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# Vegetarian Diets and Weight Status

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*The increasing global health problems of overweight and obesity are associated with coronary heart disease, hypertension, diabetes, osteoarthritis, and certain cancers, among other health concerns. Vegetarian diets are associated with reduced body weight, lower incidence of certain chronic disease, and lower medical costs compared with non-vegetarian diets. We reviewed the literature to ascertain the extent to which and by what mechanism(s) a plant-based diet may mediate body weight.*

Key words: obesity, overweight, vegan diet, vegetarian diet, weight loss



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## INTRODUCTION

Overweight and obesity are increasing not only in the United States,[1] but also globally.[2] According to the 1999–2000 National Health and Nutrition Examination Survey (NHANES), 64% of US adults were overweight, as defined by a body mass index (BMI) $\geq$ 25.0 kg/m$^2$, and 30% were obese (BMI $\geq$ 30.0 kg/m$^2$). This represented an 8% increase in prevalence of overweight and a 7% increase in obesity from 1988–1994 NHANES data.[3] The World Health Organization (WHO) estimates that a total of 1.2 billion people are overweight or obese, and that these numbers are rapidly increasing.[2] Overweight and obesity are associated with coronary heart disease, diabetes, hypertension, osteoarthritis, and certain cancers, among other health problems.

Previous reviews have noted that vegetarians tend to have a lower body weight than non-vegetarians.[4-7] If such diets cause weight loss when adopted by overweight individuals, they may be of substantial clinical value because they are also associated with other health benefits, including improved control of blood lipids,[8,9] blood pressure,[10] and diabetes,[11,12] reversal of cardiac atherosclerosis,[8,13] and a reduced incidence of certain cancers.[14,15] We therefore reviewed the published literature to ascertain the extent to which vegetarian diets are associated with reduced body weight and examined putative mechanisms that may explain these associations.

Vegetarian diets are based on plant-derived foods such as grains, beans, fruits, and vegetables. Ovo-lacto-vegetarians avoid meats but consume dairy products and eggs. Vegans avoid all food products of animal origin. References to vegetarians in this paper are to ovo-lacto-vegetarians, unless otherwise stated, as there are far fewer studies on vegans.

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## METHODS

A Medline search (National Library of Medicine, Bethesda, MD) was conducted for scientific articles containing information on vegetarians and their weight status using the key words "vegetarian diet" or "vegetarianism" and "body weight" or "body mass index" or "BMI," with the search limited to studies of adult humans published in the English language since 1966. Additional reports were identified from the references listed in these articles.

We examined each study for the presence or absence of confounding variables, particularly smoking and physical activity, body weight, and body-mass index (BMI), differences between vegetarians and non-vegetarians, and any reported differences in prevalence of overweight or obesity.

## RESULTS

### Observational Studies

We identified 40 studies reporting the weight status of vegetarians and non-vegetarians. Twenty-nine of these studies reported that vegetarians weighed significantly less than non-vegetarians as measured by BMI or body weight.[16-44]

The BMI or body weight of vegetarians was ob-

served to be lower than that of non-vegetarians in both genders,[16,18,20,21,23-25,27,28,30-35,40,42] and in African Americans,[32,43,44] Nigerians,[19] Caucasians,[16-18,20-29,33,35-41] and Asians[30,42] In addition, similar observations have been reported in widely separated geographic areas.[25,27-30,33-35,39]

Of the 11 observational studies that did not show a significantly lower weight among vegetarians, nine reported a non-significantly lower weight among vegetarians[45-51,85,86] compared with their non-vegetarian counterparts. Among these nine studies, three[45-47] had fewer than 30 participants. Two other groups reported that either weight or BMI was greater in vegetarians than in non-vegetarians.[52,53] Both of these studies had a small number of participants and included "health-conscious" volunteers.

The weight of female vegetarians ranged from 2.9 to 10.6 kg (6% to 17%) lower than the weight of female non-vegetarians. The weight of male vegetarians ranged from 4.6 to 12.6 kg (8% to 17%) lower than that of male non-vegetarians. In general, the BMI of female vegetarians ranged from 2.7% to 15.0% lower than that of non-vegetarian females, while the BMI of male vegetarians ranged from 4.6% to 16.3% lower than that of male non-vegetarians.

Because vegetarian populations may differ from non-vegetarians in their prevalence of non-dietary habits that influence body weight (e.g., smoking and exercise), investigators have controlled for these influences or compared populations with similar lifestyles but different dietary habits. As a group, vegetarians are less likely to smoke, a potential confounder in studies of body weight. However, the weight advantages of vegetarian diets persisted in studies that excluded smokers.[16,22,23,26-31,33] Researchers often have studied Seventh-Day Adventists (SDA), taking advantage of the fact that, while virtually all SDA avoid tobacco, caffeine, and alcohol, approximately half follow vegetarian diets, while half consume a moderate amount of meat products, providing a useful population for comparison. Melby[31] compared SDA vegetarians with SDA non-vegetarians, and Rouse[36] compared SDA vegetarians with Mormon non-vegetarians, both groups that proscribe smoking. In both studies, BMI and/or body weight was lower in vegetarians than in non-vegetarians. Melby[31] reported that the BMI of female vegetarians was 4.2 kg/m$^2$ lower than that of non-vegetarians ($P < 0.0001$) and that the BMI of male vegetarians was 1.8 kg/m$^2$ lower than that of non-vegetarians (non-significant). Rouse[36] reported that female vegetarians weighed 3.6 to 7.9 kg ($P < 0.01$) less than their non-vegetarian counterparts, while male vegetarians weighed 6.3 to 8.5 kg ($P < 0.01$) less than non-vegetarian males. BMI was 1.8 to 2.2 kg/m$^2$ lower in female vegetarians ($P < 0.01$) and 1.1 to 3.0 kg/m$^2$ ($P < 0.01$) lower in male vegetarians compared with non-vegetarians. Fraser[20] reported that a vegetarian male SDA weighed, on average, 6.4 kg less than his non-vegetarian counterpart ($P < 0.0001$), and a vegetarian female SDA weighed, on average, 5.5 kg less then her non-vegetarian counterpart ($P < 0.0001$). Nieman[49] compared dietary status and weight indices in a group of 37 elderly female SDA vegetarians with SDA non-vegetarians, and found that vegetarians weighed 2.5 kg ($P = 0.13$) less, on average, than non-vegetarians.

