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ORIGINAL RESEARCH

Dietary Behaviors in Psoriasis: Patient-Reported Outcomes from a U.S. National Survey

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ABSTRACT

Introduction: Psoriasis patients demonstrate high interest in the role of diet on their skin condition. However, data are lacking to describe dietary interventions among psoriasis patients and associated outcomes. This study aims to identify common dietary habits, interventions and perceptions among patients with psoriasis, and to examine patient-reported skin outcomes in response to these interventions.

Methods: We administered a 61-question survey to the National Psoriasis Foundation membership asking psoriasis patients about dietary habits, modifications, skin responses, and perceptions.

Results: A total of 1206 psoriasis patients responded to the survey. Compared to age- and sex-matched controls, psoriasis patients consumed significantly less sugar, whole grain fiber, dairy, and calcium ($p < 0.001$), while consuming more fruits, vegetables, and legumes ($p < 0.01$). Eighty-six percent of respondents reported use of a dietary modification. The percentage of patients reporting skin improvement was greatest after reducing alcohol (53.8%), gluten (53.4%), nightshades (52.1%), and after adding fish oil/omega-3 (44.6%), vegetables (42.5%), and oral vitamin D (41%). Specific diets with the most patients reporting a favorable skin response were Pagano (72.2%), vegan (70%), and Paleolithic (68.9%). Additionally, 41.8% of psoriasis respondents reported that a motivation for attempting dietary changes was to improve overall health.

Conclusion: This national survey is among the first to report the dietary behaviors of patients with psoriasis. The data provided from this large cohort may benefit patients and clinicians as they discuss the role of diet in managing both psoriasis and associated cardiometabolic comorbidities.

Keywords: Diet; Nutrition; Psoriasis; Psoriatic arthritis; Triggers

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INTRODUCTION

Psoriasis is a chronic immune-mediated disease affecting 3–4% of the world population [1]. The innate and adaptive immune systems are

thought to be responsible for psoriasis pathogenesis, while well-recognized environmental factors like smoking and emotional stress can modify disease severity [2].

One environmental factor of high interest to patients is the influence of diet on psoriasis. Although the popular literature contains many dietary recommendations for psoriasis, the scientific literature is limited, especially among randomized controlled trials (RCT). The strongest scientific evidence exists for weight loss, particularly among obese psoriatic patients [3–10], and for gluten-free diets (GFD), which have been reported to improve psoriasis in a subset of patients with celiac-specific antibodies [11–15]. Moreover, there is an absence of studies describing the effects of popular dietary recommendations and regimens, such as a Paleolithic diet or a vegetarian diet. The limited literature on diet and psoriasis represents an important knowledge gap that makes it difficult for patients and clinicians to discuss this topic.

Psoriasis is increasingly being recognized as a systemic inflammatory condition as a result of an emerging and rapidly growing body of evidence supporting an association between psoriasis and cardiometabolic disease as well as various other comorbidities [16]. As a result, a greater need to provide comprehensive care to patients with psoriasis has been recently been proposed and encouraged [17]. Thus, engaging in dietary recommendations and management options with psoriatic patients aligns with this shift towards comprehensive care for not only control and prevention of their skin disease but also for managing their overall and long-term health.

In order to understand the role of dietary modifications in the management of psoriasis, a survey of psoriasis patients with the following objectives was conducted: (1) to quantify nutrient intake in psoriasis patients compared to population controls; (2) to identify popular dietary interventions among psoriasis patients and the influence of those interventions on psoriasis improvement based on patient-reported skin responses; and (3) to understand the attitudes and perceptions of psoriasis patients regarding the role of diet in managing psoriasis.

