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Vegans report less bothersome vasomotor and physical menopausal symptoms than omnivores

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ABSTRACT

Objectives: Lifestyle modifications that may reduce menopausal symptoms have generated much interest. The vegetarian diet has been associated with a lower risk of chronic disease as well as a more healthy hormonal milieu. Our objective in this cross-sectional study was to survey peri- and postmenopausal women to investigate menopausal symptoms and dietary pattern.

Study design: Survey distribution in 2015–2016 was aimed at female vegans, vegetarians, and omnivores between the ages of 45 and 80 years, who were active on senior and vegetarian social networking websites and at vegan restaurants and events. Main outcome measures: We investigated vasomotor and physical symptoms as measured by the Menopause-specific Quality of Life Questionnaire (MENQOL) and dietary pattern classified by animal protein intakes reported in response to food frequency questions.

Results: Out of 754 participants who completed the survey, 604 reported they were perimenopausal (n = 121) or postmenopausal (n = 483), of whom 539 also completed the food frequency questions. We compared vasomotor and physical symptoms in omnivores (n = 304, consumed meat and/or poultry at least monthly) and vegans (n = 125, abstained from all animal proteins) using general linear models; covariates included age, exercise, hormone replacement therapy, presence of reproductive organs, and age at menopause. Among perimenopausal women, vegans reported less bothersome vasomotor ($p < 0.01$) and physical symptoms ($p < 0.01$) than omnivores. For both symptom types, more vegetables and less flesh food were associated with less bothersome symptoms (p values < 0.05).

Conclusion: Eating a plant-based diet may be helpful for women in menopausal transition who prefer a natural means to manage their symptoms.

1. Introduction

Most women in peri- or postmenopause report symptoms that negatively affect their quality of life. The Study of Women's Health Across the Nation (SWAN) followed mid-life changes occurring in women from various ethnic backgrounds over ten years. The study found vasomotor symptoms, or hot flashes and night sweats, are more strongly related to menopause than are other symptoms, with 60–80% prevalence [1,2]. Physical symptoms such as joint pain, fatigue, and sleep problems are also commonly experienced during this period [3,4]. While hormone replacement therapy effectively manages symptoms, risks and side effects have generated increasing demand for non-hormonal therapies [5].

Non-hormonal therapies for menopausal symptoms include lifestyle practices such as exercise regimens or use of herbal supplements such as black cohosh. However, efficacy of these therapies is generally insufficient or inconclusive [6]. There has also been much interest in single dietary factors that may be therapeutic, particularly plant foods containing phytoestrogens like isoflavones that can metabolize to estrogenic metabolites. One of the most widely used therapies for symptom management has been soy foods, based on the assumption that the high content of isoflavones would be as effective but safer than hormonal therapy [7]. Many primary studies have investigated the efficacy of phytoestrogens in reducing menopausal symptoms. While results have been conflicting [8], a recent systematic review and meta-analysis concluded that soy isoflavones were associated with modest reductions in hot flashes (but not night sweats) and vaginal dryness [9]. Because foods are rarely consumed alone and potentially therapeutic foods like soy may not be acceptable, analyzing diet patterns is a preferred strategy, as studies have demonstrated the positive impact of healthy diet patterns [10]. Although defined differently across studies, healthy diet patterns often are associated with vegetarian, vegan and

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plant based diets, which include high fiber and low fat content, large amounts of fruits, vegetables, whole grains, and legumes, and little or no animal foods [11].

Numerous studies comparing the health effects of Seventh Day Adventists who followed a vegetarian versus a non-vegetarian diet have consistently demonstrated that vegetarian diets are associated with lower body mass index and lower risk of chronic diseases such as coronary heart disease, type 2 diabetes, and cancer [12]. In fact, vegan diets which avoid all animal foods may actually confer additional disease protection for major chronic disease. Based on our literature review, no studies have explored the link between the vegan diet pattern and vasomotor or physical menopausal symptoms. Our objective was to recruit a large sample of vegan women in menopausal transition, capturing omnivores for comparison. The rationale for choosing vegans instead of vegetarians was to study a self-defined group following a diet rich in foods associated with reduced menopausal symptoms (e.g. soy, fruits, vegetables) and devoid of foods that might increase symptoms (e.g. animal fat). Animals foods consumed by vegetarians possibly decrease the proportion of plant foods consumed, making this diet less likely to correlate with symptom reduction. We hypothesized that participants on a vegan diet would report less severe vasomotor and physical menopausal symptoms than would omnivores. Our secondary aim was to investigate the relationship of specific food group consumption to menopausal symptoms.

2. Methods and materials

2.1. Study design

In our cross-sectional study, an online survey was delivered via SurveyMonkey® and later Qualtrics® from spring, 2015, through summer, 2016. The survey distribution was aimed at female vegans and omnivores, ages 45–80. The study was approved by the Institutional Review Boards (IRBs) of the collaborating universities.