Using a different strategy to control for lifestyle variables, Burr[18,54] compared the BMIs of vegetarians with non-vegetarians, all of whom were patrons of health food shops who presumably shared an interest in healthy living. The vegetarians had lower BMIs among both men (22.1 vs. 24.6; $P < 0.001$) and women (22.3 vs. 23.7; $P < 0.01$).

## Type of Diet

Several small studies in diverse locations have examined the effect of type of vegetarian diet on BMI or body weight. In a sample of 183 Dutch men, Knuiman[25] reported a gradation to both lower weights and lower BMI from non-vegetarians through near vegetarians (who eat meat and fish products less than once a week), to ovo-lacto-vegetarians and macrobiotic (who avoid most animal products and consume whole grains, beans, vegetables, and fermented soy products) men. In a study comparing the weights of 45 African-American vegans with 143 African-American ovo-lacto-vegetarians, Toohey[43] found lower weights among vegans ($P < 0.05$)

Larger diverse studies have reported cross-sectional data obtained in the course of longitudinal studies.[20,40,55] The Coronary Artery Risk Development in Young Adults (CARDIA) study assessed dietary and health indicators of 5115 young adults.[40] Those who reported eating red meat and poultry less than once a week had lower BMIs than those who consumed these foods more than once a week. In a cohort of 34,192 California SDAs followed for 6 years, at the end of the study, BMI was higher in those subjects who consumed meat more frequently compared with those who consumed meat less frequently ($P < 0.0001$).[20] These results were calculated for subjects between the ages of 45 and 60 years, but similar results were seen for both sexes and at other ages. Key and Davey[55] and Spencer[41] used the data collected for the European Prospective Investigation into Cancer and Nutrition (EPIC) study to examine the relationship between BMI and meat consumption. Among both men and women, mean BMI was highest among the meat eaters, intermediate among the fish eaters and ovo-lacto-vegetarians, and lowest among the vegans. These differences in BMI were equivalent to a 5.9-kg difference in weight between male meat eaters and vegans and a

4.7-kg difference between female meat eaters and vegans.

The data from these and other[4,14,15,56,57] large population studies suggest that, within each cohort, vegetarians have a BMI about 1 kg/m$^2$ lower than that of the non-vegetarians. The difference is similar in males and females and is seen in all age groups. In general, the BMI of vegans is lower than that of ovo-lacto-vegetarians, which, in turn, is lower than that of individuals who eat moderate amounts of meat. There were few data on the effect of length of time on a vegetarian diet on body weight or BMI. However, in studies reporting this finding, BMI was lower among those who had adhered to their diet for a longer period compared with those who had adhered to their diet for a shorter period.[41,55]

The overall lower mean BMI of vegetarians leads to a substantially lower prevalence of obesity among vegetarians.[4,16,20,21,55,87] In a cohort of 33,971 generally well-educated women (mean age 52 $\pm$ 9 years) in the UK Women's Cohort Study, although mean BMIs for all groups were low and levels of obesity were around 10%, the prevalence of obesity in the vegetarian groups was 5% to 6%.[21] In another study in the United Kingdom, Spencer[41] reported that the age-adjusted prevalence of obesity was <2% in both male and female vegetarians compared with about 5% in meat eaters. In this study, participants were excluded from the analysis if they reported conditions including cardiovascular or heart disease, hypertension, diabetes, high cholesterol, or cancer. In a recent study of 55,459 Swedish women, the prevalence of obesity or overweight was 40% among omnivores, 29% among both semi-vegetarians and vegans, and 25% among ovo-lacto vegetarians.[34]

### Randomized, Controlled Trials

Several randomized clinical trials have examined the effects of vegetarian diets on body weight. Some have combined vegetarian diets with other lifestyle interventions. Ornish[13] examined the effect of a combination of a low-fat vegetarian diet with a walking program and stress management in free-living adults with coronary artery disease and compared them with a group receiving care from their own physicians. After a year, the mean weight loss was 10.76 kg in the experimental group, compared with a gain of 1.44 kg in the usual-care control group. After 5 years of follow-up, the vegan group maintained a 5.74-kg weight loss.[8] In these studies, the effect of diet cannot be separated from that of exercise. Other studies, however, used dietary interventions in the absence of exercise recommendations.