METHODS

Study Design and Subjects

We performed an exploratory survey study of psoriasis patients via email distribution to the National Psoriasis Foundation (NPF) list-serve from August 2014 to January 2015 (survey provided in Appendix 1 within the supplemental material). The NPF was used for recruitment due to their large network and well-engaged, motivated patient community with a convenient means to access this community through a periodic newsletter. A response rate was calculated based on the "click-through rate," which reflects the number of recipients who opened the survey. The survey contained 61 questions, was voluntary and no incentives were offered. The first 30 questions were from the 2009–2010 National Health and Nutrition Examination Survey (NHANES) dietary screening questionnaire, which assesses nutrient intake in several food categories and has undergone validation using 24-h dietary recall forms [18]. The last 31 questions focused on patient-reported skin responses to dietary changes, patients' attitudes regarding diet as a management strategy for their psoriasis, and participant demographics. The latter 31 questions were developed based on topics of interest found in NPF discussion forums, popular literature, patient discussion and a review of the scientific literature. The Institutional Review Board (IRB) at the University of California, San Francisco (UCSF), approved this study. All procedures followed were in accordance with the ethical standards of the UCSF IRB and with the Helsinki Declaration of 1964, as revised in 2013. Informed consent was obtained from all patients for being included in the study. Study data were collected and managed using REDcap (Research Electronic Data Capture) electronic data capture tools hosted at UCSF [19]. Data were exported from REDcap and numerically coded for statistical analysis.

Statistical Analysis

All dietary changes, attitude/perception, and demographic data were compiled and

frequencies reported. A geographical information system plot of patients overlaid over the contiguous United States (U.S.) was created with the self-reported zip codes from each participant and created using the maps package in R 3.2.2 [20, 21]. Data processing and scoring of nutrient intake was performed using NHANES guidelines [22]. Population control data from the NHANES 2009–2010 dataset was matched to our psoriasis cohort based on age and gender. Differences in relative daily consumption of key dietary components were identified using a Mann–Whitney *U* Test in SAS, with statistical significance set to $p = 0.05$.

Patient-perceived skin responses to dietary changes were rated on a Likert scale consisting of: Worsened, No Change, Improved, and Fully Clear. A positive response was defined as participants reporting Fully Clear or Improved, while a negative response was defined as No Change or Worsened. We performed association testing between demographic variables (race, sex, age, age of onset, education, income level, self-reported psoriasis severity off treatment, self-reported BSA off treatment, psoriatic arthritis status, family history, BMI, celiac disease status, urban/rural living environment) and patient-perceived favorable responses to dietary changes. After performing univariate logistic regression (see Appendix 2 in the supplementary material) to identify individual demographic variables associated with a patient-reported favorable response to dietary changes ($p < 0.05$), we then used multivariate logistic regression to evaluate for independent effects. We report variables from multivariate analysis with $p < 0.05$. Odds ratios (OR) and their corresponding 95% confidence intervals were calculated. A similar analysis was conducted to evaluate the association of demographic variables with dietary perceptions and attitudes. A two-step cluster analysis using SPSS v.23.0 (IBM, Armonk, NY, USA) was also performed, grouping respondents based on dietary behavior/experience and comparing the influence of various demographic factors and dietary perceptions. One-way analysis of variance was performed to compare the continuous variables of age, weight, and age of onset by the two clusters. The remaining analyses used Chi-squared tests (cluster analysis data can be found in Appendix 3 within the supplementary material).

RESULTS

Demographics

Overall, 1206 psoriasis patients responded to the survey with a 60% response rate. The demographic characteristics of the patient population are shown in Table 1. The mean age of the sample population was 50.4, and 73% of respondents were female. The sample population represented all levels of psoriasis severity based on self-reported severity scores: 20.9% with mild disease, 42.2% with moderate disease, and 36.9% with severe disease. Self-reported body surface area (BSA) involvement without treatment was well distributed, with 7.8% reporting barely any or very little BSA, 29.6% reporting <5% BSA, 24.9% reporting 5–10% BSA, 19.1% reporting 11–20% BSA and 18.6% reporting >20% BSA. Concomitant psoriatic arthritis was self-reported in 43.9% of respondents. The sample population was predominantly white (87.2%) and lived in an urban setting (79%). A geographic map showing the location of respondents demonstrates representation across the U.S. (Fig. 1).

Daily Consumption in Psoriasis versus Control Group

Compared to the 2009–2010 NHANES controls, psoriasis patients in this study demonstrated a significant difference in daily consumption of specific nutrients based on the food frequency questionnaire (Table 2). On average, respondents reported less daily intake of sugar, whole grain fiber, dairy products, and calcium ($p < 0.001$), and higher daily intake of fruits/vegetables/legumes ($p = 0.007$).