2.2. Study protocol

Participants were recruited with a digital flyer posted on social networking websites and discussion boards. Gatekeepers of senior and vegan/vegetarian meet-up groups and other online communities, organizations, and events were contacted via email to request survey posting. In greater New York City and Chicago, paper flyers with the survey link were distributed at locations frequented by vegans, (e.g. health food store, restaurants, gyms, and diet-themed public events). Participants consented electronically. The survey took about 25 min. No incentive was provided for survey completion.

2.3. Measures

The Menopause-specific Quality of Life Questionnaire (MENQOL) [13] was embedded within the larger survey, and is a psychometrically sound tool for measuring menopausal symptoms/problems. It consists of 29 symptom questions that are classified into four domains: vasomotor (items 1–3), psychosocial (items 4–10), physical (items 11–26), and sexual (items 27–29). In this study, results for the vasomotor and physical subscales are reported. Vasomotor symptoms include hot flashes/flushes, night sweats, and sweating; physical symptoms include flatulence, muscle and joint aches, fatigue, sleep difficulties, neck/head/back aches, reduced strength/stamina, lethargy, skin changes, weight gain, facial hair, bloating, and frequent/involuntary urination. To reduce participant burden, we changed the format of items from a two-part (yes/no and then a "bothersome" rating) to a one-part 0–6 Likert scale asking respondents how bothersome each symptom was over the past month [13]. In the initial survey launch, three items on the MENQOL physical subscale were omitted due to clerical error; this was addressed statistically through mean substitution.

The MENQOL demonstrated validity and reliability in a postmenopausal female population aged 47–62 years old [13]. Discriminant construct validity of the physical subscale with both the Neugarten and Kraines' Menopause Symptom Checklist and Somatic and Psychosomatic Subscales was reported at 0.69; the coefficient reported for the vasomotor subscale with Somatic Subscales was lower at 0.40, but correlated with intensity of hot flushes at 0.66. Test-retest reliability correlation coefficients for the physical and vasomotor subscales were 0.81 and 0.85, and Cronbach's alpha coefficients were 0.87 to 0.82, respectively. In our study, Cronbach's alpha coefficients were 0.94 for the physical and 0.87 for the vasomotor subscales.

Because physical activity has been linked with menopausal symptom improvement [14], the survey included the Godin-Shephard Leisure-Time Physical Activity Questionnaire [15] which measures time spent over 7 days doing different kinds of exercise. Respondents reported how often they engaged in strenuous, moderate, and mild exercise. The weekly frequencies were multiplied by 9 (strenuous), 5 (moderate), or 3 (mild), and then summed to calculate total weekly activity scores. The questionnaire can accurately classify apparently healthy adults (18–64 yr.) into active and insufficiently active categories [15]. Studies measuring the reliability of the questionnaire in healthy adults found correlation coefficients of 0.75 and 0.62 for weekly activity [16,17].

Respondents answered a question about which animal foods they consumed at least monthly in order to categorize them as vegans (none endorsed) or omnivores (meat and/or poultry endorsed). More specific diet data were collected via a food frequency questionnaire. Foods included were linked to hormonal health, particularly high sources of omega-3 (n-3) fatty acids [18], polyphenol phytochemicals [19], and soy [20]. Participants were asked how frequently, on average, they consumed the food or beverage over the past year. The frequency option format was adapted from the National Institutes of Health Dietary Questionnaire II (https://aghealth.nih.gov/collaboration/qx/dhq.pdf), which consisted of: never or less than once a month, 1–3 times per month, once a week, 2–4 per week, 5–6 per week, once a day, 2–3 per day, 4–5 per day, and 6+ per day. The NIH questionnaire also asks about serving sizes, which improves dietary measurement precision. However, we only queried intake frequency to reduce respondent burden. Participants also reported total intake frequency from the following food groups: vegetables (not potatoes or corn), fruit (including dried, but not juice), flesh foods (meat, poultry, fish, or shellfish), dairy foods, egg dishes, and sweets.

Participants also reported their weight and height, which was used to compute body mass index.

2.4. Statistical analyses

Pearson correlation coefficients were utilized to examine the relationships between continuous and dichotomous variables. Analyses were conducted using general linear modeling (GLM). For both physical and vasomotor symptoms, three models were evaluated. In model 1, symptoms were regressed on to covariates, diet type, menopausal status, and the interaction between the last two variables. Model 2 added six food groups: total intake of vegetables, fruits, flesh food, dairy products, eggs, and sweets. To examine the impact of specific foods containing nutrient and/or phytochemical constituents that may affect menopausal transition, Model 3 added five more specific food elements: berries, cruciferous vegetables, leafy greens, soy, and high plant sources of omega-3 fats. Data were analyzed using SPSS, Version 24.0, and p values < 0.05 were considered significant.

3. Results

We obtained 990 responses; however, 236 volunteers did not complete the survey and were removed, leaving 754 participants who provided consent and met eligibility criteria. To obtain adequate group

Table 1
Sample characteristics of omnivores and vegans.