In a small group of individuals with type 2 diabetes who were instructed not to alter their exercise patterns, Nicholson[11] reported that the consumption of a 10% fat vegetarian diet for 12 weeks was associated with a loss of 7.2 kg in the experimental group compared with 3.8 kg ($P < 0.005$) in a control group following a diet in accordance with American Diabetes Association guidelines. In the course of a crossover trial of the effect of diet on dysmenorrhea involving 35 women (mean BMI = 25.5 $\pm$ 5.2) who were asked not to change their exercise habits, a low-fat, vegan diet without exercise led to mean reductions in body weight of 2.5 kg ($P < 0.001$) and BMI of 0.9 ($P < 0.001$) in 6 weeks. Participants with a baseline BMI over 22 lost about 3.0 kg; those with a BMI under 22 lost 1.4 kg.[9]

In another study,[58] 64 overweight, postmenopausal women were randomly assigned to a vegan diet deriving approximately 10% of energy from fat or a diet based on National Cholesterol Education Program guidelines, and all were instructed not to alter their exercise patterns. After 14 weeks, body weight had dropped 5.8 $\pm$ 3.2 kg in the vegan group, compared with 3.8 $\pm$ 2.8 kg in the control group ($P = 0.012$.) In a regression model of predictors of weight change, diet assignment ($P < 0.05$), thermic effect of food ($P < 0.05$), and resting metabolic rate ($P < 0.001$) were significant.

Three additional uncontrolled clinical trials compared final with baseline weight. McDougall[59] fed 500 men and women a 5% fat vegan diet for 12 days, which included intensive stress reduction and exercise intervention. This resulted in a 0.96% to 2.26% loss of body weight, approximately 2.5 kg for men and 1 kg for women. Lindahl et al.[60] placed 29 hypertensive patients on a vegan diet to assess the effect of the diet on hypertension. The patients were not encouraged to undertake regular fitness training. After 1 year, body weight decreased an average of 8.2 kg ($P < 0.001$) compared with baseline.

In summary, in 31 observational studies that reported body weight, 18 showed a significant difference in body weight of vegetarians compared with non-vegetarians. The differences ranged from 4% to 20% (Table 1). Most of the remaining studies found a lower body weight among vegetarians that did not reach statistical significance. Obesity prevalence ranged from 0% to 6% in vegetarians and from about 5% to 45% in non-vegetarians. In short-term, randomized, controlled trials in which the effect of a vegetarian or vegan diet on body weight was compared with control values, weight loss ranged from 2.5 to 7.2 kg, depending on initial body weight. Longer-term, uncontrolled trials have shown that this weight loss generally persists[8,60] (Table 2).

## MECHANISMS

Population studies suggest that vegans and vegetarians consume diets that are higher in carbohydrate and

**Table 1.** Observational Studies on the Difference in BMI and/or Body Weight of Vegetarians Compared with Non-Vegetarians

| Author | Country | Subjects | BMI | Weight (kg) | % Difference BMI VEG vs. NONVEG | % Difference Weight VEG vs. NONVEG |
|---|---|---|---|---|---|---|
| Appleby[16] | UK | 1914 M, 3378 F; 20–89 years of age from the Oxford Vegetarian Study | M VEG: 22.05*****<br>M NVEG: 23.18<br>F VEG: 21.32*****<br>F NVEG: 22.32<br>(age-adjusted mean BMIs) | | M: −4.87%<br>F: −4.48% | |
| Armstrong[17] | Australia | 418 SDA VEG; 290 SDA NVEG 30–79 y | | M VEG: 4.6 kg*** < M NVEG;<br>F VEG: 2.9 kg*** < F NVEG | | |
| Armstrong[85] | Australia | 106 pairs of VEG (mostly SDA) and NVEG; 17–79 y | Quetelet's index (g/cm$^2$):<br>VEG: 2.30 ± 0.45<br>NVEG: 2.39 ± 0.39 | VEG: 62.7 ± 11.6†<br>NVEG: 65.5 ± 12.0<br>†($P$ = 0.03) | −3.77% | −4.27% |
| Armstrong[86] | Australia | Postmenopausal F: 28 SDA VEG; 40 NVEG; 50–79 y | | VEG: 58.6 ± 10.7<br>NVEG: 60.2 ± 9.6 | | −2.7% |
| Barr[53] | Canada | F: 90 current VEG; 35 past vegetarians; 68 NVEG; 18–50 y | All subjects: 23.7 ± 4.7<br>VEG: 23.2 ± 3.7<br>Past vegetarian: 25.3 ± 5.2<br>NVEG: 23.5 ± 5.5 | All subjects: 64.8 ± 13.8<br>VEG: 64.3 ± 11.3<br>Past vegetarian: 68.4 ± 14.9<br>NVEG: 63.6 ± 16.0 | VEG vs NVEG 1.3% | VEG vs NVEG 1.1% |
| Burr[18] | UK | 85 VEG; 214 NVEG; 28–80 y | M <60 VEG: 20.53 ± 2.09****<br>M <60 NVEG: 24.53 ± 2.78<br>M 60+ VEG: 22.74 ± 2.98*<br>M 60+ NVEG: 24.85 ± 3.13<br>F <60 VEG: 22.40 ± 2.52<br>F <60 NVEG: 23.02 ± 3.27<br>F 60+ VEG: 22.18 ± 3.72**<br>F 60+ NVEG: 24.91 ± 3.92 | | M <60: −16.3%<br>M 60+: −8.49%<br>F <60: −2.69%<br>F 60+: −10.96% | |
| Faber[45] | South Africa | 14 M, 19 F VEG<br>10 M, 12 F NVEG; 18–40 y | M VEG: 23.9 ± 3.5<br>M NVEG: 24.6 ± 2.1<br>F VEG: 21.5 ± 3.1<br>F NVEG: 21.1 ± 1.5 | M VEG: 75.7 ± 11.0<br>M NVEG: 77.8 ± 7.2<br>F VEG: 57.7 ± 9.7<br>F NVEG: 59.7 ± 7.5 | M: −2.9%<br>F: −1.9% | M: −2.7%<br>F: −3.4% |