Perceived Dietary Triggers and Helpful Additives

About 37% of respondents reported that they did not recognize any dietary triggers which

Table 1 Demographic characteristics of survey respondents

Variable	Value
Age, mean (SD)	50.4 (14.3)
Sex, *n* (%)	
Male	322 (26.7)
Female	884 (73.3)
Average age at onset of psoriasis, mean (SD)	27.2 (17.2)
Severity of skin condition (without treatment), *n* (%)	
Mild	252 (20.9)
Moderate	509 (42.2)
Severe	444 (36.9)
Body surface area (without treatment), *n* (%)	
Barely any or very little	94 (7.8)
<5% body surface	357 (29.6)
5–10% body surface	300 (24.9)
11–20% body surface	230 (19.1)
>20% body surface	224 (18.6)
Presence of psoriatic arthritis	529 (43.9)
Family history of skin condition, *n* (%)	581 (48.3)
Average BMI, mean (SD)	28.4 (7.4)
Underweight (<18.5), *n* (%)	35 (2.9)
Normal (18.5–24.9), *n* (%)	403 (33.6)
Overweight (25–29.9), *n* (%)	360 (30.3)
Obese 30+, *n* (%)	396 (32.8)
Race, *n* (%)	
White	1066 (87.2)
Asian/Pacific Islander	60 (5)
Hispanic	47 (3.9)
Native American	16 (1.3)
African American	8 (0.7)
Other	25 (2.1)
Highest level of education, *n* (%)	
Less than high school	14 (1.2)
High school graduate	207 (17.3)
Undergraduate	371 (30.9)
Graduate/professional degree	608 (50.7)
Area in which you live, *n* (%)	
Urban/suburban	945 (79)
Rural	251 (21)
Average annual household income, *n* (%)	
<$20,000	88 (7.4)
$20,000–$40,000	151 (12.7)
$40,001–$60,000	168 (14.1)
$60,001–$100,000	242 (20.4)
>$100,000	298 (25.1)
Prefer not to say	242 (20.4)

may worsen their psoriasis or left the survey field blank (Fig. 2). Among respondents, the most common reported triggers were sugar (13.8%), alcohol (13.6%), tomato (7.4%), gluten (7.2%), and dairy (6%). Less commonly reported triggers (2–5% of reported triggers) included meat, processed foods, soda, bread, beer, wine, eggs, and spicy foods.

Respondents also reported dietary items that may improve psoriasis. This included consumption of dietary supplements (35.1%), vegetables (26.5%), fruits (21.8%), water (11.2%), and fish (9.2%) (Fig. 3).

Dietary Modifications and Reported Outcomes

Among respondents, 1037 reported a trial of avoiding or reducing specific foods and 988 noted a trial of adding certain foods; a complete list is shown in Table 3. The most common dietary reductions associated with patient-reported positive skin response were alcohol (53.8%), gluten (53.4%), nightshades (52.1%), junk foods (50%), and white flour products (49.9%). A positive skin response was also reported by respondents when adding fish oil/omega-3 (44.6%), vegetables (42.5%), oral vitamin D (41%), probiotics (40.6%), organic foods (38.4%), and fruits (34.6%) (Table 4).

Among all respondents, 481 respondents (40%) reported trying a special diet for their psoriasis, the most common being gluten-free (35.6%), low carbohydrate–high protein (16.6%), and Paleolithic (11.6%) diets (Table 5). The three diets with the highest patient-reported positive response were the Pagano, vegan, and Paleolithic diets. Other diets that patients reported to improve their psoriasis included gluten-free, low carbohydrate–high protein, Mediterranean and vegetarian diets. Across all special diets, 69% of patients reported weight loss.