	OMN n = 304 Mean ± SD	VG n = 125 Mean ± SD	p value*
Age (years; n = 429)	59.21 ± 7.87	55.58 ± 6.55	< 0.001
U.S./outside U.S. (number of participants; n = 429)	293 / 11	100 / 25	< 0.001
White/other (number of participants; n = 429)	276 / 28	105 / 20	0.043
Education yrs after high school (n = 429)	5.51 ± 3.67	4.84 ± 3.43	0.082
BMI (kg/m^2; n = 382)	28.42 ± 6.93	27.04 ± 6.85	0.076
Total weekly leisure exercise (minutes; n = 429)	46.06 ± 23.48	55.33 ± 30.72	0.003

* $p < 0.05$ is significant; independent samples t test.

sizes, responses were collapsed into two groups: omnivores (OMN: n = 404), and vegans (VG: n = 248). Those who reported consuming no flesh food except seafood, eggs and/or dairy foods (n = 42), were omitted from further analyses, as there were insufficient responses for comparison. Regarding hormonal status, 137 indicated they were pre-menopausal and were removed, leaving 539 participants who identified as either omnivore or vegan and either perimenopausal (n = 121) or postmenopausal (n = 483). When participants with missing data for covariates were removed, 429 participants were left for further analyses. The final sample included 87 peri-menopausal women, of whom 57 were omnivores and 30 were vegans, and 342 postmenopausal women, of whom 247 were omnivores and 95 were vegans.

The mean age was 58.16 years old; vegans were significantly younger than omnivores (see Table 1). Non-Hispanic whites made up a majority of the sample at 88.8%, and 91.6% lived in the U.S. The mean BMI was 28.02 (kg/m^2), with no significant difference between omnivores and vegans. Vegans reported significantly more total leisure exercise than omnivores. Only 62 participants reported taking menopausal hormone therapy, i.e., medications containing female hormones, of whom 42 were omnivores and 20 were vegans.

Zero-order correlations revealed age and total vegetable, fruit, soy, and high omega-3 plant food intake were inversely correlated with both vasomotor and physical symptom severity ($p < 0.05$; see Table 2).

Table 2
Pearson Correlation Coefficients with Vasomotor and Physical Symptoms.

	Vasomotor Symptoms	Physical Symptoms
Age	−0.27**	−0.14**
Education	−0.03	−0.06
Married (yes/no)	−0.07	0.01
BMI	0.12**	0.24**
Moderate exercise X/week	−0.05	−0.18**
Yoga practice (yes/no)	0.06	0.16**
Dieted in last year (yes/no)	−0.06	−0.13**
Cigarette smoker (yes/no)	−0.08	−0.08
Vegetable intake	−0.16**	−0.22**
Fruit intake	−0.11*	−0.14**
Flesh food intake (meat/fish/poultry)	0.11**	0.10*
Dairy intake	0.09*	0.11*
Egg intake	0.08	0.06
Sweets intake	0.08	0.13**
Soy intake	−0.10*	−0.13**
Tea intake	−0.07	−0.06
High omega-3 fish intake	0.19*	0.19*
High omega-3 plant food intake	−0.15**	−0.19**
Berry intake	0.15	−0.15

Note: Food item intake is frequency over the past year. All dietary factors were coded as follows: 1 = Never or less than once a month; 2 = 1-3X per month; 3 = Once a week; 4 = 2-4X per week; 5 = 5-6X per week; 6 = Once a day; 7 = 2-3X per day; 8 = 4-5X per day; 9 = 6+ per day.
*p value < 0.05. **p value < 0.01.

Table 3
Symptoms by Diet Type and Menopausal Status.[a]

Source	F	ηp^2	p
STEP 1			
Vasomotor symptoms			
Diet Type	9.972	0.023	0.002
Menopausal Status	4.219	0.010	0.041
Diet Type * Menopausal Status	3.405	0.008	0.066
Physical symptoms			
Diet Type	8.446	0.020	0.004
Menopausal Status	0.294	0.001	0.588
Diet Type * Menopausal Status	3.727	0.009	0.054
STEP 2 (general food groups)[b]			
Vasomotor symptoms			
Vegetable total	4.842	0.012	0.028
Fruit total	0.012	< 0.001	0.914
Flesh food total (meat/fish/poultry)	1.998	0.005	0.158
Dairy total	0.257	0.001	0.612
Egg total	0.016	< 0.001	0.900
Sweets total	0.813	0.002	0.368
Physical symptoms			
Vegetable total	8.196	0.020	0.004
Fruit total	0.184	< 0.001	0.668
Flesh food total (meat/fish/poultry)	2.091	0.005	0.149
Dairy total	0.566	0.001	0.452
Egg total	0.585	0.001	0.445
Sweets total	1.157	0.003	0.283
STEP 3 (specific food groups)[b]			
Vasomotor symptoms			
Berries	4.406	0.012	0.036
Cruciferous vegetables	0.219	0.001	0.640
Leafy greens	0.046	< 0.001	0.831
Soy foods	0.033	< 0.001	0.857
High omega-3 plant foods	0.246	0.001	0.620
Physical symptoms			
Berries	3.240	0.009	0.073
Cruciferous vegetables	1.777	0.005	0.183
Leafy greens	4.834	0.013	0.029
Soy foods	0.092	< 0.001	0.762
High omega-3 plant foods	0.092	< 0.001	0.761

[a] General linear model. ηp^2 refers to partial eta-squared (effect size); Diet Type refers to omnivores versus vegans; Menopausal Status refers to perimenopausal vs postmenopausal status. The model controls for age, exercise, hormone replacement therapy, presence of reproductive organs (i.e., uterus, ovaries, cervix), and age of menopause.
[b] Individual foods/food groups refer to the reported intake frequency over the past year.