**Table 1.** (Cont'd) Observational Studies on the Difference in BMI and/or Body Weight of Vegetarians Compared with Non-Vegetarians

| Author | Country | Subjects | BMI | Weight (kg) | % Difference BMI VEG vs. NONVEG | % Difference Weight VEG vs. NONVEG |
|---|---|---|---|---|---|---|
| Famodu[19] | Nigeria | 76 SDAs; 18–60 y | VEGAN: 26.9 ± 0.7<br>LOVEG: 28.9 ± 0.7<br>NVEG: 29.1 ± 0.6 | VEGAN: 75.0 ± 1.9****[a]<br>LOVEG: 77.3 ± 1.8*[a]<br>NVEG: 80.8 ± 1.8<br>[a]compared to NVEG | LOVEG vs. NVEG: −0.7% | LOVEG vs. NVEG: −4.3% |
| Fraser[20] | USA | 34,192 California SDAs; 25 y or older | M VEG: 24.26*****[a]<br>M SVEG: 25.18*****[a]<br>M NVEG: 26.24*****[a]<br>F VEG: 23.7*****[a]<br>F SVEG: 24.83*****[a]<br>F NVEG: 25.88*****[a]<br>[a]diet status and BMI | | M: −7.55%; F: −8.31% | |
| Greenwood[21] | UK | 33,971 F 35–69 y | Monotonous low quantity omnivores: 25 ± 5****[a]<br>Health conscious: 24 ± 4****[a]<br>Higher diversity, traditional omnivores: 25 ± 4****[a]<br>Conservative omnivores: 25 ± 4****[a]<br>Low diversity vegetarians: 23 ± 4****[a]<br>High diversity vegetarians: 23 ± 4****[a]<br>[a](dif between clusters) | | −8% | |
| Haddad[22] | USA | NVEG 20<br>VEGAN 25 | NVEG 25.5 ± 3.1<br>VEGAN 20.5 ± 2.5**** | | −19.6% | |
| Harman[46] | New Zealand | 12 M, 12 F VEG SDA; 11 M, 12 F NVEG SDA; 20–65 y | M VEG: 24.1 ± 3.1<br>M NVEG: 26.4 ± 3.3<br>F VEG: 23.6 ± 3.1<br>F NVEG: 25.8 ± 2.9 | | M: −8.7%<br>F: −8.5% | |
| Hebbelinck[47] | Belgium | 8 M 18–30 y<br>11 F 16–30 y compared with reference values | M VEG: 22.1 ± 2.8<br>M NVEG reference value: 22.0<br>F VEG: 21.8 ± 2.24<br>F NVEG reference value: 22.8 | M VEG: 69.2 ± 5.7<br>M NVEG reference value: 72.3<br>F VEG: 59.3 ± 7.5<br>F NVEG reference value: 60.3 | M: −0.5%<br>F: −4.4% | M: −4.3%<br>F: −1.7% |
| Hoffmann[23] | Germany | F, 25–65 y; Wholesome nutrition: 111<br>LOVEG, 132 low-meat eaters; 175 NVEG | BMI NVEG Low-meat LOVEG<br><19 4% 11%*[a] 17%*[b]<br>19–24 46% 68%*[a] 64%*[b]<br>24–30 39% 18%*[a] 18%*[b]<br>>30 9% 2%*[a] 1%*[b]<br>[a]LOVEG and NVEG;<br>[b]low-meat eaters and NVEG | | | |

**Table 1.** (Cont'd) Observational Studies on the Difference in BMI and/or Body Weight of Vegetarians Compared with Non-Vegetarians

| Author | Country | Subjects | BMI | Weight (kg) | % Difference BMI VEG vs. NONVEG | % Difference Weight VEG vs. NONVEG |
|---|---|---|---|---|---|---|
| Kennedy[24] | USA | 10,014 people from the 1994–1996 Continuing Survey of food Intake by Individuals (CSFII); 19 y and older | VEG men: 25.2 ± 0.35*<br>NVEG men: 26.4 ± 0.10<br>VEG women: 24.6 ± 0.33*<br>NVEG women: 25.7 ± 0.15 | | M: −4.6%<br>F: −4.3% | |
| Knuiman[25] | Netherlands | M 30–39y | All VEG pooled: 21.5 ± 2.1**[a]<br>Macrobiotic: 20.9 ± 2.1**[a]<br>LVEG: 21.4 ± 1.7**[a]<br>Semi-LVEG: 22.2 ± 2.3**[a]<br>NVEG: 24.4 ± 2.3<br>[a]comparison with NVEG | All VEG pooled: 69 ± 8**[a]<br>Macrobiotic: 65 ± 8**[a]<br>LVEG: 69 ± 7**[a]<br>Semi-LVEG: 72 ± 9**[a]<br>NVEG: 77 ± 8<br>[a]comparison with NVEG | −12% | −10% |
| Knutsen[26] 1992 | USA | 5761 M VEG<br>9467 F VEG;<br>4706 M NVEG<br>7832 F NVEG;<br>25 y and older | M VEG: 24.2 ± 0.04<br>M NVEG: 25.7 ± 0.05****<br>F VEG: 23.6 ± 0.05<br>F NVEG: 25.2 ± 0.05**** | | M: −5.8%<br>F: −6.4% | |
| Krajcovicova-Kudlackova[27] 1995 | Slovakia | 29M, 38F VEG non-smokers 34–60 y; matched with 38 M, 37 F NVEG | M VEG: 22.6 ± 0.4****<br>M NVEG: 25.6 ± 0.3<br>F VEG: 22.7 ± 0.2****<br>F NVEG: 25.4 ± 0.4 | M VEG: 69.4 ± 1.6<br>M NVEG: 79.9 ± 1.2<br>F VEG: 62.4 ± 0.7<br>F NVEG: 68.9 ± 1.1 | M: −11.7%<br>F: −10.6% | M: 13.1%<br>F: −9.4% |
| Krajcovicova-Kudlackova[28] 1996 | Slovakia | 42M, 39F VEG, 29 M, 33 F NVEG 19–39 y | M VEG: 21.7 ± 0.2****<br>M NVEG: 23.5 ± 0.2<br>F VEG: 20.7 ± 0.1****<br>F NVEG: 23.0 ± 0.1 | M VEG: 70.1 ± 0.8****<br>M NVEG: 76.6 ± 0.5<br>F VEG: 57.4 ± 0.4****<br>F NVEG: 61.8 ± 0.4 | M: −7.7%<br>F: −10.0% | M: −8.5%<br>F: −7.1% |
| Li[29] 1999 | Australia | 18 M VEGAN, 43 M LOVEG, 60 M moderate meat-eaters, 18 M high meat-eaters; 20–55 y | VEGAN; 23.3 ± 3.5****[a]<br>LOVEG: 23.6 ± 2.8****[a]<br>Moderate meat-eaters: 26.4 ± 3.4<br>High meat-eaters: 27.0 ± 3.4<br>[a]compared to both moderate & high meat-eaters | | Mod meat-eaters vs. LOVEG: −10.6%<br>High meat-eaters vs. LOVEG: −12.6% | |