Demographic Factors Associated with Favorable Dietary Outcomes

We examined whether demographic factors were associated with patient-reported favorable dietary responses (Table 6). We found that

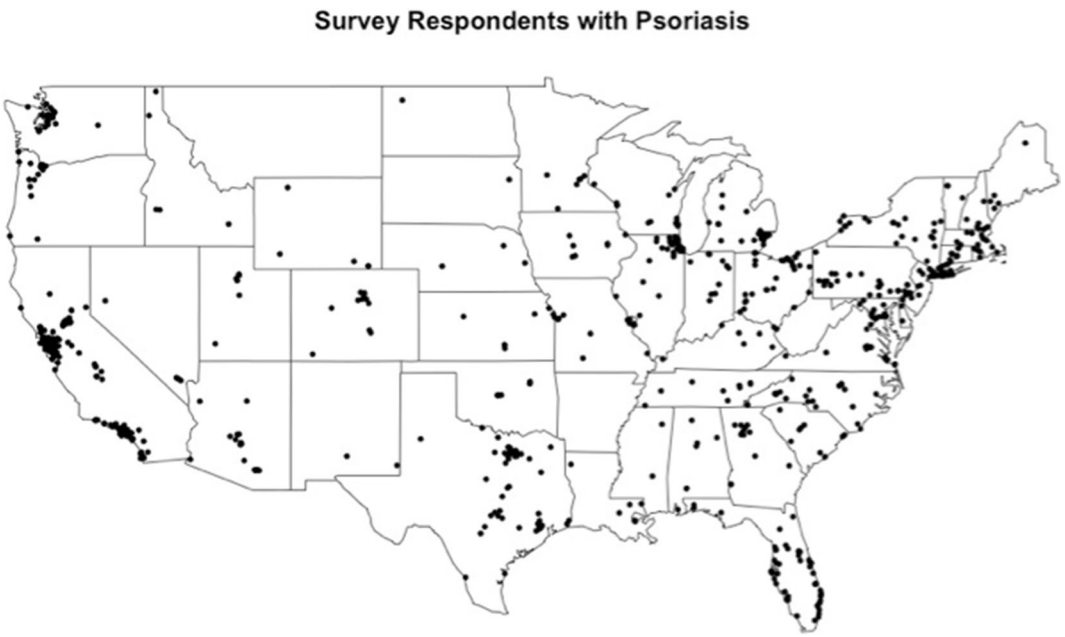

Fig. 1 Geographic location of psoriasis survey respondents

Table 2 Relative daily consumption of key dietary components in psoriasis versus control groups

Dietary intake	Psoriasis data (n = 1017) Mean ± SD	NHANES data Mean ± SD (n)	p value
Daily added sugar (tsp.)	10.6 ± 7.64	15.3 ± 10.7 (2815)	<0.0001
Daily whole grain (oz.)	0.704 ± 1.17	0.846 ± 1.35 (2842)	<0.0001
Daily fiber (g)	13.7 ± 5.69	14.5 ± 5.64 (2609)	0.0002
Daily dairy (cup)	1.25 ± 0.891	1.45 ± 0.91 (2847)	<0.0001
Daily calcium (mg)	741 ± 397	827 ± 423 (2609)	<0.0001
Daily fruit/vegetable/legume (cup)	2.58 ± 0.957	2.51 ± 1.08 (2724)	0.0070

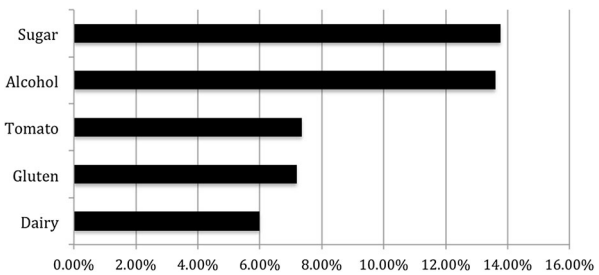

Fig. 2 Reported dietary triggers that worsen psoriasis. Only responses >5% listed. Less commonly reported triggers (2–5%) included meat, processed foods, soda, bread, beer, wine, eggs, and spicy foods

younger age was associated with greater reported positive response to avoidance of red meat, high fat foods, sodium, white flour, and alcohol, with an effect size of 1–3% decrease in odds per additional year of age. Non-white race was associated with a greater patient-reported favorable response to avoidance of red meat, pork, high fat foods, sodium, and addition of fruits, with non-white race increasing the odds of patient-reported positive response by approximately two- to fourfold. Patients who reported having severe psoriasis reported responding better to avoidance of caffeine

