate the precise dietary mechanisms responsible for this association, and prospective or intervention studies that adjust for physical activity and other confounders are also needed. The advice to consume more plant foods and less animal products may help individuals control their weight.

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