**Table 1.** (Cont'd) Observational Studies on the Difference in BMI and/or Body Weight of Vegetarians Compared with Non-Vegetarians

| Author | Country | Subjects | BMI | Weight (kg) | % Difference BMI VEG vs. NONVEG | % Difference Weight VEG vs. NONVEG |
|---|---|---|---|---|---|---|
| Lin[48] 2001 | Taiwan | Healthy nonobese subjects >50 y; 10 M, 10 F VEG 10 M, 10 F NONVEG | VEG: 23.1 ± 3.1†<br>NVEG: 24.8 ± 0.1<br>(†($P$ = 0.085) | | −6.9% | |
| Lu[30] | Taiwan | 109 long-term VEGAN and LOVEG matched with NVEG; 31–45 y; Taipei and Hualien areas | Taipei M VEG: 20.8 ± 3.0*<br>Taipei M NVEG: 22.9 ± 2.4<br>Taipei F VEG: 20.0 ± 2.8*<br>Taipei F NVEG: 22.5 ± 3.0<br>Hualien F VEG: 20.7 ± 2.6*<br>Hualien F NVEG: 22.0 ± 2.6 | Taipei M VEG: 59.4 ± 8.4*<br>Taipei M NVEG: 66.0 ± 9.1<br>Taipei F VEG: 48.8 ± 7.6*<br>Taipei F NVEG: 56.6 ± 8.1<br>Hualien F VEG: 51.1 ± 6.4*<br>Hualien F NVEG: 55.4 ± 6.8 | Taipei M: −9.2%<br>Taipei F: −11.1%<br>Hualien F: −5.9% | Taipei M: −10.0%<br>Taipei F: −13.8%<br>Hualien F: −7.8% |
| Melby[31] | USA | 41 M, 93 F VEG, 12 M, 41 F NVEG; ≥20 y | M VEG: 25.3 ± 3.5 ($p$ = .16)<br>M NVEG: 27.1 ± 4.9<br>F VEG: 23.9 ± 4.0*****<br>F NVEG: 28.1 ± 5.3 | | M: −6.6%<br>F: −15.0% | |
| Melby[32] | USA | SDAs: 27 black VEG; 37 black NVEG; 85 white VEG; 54 white NVEG; ≥55 y | black VEG: 27.0 ± 0.7*[a]<br>black NVEG: 31.7 ± 1.1<br>white VEG: 25.0 ± 0.5*[b]<br>white NVEG: 27.6 ± 0.7<br>[a]black VEG vs. NVEG<br>[b]white VEG vs. NVEG | black VEG: 71.4 ± 2.4*[a]<br>black NVEG: 83.5 ± 2.3<br>white VEG: 66.8 ± 1.5<br>white NVEG: 72.1 ± 1.9<br>[a]black VEG vs. NVEG | Black −14.8%<br>White: −9.4% | Black: −14.5%<br>White: −7.4% |
| Melby[44] | USA | African-American SDAS: 66 VEG; 56 SVEG; 45 NVEG; mean 46–49 y | VEG: 26.8 ± 0.8<br>SVEG: 29.2 ± 0.8<br>NVEG: 28.6 ± 0.8 | VEG: 74.7 ± 2.1*[a]<br>SVEG: 81.9 ± 1.9*[a]<br>NVEG: 79.4 ± 2.3<br>[a]VEG and SVEG vs NVEG | VEG vs. NVEG: −6.3% | VEG vs. NVEG: −5.9% |
| Millet[33] | France | 11 M VEG 26 F VEG 33 M NVEG 36 F NVEG; 35–50 y | Quetelet's index (kg/cm$^2$):<br>M VEG: 0.212 ± 0.022<br>M NVEG: 0.247 ± 0.029****<br>F VEG: 0.200 ± 0.027<br>F NVEG: 0.233 ± 0.032**** | M VEG: 63.4 ± 5.2<br>M NVEG: 76.0 ± 9.5****<br>F VEG: 53.8 ± 4.4<br>F NVEG: 60.5 ± 8.5*** | M: −14.17%<br>F: −14.16% | M: −16.6%<br>F: −11.1% |