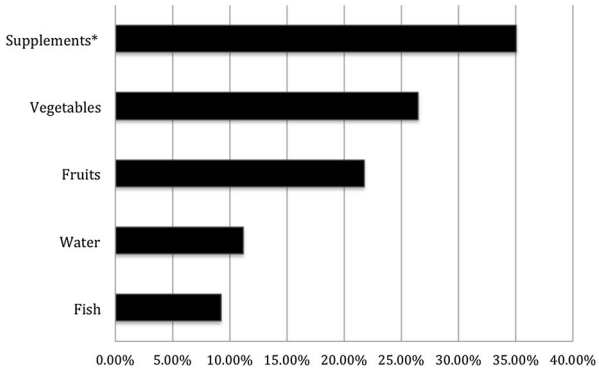

Fig. 3 Reported dietary additions that Improve psoriasis. Only responses >5% listed. *Common dietary supplements reported include: vitamin D, fish oil/omega-3, probiotics, vitamin B, vitamin E, vitamin C, vitamin A, and turmeric capsules

Table 3 Reported dietary modifications in psoriasis patients

Dietary removals	Dietary additions
% of respondents reporting trial of dietary item removal ($n = 1037$)	% of respondents reporting dietary item addition ($n = 988$)
Junk foods[a]: 66.7%	Vegetables: 58.8%
White flour products: 55.7%	Fish oil/omega-3: 56.8%
High fat foods: 50.4%	Oral vitamin D: 55.6%
Red meat: 49.5%	Fruits: 54.7%
Alcohol: 45%	Probiotics: 44.4%
Gluten: 44.6%	Organic foods: 39.6%
Dairy: 41.3%	Other: 9.2%
Tobacco: 36.1%	
Sodium/salt: 34.5%	
Nightshades[b]: 28.8%	
Caffeine: 27%	
Pork: 26.8%	
Shellfish: 18%	
Other: 9.2%	

[a] Junk foods: candy and pastries, chocolate, french fries, potato chips, sweets

[b] Nightshades: tomatoes, eggplant, peppers, paprika, white potatoes

Table 4 Outcomes to dietary interventions in psoriasis patients

Dietary removals Respondents reporting full clearance or improvement of psoriasis with removal of the following from their diet (%)	Dietary additions Respondents reporting full clearance or improvement of psoriasis after addition of the following to their diet (%)
Alcohol: 251 of 462(53.8%)	Fish oil/omega-3: 250 of 556 (44.6%)
Gluten: 247 of 459 (53.4%)	Vegetables: 247 of 575 (42.5%)
Nightshades[a]: 156 of 297 (52.1%)	Oral vitamin D: 216 of 545 (41%)
Junk foods[b]: 346 of 687 (50%)	Probiotics: 178 of 434 (40.6%)
White flour products: 288 of 573 (49.9%)	Organic foods: 150 of 388 (38.4%)
Dairy: 204 of 424 (47.7%)	Fruits: 187 of 534 (34.6%)
Shellfish: 73 of 186 (39%)	
High fat foods: 193 of 519 (36.9%)	
Caffeine: 102 of 275 (36.4%)	
Pork: 99 of 276 (35.6%)	
Tobacco: 131 of 370 (35%)	
Red meat: 156 of 509 (30.4%)	
Sodium/salt: 76 of 356 (21.2%)	

[a] Nightshades: tomatoes, eggplant, peppers, paprika, white potatoes

[b] Junk Foods: candy and pastries, chocolate, french fries, potato chips, and sweets

(OR = 2.3), while those with celiac disease reported faring better with avoidance of white flour (OR = 4.3).

Attitudes and Perceptions About Diet

Attitudes surrounding diet as a management strategy for their disease are reported in Table 7.

Table 5 Frequencies of special diets used for psoriasis and outcomes

Special diets	
% of respondents reporting trial of special diet ($n = 481$)	**Respondents reporting full clearance or improvement of psoriasis after special diet (%)**
Gluten-free: 35.6%	Pagano diet (13 of 18, 72.2%)
Low carbohydrate–high protein: 16.6%	Vegan diet (20 of 29, 70%)
Paleolithic: 11.6%	Paleolithic diet (42 of 62, 68.9%)
Vegetarian: 9.7%	Gluten-free diet (101 of 191, 52.9%)
Mediterranean: 5.8%	Low carbohydrate–high protein diet (45 of 89, 51.7%)
Vegan: 5.4%	Mediterranean diet (15 of 31, 48.4%)
Other: 9.7%	Vegetarian diet (21 of 52, 40.4%).