Specifically, as women age and likely shift towards postmenopausal status, they report fewer vasomotor and physical menopausal symptoms. Similarly, as vegetable, fruit, soy, and high omega-3 plant food intake increases, vasomotor and physical symptoms decrease. Conversely, BMI, flesh food intake, dairy intake, and high omega-3 fish intake were positively correlated with both vasomotor and physical symptoms severity. Therefore, as BMI increases and women eat more flesh food, dairy, and omega-3 fish, vasomotor and physical menopausal symptoms also increase. Physical symptom severity was inversely correlated with moderate exercise and history of dieting and positively correlated with yoga practice and sweets intake. Years of education, marital status, cigarette smoking, and intake of eggs, tea, and berries were not associated with either symptom group.

Using the GLM, we compared vasomotor and physical symptoms in vegans and omnivores in both perimenopausal and postmenopausal women (see Table 3). Model covariates included age, level of exercise, use of menopausal hormone therapy, presence of three reproductive organs (uterus, ovaries, cervix), and age of menopause. These were included as they have previously been shown to be associated with menopausal symptoms [21–23]. As is common practice in analyses involving covariates, all covariates were retained in subsequent steps regardless of significance. In Step 1, the significance tests for the

Table 4
Adjusted symptom means and standard error (SE) for omnivores and vegans in peri- and postmenopausal women.*

	Perimenopausal women (n = 87)				Postmenopausal women (n = 342)			
	Omnivore (n = 57)		Vegan (n = 30)		Omnivore (n = 247)		Vegan (n = 95)	
	M	*SE*	*M*	*SE*	*M*	*SE*	*M*	*SE*
Vasomotor	3.00*	0.25	2.07*	0.32	2.09	0.10	1.84	0.16
Physical	2.62*	0.19	1.93*	0.24	2.46	0.08	2.32	0.12

Note: These data were derived from the Step 1 general linear model analyses.
* Groups were significantly different with p value < 0.01.

interaction between diet type and menopausal status approached significance for both vasomotor and physical symptoms. We found that in perimenopausal women, vegans reported significantly less bothersome vasomotor symptoms than omnivores ($p = 0.004$) after adjusting for covariates (see Table 4). In regard to physical symptoms, we found perimenopausal vegans reported significantly less bothersome symptoms than perimenopausal omnivores ($p = 0.006$) after adjusting for covariates. Steps 2 and 3 of the regression analyses revealed more vegetable intake ($p = 0.028$) and more berry intake ($p = 0.036$) were associated with less bothersome vasomotor symptoms, while greater vegetable intake ($p = 0.004$) and leafy green intake ($p = 0.029$) correlated with less bothersome physical symptoms. Of note, the partial eta-squared effect sizes for significant findings were small, ranging from 0.012 to 0.023.

4. Discussion

Vegan perimenopausal and postmenopausal women reported less bothersome vasomotor and physical symptoms than omnivores as measured by the MENQOL, although the reduction in symptom severity was only significant in perimenopausal women. The lack of a significant reduction in postmenopausal women is not surprising because physical and vasomotor symptoms peak during perimenopause, with the median duration of vasomotor symptoms being 4.5 years after the last period [24]. Hence, the inclusion in our sample of women up to age 80 meant that many older women were less symptomatic across the board.

We observed some discrepancies in relationships between food group intakes and symptoms. Total vegetable, fruit, soy and high n-3 plant food intakes were correlated to lower symptom severity; in contrast, total flesh food, dairy, and high n-3 fish intakes were correlated to higher symptom scores. However, in adjusted analyses, only total vegetable, berries, and leafy green intakes accounted for a significant portion of the variance in symptom severity that differentiated vegans and omnivores. The differences between these two results indicate that the correlational results were in some cases accounted for by relationships with the covariates. Total vegetable intake was the only food group shown to be significantly related to diminished symptoms regardless of statistical test.