**Table 1.** (Cont'd) Observational Studies on the Difference in BMI and/or Body Weight of Vegetarians Compared with Non-Vegetarians

| Author | Country | Subjects | BMI | Weight (kg) | % Difference BMI VEG vs. NONVEG | % Difference Weight VEG vs. NONVEG |
|---|---|---|---|---|---|---|
| Neiman[49] | USA | F: 23 VEG<br>14 NVEG; >70 y (subset of Adventist Health Study | VEG 22.8 ± 0.5<br>NVEG 24.2 ± 0.8 | VEG 60.0 ± 1.7<br>NVEG 62.5 ± 3.1 | −5.8% | −4.0% |
| Newby[34] | Sweden | F: 54257<br>OMNIV<br>960 SEMIVEG<br>159 LVEG<br>83 VEGAN | OMNIV 24.7 ± 3.9<br>SEMIVEG 23.6 ± 5.5***[a]<br>LVEG 23.4 ± 3.5***[a]<br>VEGAN 23.3 ± 3.8***[a]<br>[a]each VEG vs NONVEG | OMNIV 66.6 ± 10.9<br>SEMIVEG 63.6 ± 10.0*[a]<br>LVEG: 64.0 ± 10.9*[a]<br>VEGAN: 62.4 ± 10.7*[a]<br>[a]each VEG vs NONVEG | −5.3% | −4.9% |
| Rottka[35] | Germany | matched pairs of VEG and NVEG; 37 M, 61 F, 21–77 y | M VEG: 22.1 ± 2.5****<br>M NVEG: 24.4 ± 3.4<br>F VEG: 22.2 ± 2.8*<br>F NVEG: 23.7 ± 3.6 | M VEG: 68.2 ± 9.8****<br>M NVEG: 74.4 ± 10.9<br>F VEG: 58.2 ± 6.3*<br>F NVEG: 62.5 ± 8.9 | M: −9.4%<br>F: −6.3% | M: −8.3%<br>F: − 6.9% |
| Rouse[36] | Australia | 98 SDA LOVEG; 82 SDA NVEG; 113 Mormon NVEG; 25–44 y | M SDA VEG: 22.9 ± 3.3<br>M SDA NVEG: 24.7 ± 3.2*<br>M Mormon NVEG: 25.1 ± 3.2**<br>F SDA VEG: 23.3 ± 2.8<br>F SDA NVEG: 24.4 ± 3.5<br>F Mormon NVEG: 26.3 ± 5.4** | M SDA VEG: 68.8 ± 10.8<br>M SDA NVEG: 75.1 ± 10.7*<br>M Mormon NVEG: 77.3 ± 9.2**<br>F SDA VEG: 60.3 ± 7.0<br>F SDA NVEG: 63.9 ± 11.4<br>F Mormon NVEG: 68.2 ± 13.5** | M SDA NVEG vs SDA VEG: −7.3%<br>F SDA NVEG vs SDA VEG: −4.5% | M SDA NVEG vs VEG: −8.4%<br>F SDA NVEG vs VEG: −5.6%) |
| Sacks[37] | USA | 115 pairs of VEG and NVEG; 16–62 y | | VEG: 58 ± 9<br>NVEG: 73 ± 15<br>Mean difference: 15 ± 16**** | | −20.6% |
| Sanders[38] | UK | 22 VEGAN; 22 NVEG; 21–66 y | | Standard wt for ht:<br>VEGAN: 91* (mean) range 71–125<br>NVEG: 102 (mean) range 86–117 | | difference in standard wt for ht: −10.8% |
| Shultz[52] | USA | 20 M, 31 F SDA VEG; 20–83y<br>9 M 7 F SDA NVEG 24–38y<br>18M, 36 F non-SDA NVEG; 19–78 y | M SDA VEG: 24 ± 5<br>M SDA NVEG: 25 ± 2<br>M non-SDA NVEG: 24 ± 3<br>F SDA VEG: 23 ± 4<br>F SDA NVEG: 22 ± 2<br>F non-SDA NVEG: 24 ± 4 | M SDA VEG: 76 ± 14<br>M SDA NVEG: 77 ± 10<br>M non-SDA NVEG: 78 ± 11<br>F SDA VEG: 63 ± 12<br>F SDA NVEG: 59 ± 13<br>F non-SDA NVEG: 65 ± 11 | M SDA VEG vs NVEG: 4.0%; F SDA VEG vs NVEG: −4.6% | M SDA VEG vs NVEG: 1.3%; F SDA VEG vs NVEG: −6.7% |

**Table 1.** (Cont'd) Observational Studies on the Difference in BMI and/or Body Weight of Vegetarians Compared with Non-Vegetarians