The majority of respondents were not sure how diet affected their skin (43.2%); however, 16.7% felt diet was significantly helping their skin and 17.4% felt diet was slightly helping their skin.

Of note, 57.9% of patients found it very or somewhat difficult to follow a special diet, 17.4% of patients found it very time consuming, and 11.4% found it very expensive to follow a special diet.

Motivation for using diet to improve psoriasis varied among patients. The most commonly reported reasons include: diet may improve other health problems (41.8%), diet is a natural method (32.2%), and previous treatments failed (26.5%). Although 86% of respondents had tried a dietary modification, and 88.8% found it very or somewhat important that physicians discuss with patients the role of diet in managing skin disease, only 30.7% had actually discussed dietary changes with a dermatologist.

Patients were asked to rate the importance of diet compared to other interventions or treatments for management of their psoriasis: 41.5% of respondents rated diet to be more important than over-the-counter medications; diet was also rated as more important than complementary medications in 31.9%, prescription medications in 31%, exercise in 21.3%, and stress reduction in 8.9%.

Demographic Factors Associated with Perceptions and Attitudes About Diet

Similarly, we performed an analysis examining demographic predictors for perceptions regarding dietary management of psoriasis (Supplementary Table 1). The belief that "diet plays an important role in managing psoriasis" was associated with younger age and patients reporting less severe psoriasis. The belief that "following a specific diet is burdensome" was associated with younger age, female gender, and those with psoriatic arthritis. Interestingly, respondents who reported discussing dietary changes with a dermatologist were more likely to report having severe psoriasis or higher BSA involvement.

Cluster Analysis

Cluster analysis based on dietary behavior identified two groups: Cluster 1 was highly active in their dietary modifications and frequently engaged in avoiding red meat, pork, sodium, high fat foods, caffeine, alcohol and tobacco and were more likely to add fruits, vegetables, organic foods, probiotics, fish and vitamin D; Cluster 2 was a less active dietary-modifying group and instead selectively avoided shellfish, gluten, white flour and junk food. Examination of variations in demographic factors between the two groups found significant differences, whereby Cluster 2 was younger ($p < 0.001$), had an earlier mean age of onset ($p = 0.012$), weighed less ($p = 0.011$), had a higher prevalence of celiac disease ($p = 0.017$), and had greater racial diversity ($p < 0.001$). Cluster 2 was also significantly more likely to discuss with their dermatologist regarding dietary modifications ($p < 0.001$), and believed that

Table 6 Demographic factors associated with response to dietary change

Intervention	Multivariate analysis		
	Variable	*p* value	OR (95% CI)
Avoidance of red meat	Age (increasing)	0.04	0.98 (0.97–0.99)[a]
	Race (white)	0.0084	0.46 (0.26–0.82)[b]
Avoidance of pork	Race (white)	0.03	0.45 (0.22–0.92)
Avoidance of high fat foods	Age (increasing)	0.03	0.99 (0.97–1.00)
	Race (white)	0.03	0.53 (0.30–0.93)
Avoidance of sodium	Age (increasing)	0.0008	0.97 (0.95–0.99)
	Race (white)	0.03	0.45 (0.22–0.93)
Avoidance of white flour	Age (increasing)	0.03	0.98 (0.96–0.998)
	Positive of celiac disease	0.005	4.3 (1.5–11.9)[c]
Avoidance of caffeine	Severe psoriasis	0.004	2.30 (1.30–4.00)[d]
Avoidance of alcohol	Age	0.0001	0.97 (0.95–0.98)
Addition of fruits	Race (white)	<0.0001	0.22 (0.11–0.45)
	Positive family history of psoriasis	0.04	1.76 (1.03–3.0)[e]

[a] OR of patient-perceived favorable response with increasing age
[b] OR of patient-perceived favorable response in white race vs. non-white race
[c] OR of patient-perceived favorable response in individuals with celiac disease vs. individuals without celiac disease
[d] OR of patient-perceived favorable response in severe psoriasis vs. mild/moderate psoriasis
[e] OR of patient-perceived favorable response in patients with positive family history vs. negative family history of psoriasis

speaking with a dermatologist regarding diet is particularly important ($p < 0.001$). The groups did not significantly differ in sex, education level, living environment, income level, and prevalence of family history of psoriasis.