The associations we observed between diet and menopausal symptoms were more extensive than those found in previous studies. In the SWAN study, vasomotor symptoms were not associated at all with dietary factors; even an early association with soy isoflavones did not hold in later analyses [21,25]. However, consumption of certain polyphenols such as hydroxybenzoic acid (in beer, wine, spices) and anthocyanidin (in berries and other plant foods) was associated with favorable urinary concentrations of an estrogen metabolite [18]. High fiber intake was associated with decreased symptom severity in women with early-stage breast cancer in the Women's Healthy Eating and Living trial [26]. Women in the Australian Longitudinal Study on Women's Health who consumed a higher pattern of fruit or a Mediterranean-style diet and a lower pattern of high-fat/high-sugar reported fewer vasomotor symptoms [27]. Finally, Chinese menopausal women with a higher intake of whole plant foods reported lower menopausal symptoms in general [28]. While we found no studies that reported associations of diet with physical menopausal symptoms, numerous studies found that a plant-based diet was associated with an improvement in physical conditions characterized by symptoms similar to those common in menopause, such as joint pain and fatigue [29,30]. A diet with abundant plant foods may be important for easier adaptation to the menopausal transition. Plant foods are rich in fiber and antioxidant nutrients, but also contain carotenoids and polyphenols that can boost antioxidant activity [31,32].

Interestingly, foods high in omega-3 fats consumed were related to very different symptom reports, with intake of high omega-3 animal food sources such as salmon related to more bothersome symptoms and high omega-3 plant food sources such as flaxseed related to less bothersome symptoms. Animal sources of omega-3 fats are more bioactive than the plant variety due to conversion to regulatory hormones that can lower inflammation; these fats, however, contain more double bonds thus are more susceptible to oxidation which may contribute to oxidative stress, particularly with high heat preparation [33].

We cannot directly address the mechanisms underlying our results; however, there is evidence that a plant-based diet is associated with biomarkers that are related to hormonal function and transition. The uncomfortable signs and symptoms of menopause are largely associated with increased oxidative stress, downstream inflammation and unhealthy blood lipids that occur as estrogen and its natural antioxidant properties decline [34–36]. In a study of antioxidant defense activity, pro-inflammatory biomarkers were higher and antioxidant enzymes were lower in peri- and postmenopausal versus premenopausal women [37]. Studies have shown that lipid and antioxidant profiles of those on a plant-based diet may more closely align with premenopausal women than those in transition. Long-term vegetarians were found to have lower blood cholesterol concentrations and lower oxidative stress and inflammation than long-term omnivores [38,39].

Emerging research linking dietary pattern, hormones and cancer may further illuminate the association we observed between the vegan diet and menopausal symptoms. A plant-based dietary pattern was associated with reduced risk of hormone-related breast tumors (estrogen/progesterone receptor-negative) [40]. Similarly, a diet consisting of whole grains, vegetables, fruit, and fish vs the typical Western diet was inversely associated with overall breast cancer risk, as well as premenopausal onset and tumors [41].

Of note, our study found an association between flesh food intake and menopausal symptoms. There is evidence from observational studies that consumption of meat, a food relatively high in total and saturated fat, may result in adverse health effects, although we are unaware of specific links with hormonal effects. In the Australian cohort study, vasomotor symptoms were not only related to lower fiber but also to higher fat intakes [42].

We also found associations between menopausal symptoms and both soy and moderate exercise. Soy intake was associated with less bothersome vasomotor and physical symptoms, although it did not account for differences between vegan and omnivore women. The natural estrogens in soy are nonsteroidal estrogens and bind to estrogen receptors, albeit more weakly than endogenous estrogens [43]. Asian

populations consuming a soy-rich diet typically report fewer menopausal symptoms than American women [44]. Our findings are consistent with the idea that features of the Asian diet such as intake of soy, more vegetables, and less meat may account for the finding of reduced menopausal symptoms in Asian women. Moderate exercise was associated with less bothersome physical but not vasomotor symptoms. While there is limited evidence to conclude exercise reduces menopausal symptoms, these data support previous inverse associations of moderate exercise and physical symptoms such as sleep problems [45].

Weight gain has been viewed as one of the physical symptoms of menopause and was surveyed on the MENQOL. Longitudinal follow-up analyses of SWAN study data, however, has shown that concurrent weight (BMI and waist circumference), not changes in weight, were related to incidence of vasomotor symptoms [46]. Higher weight may increase the need to dissipate excess body heat but also increases systemic inflammation, thereby increasing vasomotor symptoms [47]. We found that BMI was associated with both vasomotor and physical menopausal symptoms, although weight/height was self-reported. In a recent study with a healthy multiethnic population of premenopausal women, overweight/obese women had higher levels of biomarkers associated with oxidative stress and inflammation than women of normal weight status [48]. In the Women's Healthy Eating and Living trial, BMI was associated with increased severity of vasomotor symptoms at one year [26]. Similarly, postmenopausal women in the Women's Health Initiative Dietary Modification trial who lost at least 10 lb or 10% of their baseline body weight after one year were more likely to eliminate their vasomotor symptoms [49].

Maintenance of healthy weight early in the menopausal transition may help prevent symptoms. The vegetarian diet with its lower fat and higher fiber improves weight management more than a nonvegetarian diet [50]. A recent meta-analysis of randomized controlled trials comparing body weight changes found that participants who followed vegetarian diets lost about 2 kg more body weight than nonvegetarians and lacto-ovo-vegetarians [51]. Moreover, overweight postmenopausal women randomized to a vegan diet without dietary restriction lost more weight at one and two year follow-ups than those randomized to a low-fat diet [52]. Consequently, lower BMI may account for those following a vegan diet experiencing reduced vasomotor symptoms, although in our sample this difference was not significant.