| Author | Country | Subjects | BMI | Weight (kg) | % Difference BMI VEG vs. NONVEG | % Difference Weight VEG vs. NONVEG |
|---|---|---|---|---|---|---|
| Simons[39] | Australia | 20 SDA VEG; 17 SDA NVEG; 38 NVEG | | VEG SDA: 59 ± 8**<br>NVEG: 70 ± 14<br>NVEG SDA: 70 ± 7 | | NVEG SDA vs VEG SDA: −15.1% kg |
| Slattery[40] | USA | 5115 MF<br>18–30 y<br>CARDIA study<br>Frequency of meat consump <1/wk–>3/d | Meat consumpt. <1/wk = 22.7<br>1–3/wk = 23.4**[a]<br>>3/w = 24.6**[a]<br>[a](both grps compared to . <1/wk) | | <1/wk vs. 1–3/wk = −3.0%<br><1/wk vs. >3 wk = −4.9% | |
| Spencer[41] | UK | 37875 healthy M, F: 20–97 y participating in EPIC-Oxford | M VEGAN: 22.34<br>M VEG: 23.28<br>M fish-eaters: 23.29<br>M NVEG: 24.49<br>F VEGAN: 21.75<br>F VEG: 22.51<br>F fish-eaters: 22.60<br>F NVG: 23.69 | | M NVEG vs VEG: −4.94%<br>F NVEG vs VEG: −4.98% | |
| Supawan[42] | Thailand | 64 M VEG<br>68 F VEG<br>32 M NONVEG<br>36 F NONVEG | MVEG 19.8†<br>M NONVEG 21.4<br>†($P. < 0.0017$)<br>F VEG 19.9†<br>F NONVEG 20.6<br>†($P. < 0.0381$) | M VEG 54.7†<br>M NONVEG 59.8<br>†($P. < 0.0004$)<br>F VEG 47.9†<br>F NONVEG 49.<br>†($P. < 0.0036$) | M −7.5%<br>F −3.4% | M −8.5%<br>F −3.6% |
| Taber[50] | USA | 25 M, 24 F NVEG; 9 M, 11 F fish-eaters; 15 M, 13 F VEG; 20–50y | | M VEG: 72.6 ± 8.12<br>M fish-eaters: 71.3 ± 9.26<br>M NVEG: 78.4 ± 11.83<br>F VEG: 59.8 ± 8.53<br>F fish-eaters: 57.1 ± 3.95<br>F NVEG: 60.1 ± 8.98 | | M: −7.4%<br>F: −0.5% |
| Toohey[43] | USA | 14 M VEGAN<br>49 M LOVEG<br>31 F VEGAN<br>94 F LOVEG | M VEGAN: 23.6 ± 0.9<br>LOVEG: 26.1 ± .05<br>F VEGAN 25.3 ± 0.6<br>LOVEG: 26.7 ± 0.6 | M VEGAN: 71.8 ± 3.2*<br>LOVEG: 79.2 ± 1.9<br>F VEGAN: 66.5 ± 1.8*<br>LOVEG: 69.6 ± 1.6 | M VEGAN vs LOVEG −9.5%<br>F VEGAN vs LOVEG: −5.2% | M VEGAN vs LOVEG: −9.3%<br>F VEGAN vs LOVEG: −4.5% |
| Toth[51] | USA | M: 17 VEG<br>40 NVEG;<br>18–36 y | | VEG: 75 ± 10<br>NVEG: 76 ± 11 | | −1.32% |

LOVEG = ovo-lacto vegetarians; NONVEG = non-vegetarians; SDA = Seventh-Day Adventists; VEG = vegetarians
* = $P < 0.05$; ** = $P < 0.01$; *** = $P < 0.005$; **** = $P < 0.001$; ***** = $P < 0.0001$.

**Table 2.** Randomized Controlled Studies on the Differences in Body Weight and/or Body-Mass Index (BMI) in Participants Placed on a Vegetarian or Vegan Diet

| Author | Design | Body Weight | BMI |
|---|---|---|---|
| Barnard[58] | Randomized control (N = 64)<br>Age range 41–73, postmenopausal, overweight<br>• Treatment: low-fat vegan diet<br>• Control: National Cholesterol Education guidelines<br>14 weeks | Low-fat vegan diet<br>−5.8 ± 3.2. kg<br>Control<br>−3.8 ± 2.8 kg<br>($P$ = 0.012) | |
| Bernard[9] | Randomized crossover (N = 35)<br>Age range 22–48, F<br>• Low-fat vegetarian<br>• Daily supplement pill<br>Two menstrual cycles each | Low-fat vegetarian<br>66.9 ± 12.5 kg**<br>Baseline<br>69.4 ± 12.9 kg<br>(−3.6%) | Low-fat veg<br>24.6 ± 4.9**<br>vs Baseline<br>25.5 ± 5.2<br>(−3.5%) |
| Lindahl[60] | Hypertensive patients (N = 26)<br>Age range 25–70 yr<br>Vegan diet for 1 yr | Vegan diet<br>70.4 ± 14.3 kg**<br>Baseline<br>78.2 ± 15.3 kg (−10.0%) | |
| Margetts[61] | Randomized crossover (N = 1788) 25% F, 75% M<br>Age range 39–61:<br>• Group I: ovo-lacto vegetarian diet 1st 6 weeks<br>• Group II: ovo-lacto vegetarian diet 2nd 6 weeks<br>• Control | <br><br>ND<br><br>+2 kg | |
| McDougall[59] | Hypercholesterolemic patients (N = 500) 303 F 197 M<br>Age range 40–65 yr<br>Vegan diet for 12 days | Vegan diet vs baseline<br>>50 yr (M, F)<br>−1.01% to 2.26%<br>≥50 to <65 (M, F)<br>−0.41% to −2.21%<br>≥65 (M, F)<br>−0.52% to 2.20% | |
| Nicholson[11] | Randomized Control (N = 11) 5 F, 6 M<br>Age range 34–74 yr<br>• Low-fat vegan diet<br>• Conventional low-fat diet (control)<br>12 weeks | Low-fat vegan diet<br>89.5 ± 14.4 kg*<br>Baseline<br>96.7 ± 13.3 kg (−7.5%)<br>Control<br>93.2 ± 22.2 kg<br>Baseline<br>97.0 ± 22.9 kg (−3.9%) | |
| Ornish[13] | Randomized control (N = 41) 5 F, 36 M<br>Age range 35–75<br>• Low-fat vegetarian<br>• Usual care<br>1 year | Low-fat vegetarian<br>81.0 ± 11.4 kg***<br>Baseline<br>91.1 ± 15.5 kg (−11%)<br>Control vs control baseline: ND | |
| Ornish[8] | Randomized control (N = 35) 3 F, 32 M<br>Age range 35–75 yr<br>• Low-fat vegetarian<br>• Usual care<br>5-year follow-up to above study | Low-fat vegetarian<br>85.3 kg<br>Baseline<br>91.1 ± 15.5 kg (−6.3%)<br>Control vs control baseline: ND | |