Increasing the proportion of dietary plant foods would be healthful for everyone. Those selecting a vegan diet, however, must ensure adequate calcium and vitamins B12 and D [53]. Despite these potential micronutrient shortfalls, a well-planned vegan diet may be beneficial for women in menopausal transition [53,54].

4.1. Strengths and limitations

With regard to strengths, the sample included a moderately large number of vegans, which was international in scope. The numbers were sufficient to enable analysis of perimenopausal and postmenopausal subsamples. The measures selected were well researched with good psychometric data. As to limitations, some volunteers opted out of participation perhaps due to the length and personal nature of survey questions. Data were self-reported, and subject to recall bias. The psychometric data evaluating the Godin-Shepherd scale provided only modest support for its use and were collected in a young to middle-aged adult sample, not an older adult sample, which may have affected our results. As our data were collected at only one time point, we were not able to replicate the test-retest reliability correlation coefficients with our sample, so the stability of the measure is unknown. Food frequency data were recalled over a six-month period and linked to normal serving sizes instead of querying actual portion sizes, so recall bias may have been compounded by portion inaccuracies. Because the sample was recruited online and in specialized settings, and was highly educated and overall more diet and health conscious due to study aims, results are less generalizable to the broader population. Finally, this is a cross-sectional study examining associations. As it is not experimental, potential causal links cannot be determined.

5. Conclusion

To date, this is the first study comparing menopausal symptoms in vegans and omnivores. These results are consistent with other studies demonstrating reduced menopausal symptoms in those consuming greater quantities of plant based foods and less meat. Eating more plants and fewer animal foods along with engaging in regular physical activity may prove effective for older women who prefer a natural solution to help manage their menopausal symptoms. Future experimental studies investigating a causal link between the vegan diet and reduction of menopausal symptoms are warranted.

Contributors

Bonnie Beezhold was responsible for study design, acquisition of data, interpretation of data, and drafting the article.

Cynthia Radnitz was responsible for study conception and design, acquisition of data, interpretation of data, and revising the article.

Robert McGrath was responsible for analysis and interpretation of data, and revising the article.

Arielle Feldman was responsible for acquisition and analysis of data, and revising the article.

All authors saw and approved the final version.

Conflict of interest

The authors declare that they have no conflict of interest.

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Ethical approval

Ethical approval of this study was granted by the Institutional Review Boards of Benedictine University and Fairleigh Dickinson University.

Provenance and peer review

This article has undergone peer review.

Research data (data sharing and collaboration)

There are no linked research data sets for this paper. The authors do not have permission to share data.

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References

[1] E.B. Gold, A. Colvin, N. Avis, et al., Longitudinal analysis of the association between vasomotor symptoms and race/ethnicity across the menopausal transition: study of women's health across the nation, Am. J. Public Health 7 (2006) 1226–1235.
[2] R.E. Williams, K.B. Levine, L. Kalilani, J. Lewis, R.V. Clark, Menopause-specific questionnaire assessment in US population-based study shows negative impact on health-related quality of life, Maturitas 2 (2009) 153–159.
[3] E.B. Gold, B. Sternfeld, J.L. Kelsey, et al., Relation of demographic and lifestyle

factors to symptoms in a multi-racial/ethnic population of women 40–55 years of age, Am. J. Epidemiol. 5 (2000) 463–473.
[4] N.E. Avis, S. Brockwell, A. Colvin, A universal menopausal syndrome, Am. J. Med. (2005) 37–46.
[5] R. Sood, S.S. Faubion, C.L. Kuhle, J.M. Thielen, L.T. Shuster, Prescribing menopausal hormone therapy: an evidence-based approach, Int. J. Womens Health (2014) 47–57.
[6] M. Hickey, R.A. Szabo, M.S. Hunter, Non-hormonal treatments for menopausal symptoms, BMJ (2017) j5101.
[7] E.M. Kupferer, S.L. Dormire, H. Becker, Complementary and alternative medicine use for vasomotor symptoms among women who have discontinued hormone therapy, J. Obstet. Gynecol. Neonatal Nurs. 1 (2009) 50–59.
[8] S. Levis, M.L. Griebeler, The role of soy foods in the treatment of menopausal symptoms, J. Nutr. 12 (2010) 2318S–2321S.
[9] O.H. Franco, R. Chowdhury, J. Troup, et al., Use of plant-Based therapies and menopausal symptoms: a systematic review and meta-analysis, JAMA 23 (2016) 2554–2563.
[10] E.M. Cespedes, F.B. Hu, Dietary patterns: from nutritional epidemiologic analysis to national guidelines, Am. J. Clin. Nutr. 5 (2015) 899–900.
[11] P.J. Tuso, M.H. Ismail, B.P. Ha, C. Bartolotto, Nutritional update for physicians: plant-based diets, Perm. J. 2 (2013) 61–66.
[12] L.T. Le, J. Sabate, Beyond meatless, the health effects of vegan diets: findings from the Adventist cohorts, Nutrients 6 (2014) 2131–2147.
[13] J.R. Hilditch, J. Lewis, A. Peter, et al., A menopause-specific quality of life questionnaire: development and psychometric properties, Maturitas 1–2 (2008) 107–121.
[14] N.M. Grindler, N.F. Santoro, Menopause and exercise, Menopause 12 (2015) 1351–1358.
[15] S. Amireault, G. Godin, The Godin-Shephard leisure-time physical activity questionnaire: validity evidence supporting its use for classifying healthy adults into active and insufficiently active categories, Percept. Mot. Skills 2 (2015) 604–622.
[16] G. Godin, R.J. Shephard, A simple method to assess exercise behavior in the community, Can. J. Appl. Sport Sci. 3 (1985) 141–146.
[17] D.R. Jacobs Jr., B.E. Ainsworth, T.J. Hartman, A.S. Leon, A simultaneous evaluation of 10 commonly used physical activity questionnaires, Med. Sci. Sports Exerc. 1 (1993) 81–91.
[18] M.R. Sowers, S. Crawford, D.S. McConnell, et al., Selected diet and lifestyle factors are associated with estrogen metabolites in a multiracial/ethnic population of women, J. Nutr. 6 (2006) 1588–1595.
[19] C. Manach, A. Scalbert, C. Morand, C. Remesy, L. Jimenez, Polyphenols: food sources and bioavailability, Am. J. Clin. Nutr. 5 (2004) 727–747.
[20] M. Messina, Soy foods, isoflavones, and the health of postmenopausal women, Am. J. Clin. Nutr. (2014) 423S–430S.
[21] E.B. Gold, G. Block, S. Crawford, et al., Lifestyle and demographic factors in relation to vasomotor symptoms: baseline results from the Study of Women's Health Across the Nation, Am. J. Epidemiol. 12 (2004) 1189–1199.
[22] L.M. McAndrew, M.A. Napolitano, A. Albrecht, N.C. Farrell, B.H. Marcus, J.A. Whiteley, When, why and for whom there is a relationship between physical activity and menopause symptoms, Maturitas 2 (2009) 119–125.
[23] M.S. Hunter, A. Gentry-Maharaj, A. Ryan, et al., Prevalence, frequency and problem rating of hot flushes persist in older postmenopausal women: impact of age, body mass index, hysterectomy, hormone therapy use, lifestyle and mood in a cross-sectional cohort study of 10,418 British women aged 54–65, BJOG 1 (2012) 40–50.
[24] N.E. Avis, S.L. Crawford, G. Greendale, et al., Duration of menopausal vasomotor symptoms over the menopause transition, JAMA Intern. Med. 4 (2015) 531–539.
[25] R.C. Thurston, H. Joffe, Vasomotor symptoms and menopause: findings from the Study of Women's Health across the Nation, Obstet. Gynecol. Clin. North Am. 3 (2011) 489–501.
[26] E.B. Gold, S.W. Flatt, J.P. Pierce, et al., Dietary factors and vasomotor symptoms in breast cancer survivors: the WHEL Study, Menopause 3 (2006) 423–433.
[27] G.C. Herber-Gast, G.D. Mishra, Fruit, Mediterranean-style, and high-fat and − sugar diets are associated with the risk of night sweats and hot flushes in midlife: results from a prospective cohort study, Am. J. Clin. Nutr. 5 (2013) 1092–1099.
[28] Z.M. Liu, S.C. Ho, Y.J. Xie, J. Woo, Whole plant foods intake is associated with fewer menopausal symptoms in Chinese postmenopausal women with pre-hypertension or untreated hypertension, Menopause 5 (2015) 496–504.
[29] C.M. Clinton, S. O'Brien, J. Law, C.M. Renier, M.R. Wendt, Whole-foods, plant-based diet alleviates the symptoms of osteoarthritis, Arthritis (2015) 708152.