ND = no difference; *$P < 0.005$; **$P < 0.001$; ***$P < 0.001$.

dietary fiber, lower in energy, protein, total fat, cholesterol, and saturated fat, and have a higher polyunsaturated fat to saturated fat ratio compared with the diets of non-vegetarian groups.[4,22,24,62,63,67,76] In controlled trials, vegetarian and vegan diets tend to reduce energy, fat, saturated fat, protein, and cholesterol, and increase intakes of carbohydrate and fiber.[8,13,58,64] These differences support physiological mechanisms that account for the observed weight loss.

## Total Energy

Energy intake of vegetarians may be lower than that of non-vegetarians.[7,24,49,62,63] In general, energy intake of vegans and vegetarians ranged from 5% to 22% lower than that of non-vegetarians.[24,41] In the short-term studies that reported energy intake of individuals who adopted a vegetarian diet, most showed a decrease in energy intake.[8,9,13,58,64,65] Although energy intake and portion size was not limited in studies of low-fat vegan diets,[9,58,64] mean body weight dropped significantly in the intervention groups.

## Fiber

The reduced energy intake on typical vegetarian diets appears to be mainly due to higher fiber content and, to a lesser extent, higher carbohydrate and lower fat content.[20,22,66,67] The EPIC-Oxford study[16] of 5292 persons between the ages of 20 and 89 years indicated that, of all of the components of the diet, dietary fiber contributed the most to the observed age-adjusted differences in BMIs, equivalent to body-weight differences of 3.6 and 2.7 kg for men and women, respectively. Davey[76] reported that fiber intake as non-starch polysaccharides was 41% higher in vegan men than in men who ate meat and 36% higher in vegan women than in meat-eating women. The results of a recent meta-analysis suggested that when energy intake is ad libitum, the consumption of an additional 14 g/d fiber is associated with a 10% decrease in energy intake and a body weight loss of 1.9 kg over 3.8 months.[68] Dietary fiber reduces energy density[69] and influences lean body weight via effects on satiety[68] and insulin control.[70]

## Carbohydrates

Diets that are low or moderate in fat but high in carbohydrates are associated more closely with lower BMIs than are diets low in carbohydrates.[24,76] People eating higher-carbohydrate diets may consume more food by weight compared with people eating lower-carbohydrate diets, but take in less total energy due to the low energy density of the foods consumed.[24] Typically, vegetarian diets derive more than 50% of energy from carbohydrate from fruits, vegetables, legumes, nuts and whole-grain breads and cereals.[22,63,66,67] High-carbohydrate diets tend to increase postprandial energy expenditure (thermic effect of food), presumably by increasing insulin sensitivity and hence facilitating the entry of nutrients into cells, where they can be metabolized.[58,71-73]

## Fat

Data from the Continuing Survey of Food Intakes by Individuals (CSFII 1994–1996)[24] and other studies[63,74,75] have shown that vegetarians have a lower intake of total and saturated fat as a percentage of energy compared with non-vegetarians. Fat, of course, is the most energy-dense of the macronutrients. However, in both the vegan and vegetarian diet, there is also a consistently higher polyunsaturated fat to saturated fat ratio compared with the non-vegetarian diet.[20,63,76] Spencer[41] observed an inverse association between percent polyunsaturated fat in the diet and BMI. The mechanism by which total fat or the polyunsaturated fat to saturated fat ratio exerts an influence on body weight is unclear. McCarty[77] has suggested that since hepatic fatty acid oxidation promotes appetite control and lowers the respiratory quotient, a relative disinhibition of this pathway may play a role in appetite suppression in vegans and/or vegetarians.

## Protein

Protein (as percentage of energy intake) was correlated positively with BMI in the large EPIC-Oxford cohort, both within groups (except for vegans) and across groups, for both men and women.[16,41] Similar observations were reported in an EPIC cohort in Greece.[79] Most,[22,24,40,62,80] but not all,[42,43] studies support this finding.

The total amount of protein provided in a vegetarian diet, although adequate, is less than that provided in a non-vegetarian diet. However, all essential and non-essential amino acids can be supplied by plant sources.[81] Some investigators[77,78] have hypothesized that down-regulation of insulin and up-regulation of glucagon may occur in response to the relative amount of non-essential amino acids in the diet. Because "high-quality" animal protein has greater efficacy for releasing insulin, and "lower-quality" plant proteins have a greater impact on glucagon, a vegetarian diet may exert a downward effect on body weight. The role of plant proteins in modulating the insulinemic response in vegan diets merits further study.

## Health Benefits

Observational studies indicate that the weight and BMI of both male and female vegetarians, on average, is approximately 3% to 20% lower than that of non-vegetarians. Obesity prevalence ranges from 0% to 6% in vegetarians and from about 5% to 45% in non-vegetarians. Randomized trials suggest that dietary factors influencing energy intake and possibly thermic effect of food may be responsible for these differences. Because vegetarian diets are associated with reduced body weight and lower rates of obesity, vegetarians generally have a lower risk of coronary heart disease,[82,83] hypertension,[10,84] and diabetes.[12] A 1995 study estimated that vegetarians also incur significantly lower medical costs compared with non-vegetarians.[88] The positive effects of a plant-based diet on chronic disease prevention may be mediated, in part, by changes in body weight.

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