[30] V. Yadav, G. Marracci, E. Kim, et al., Low-fat, plant-based diet in multiple sclerosis: a randomized controlled trial, Mult. Scler. Relat. Disord. 8 (2016) 80–90.
[31] M.T. Lee, W.C. Lin, B. Yu, T.T. Lee, Antioxidant capacity of phytochemicals and their potential effects on oxidative status in animals – a review, Asian-Aust. J. Anim. Sci. 3 (2017) 299–308.
[32] M.S. Markussen, M.B. Veierod, A.K. Sakhi, et al., Evaluation of dietary patterns among Norwegian postmenopausal women using plasma carotenoids as biomarkers, Br. J. Nutr. 4 (2015) 672–682.
[33] Y.E. Finnegan, A.M. Minihane, E.C. Leigh-Firbank, et al., Plant- and marine-derived n-3 polyunsaturated fatty acids have differential effects on fasting and postprandial blood lipid concentrations and on the susceptibility of LDL to oxidative modification in moderately hyperlipidemic subjects, Am. J. Clin. Nutr. 4 (2003) 783–795.
[34] S.B. Doshi, A. Agarwal, The role of oxidative stress in menopause, J. Midlife Health 3 (2013) 140–146.
[35] S. Salhotra, S. Arora, S.S. Anubhuti Trivedi, J. Bhattacharjee, Influence of menopause on biochemical markers of endothelial dysfunction-a case-control pilot study in North Indian population, Maturitas 2 (2009) 166–170.
[36] O. Taleb-Belkadi, H. Chaib, L. Zemour, A. Fatah, B. Chafi, K. Mekki, Lipid profile, inflammation, and oxidative status in peri- and postmenopausal women, Gynecol. Endocrinol. 12 (2016) 982–985.
[37] L. Kolesnikova, N. Semenova, I. Madaeva, et al., Antioxidant status in peri- and postmenopausal women, Maturitas 1 (2015) 83–87.
[38] M.K. Kim, S.W. Cho, Y.K. Park, Long-term vegetarians have low oxidative stress, body fat, and cholesterol levels, Nutr. Res. Pract. 2 (2012) 155–161.
[39] Y.T. Szeto, T.C. Kwok, I.F. Benzie, Effects of a long-term vegetarian diet on biomarkers of antioxidant status and cardiovascular disease risk, Nutrition 10 (2004) 863–866.
[40] L.B. Link, A.J. Canchola, L. Bernstein, et al., Dietary patterns and breast cancer risk in the California Teachers Study cohort, Am. J. Clin. Nutr. 6 (2013) 1524–1532.
[41] T. Agurs-Collins, L. Rosenberg, K. Makambi, J.R. Palmer, L. Adams-Campbell, Dietary patterns and breast cancer risk in women participating in the Black Women's Health Study, Am. J. Clin. Nutr. 3 (2009) 621–628.
[42] G.C. Herber-Gast, G.D. Mishra, Y.T. van der Schouw, W.J. Brown, A.J. Dobson, Risk factors for night sweats and hot flushes in midlife: results from a prospective cohort study, Menopause 9 (2013) 953–959.
[43] K. Morito, T. Hirose, J. Kinjo, et al., Interaction of phytoestrogens with estrogen receptors alpha and beta, Biol. Pharm. Bull. 4 (2001) 351–356.
[44] C. Nagata, N. Takatsuka, N. Kawakami, H. Shimizu, Soy product intake and hot flashes in Japanese women: results from a community-based prospective study, Am. J. Epidemiol. 8 (2001) 790–793.
[45] B. Sternfeld, K.A. Guthrie, K.E. Ensrud, et al., Efficacy of exercise for menopausal symptoms: a randomized controlled trial, Menopause 4 (2014) 330–338.
[46] E.B. Gold, S.L. Crawford, J.F. Shelton, et al., Longitudinal analysis of changes in weight and waist circumference in relation to incident vasomotor symptoms: the Study of Women's Health Across the Nation (SWAN), Menopause 1 (2017) 9–26.
[47] A.W. Fogarty, C. Glancy, S. Jones, S.A. Lewis, T.M. McKeever, J.R. Britton, A prospective study of weight change and systemic inflammation over 9 y, Am. J. Clin. Nutr. 1 (2008) 30–35.
[48] Y. Morimoto, F. Beckford, R.V. Cooney, A.A. Franke, G. Maskarinec, Adherence to cancer prevention recommendations and antioxidant and inflammatory status in premenopausal women, Br. J. Nutr. 1 (2015) 134–143.
[49] C.H. Kroenke, B.J. Caan, M.L. Stefanick, et al., Effects of a dietary intervention and weight change on vasomotor symptoms in the Women's Health Initiative, Menopause 9 (2012) 980–988.
[50] B. Farmer, B.T. Larson, V.L. Fulgoni 3rd, A.J. Rainville, G.U. Liepa, A vegetarian dietary pattern as a nutrient-dense approach to weight management: an analysis of the national health and nutrition examination survey 1999–2004, J. Am. Diet. Assoc. 6 (2011) 819–827.
[51] R.Y. Huang, C.C. Huang, F.B. Hu, J.E. Chavarro, Vegetarian diets and weight reduction: a meta-analysis of randomized controlled trials, J. Gen. Intern. Med. 1 (2016) 109–116.
[52] G.M. Turner-McGrievy, N.D. Barnard, A.R. Scialli, A two-year randomized weight loss trial comparing a vegan diet to a more moderate low-fat diet, Obesity (Silver Spring) 9 (2007) 2276–2281.
[53] W.J. Craig, Nutrition concerns and health effects of vegetarian diets, Nutr. Clin. Pract. 6 (2010) 613–620.
[54] P. Clarys, T. Deliens, I. Huybrechts, et al., Comparison of nutritional quality of the vegan, vegetarian, semi-vegetarian, pesco-vegetarian and omnivorous diet, Nutrients 3 (2014) 1318–1332.