DISCUSSION

Relative Daily Consumption in Psoriasis vs. Control Group

Compared to the NHANES 2009–2010 control dataset, the psoriasis cohort presented here consumed less sugar, whole grain fiber, dairy, and calcium, while consuming more fruits and vegetables. These differences may be attributable to psoriasis patients following recommendations in the popular literature, which suggests that sugar, gluten, and dairy may serve as triggers, while fruits and vegetables have health benefits. Individuals participating in our survey may have had greater interest in the topic of diet and therefore engaged in these dietary changes. This is supported by 86% of respondents reporting a history of using some form of dietary modification, and almost half of respondents reported reducing gluten. The lower sugar intake observed in our cohort is consistent with findings of another study using the NHANES data where psoriasis patients reported decreased sugar intake compared to healthy controls [23].

Reported Triggers and Helpful Additives

The most common psoriasis triggers reported by respondents were sugar, alcohol, nightshades, and gluten. The mechanism of how each of these triggers may induce or exacerbate psoriasis is unclear. However, prior studies have

Table 7 Attitudes surrounding diet as management strategy for psoriasis

Questions and responses	*n* (%)
Currently, what role is diet playing in managing your skin condition?	
Skin condition completely controlled by diet	27 (2.2)
Diet is helping significantly with skin condition	201 (16.7)
Diet is helping slightly with skin condition	210 (17.4)
Diet has no effect on skin condition	200 (16.6)
Not sure how diet affects skin condition	521 (43.2)
Other	47 (3.9)
How difficult/burdensome is it to follow a special diet?	
Very difficult	226 (18.7)
Somewhat difficult	473 (39.2)
Not difficult	324 (26.9)
Not applicable	183 (15.2)
What difficulties did you encounter in modifying your diet?	
Will power/too limiting	237 (36.5)
Time/inconvenience	113 (17.4)
Family/social pressures	88 (13.6)
Dining out/travel	88 (13.6)
Affordability	74 (11.4)
Access	48 (7.4)
How important is it that physicians discuss with patients the role of diet in managing skin disease?	
Very important	781 (64.8)
Somewhat important	290 (24)
Minimally important	102 (8.5)
Not important at all	33 (2.7)

implicated these dietary components in causing alterations in the intestinal microbiome composition, irritating the intestinal lining, and upregulation of the immune system. Evidence suggests that dietary simple sugars lead to dysbiosis of the gut microbiome favoring injurious bacterial taxa and an increase in inflammatory cytokines [24–35]. Alternatively, complex carbohydrates with high fiber, such as those found in fruits and vegetables, have been found to have an opposite effect on the gut microbiome and reduce inflammation [36–43].

An increase in inflammatory cytokines may also explain the link between alcohol and psoriasis. Excessive alcohol intake has been associated with the development of psoriasis and is correlated with psoriasis severity [44, 45]. Proposed mechanisms for the interaction of alcohol in psoriasis include enhancement of mitogen-driven lymphocyte proliferation and upregulation of pro-inflammatory cytokines [46, 47].

In addition to upregulation of inflammatory cytokines, factors proposed to disturb the intestinal lining, such as nightshades, may also contribute to the exacerbation of immune-related disorders. Nightshades are part of a plant family called Solanaceae, which includes tomato, potato, eggplant, tobacco, pepper, and petunia, and have been found to affect digestion and absorption of nutrients in humans and animals [48]. Nightshades produce alkaloids, which have been shown to adversely affect the mammalian intestine and to aggravate inflammatory bowel disease (a common comorbidity in psoriasis patients) in the murine model [49].

Several studies have documented celiac disease and psoriasis coexistence and the improvement of psoriatic lesions after starting a GFD [11, 12, 50]. The benefit of GFD has been shown to extend to patients who are antigliadin antibody-positive but without clinical and histological markers of celiac disease [13–15]. These findings explain both a common trigger among respondents in this study being gluten and a patient-reported improvement of their psoriasis following a GFD.

While some dietary elements are posited to trigger psoriasis, other foods have been suggested to improve disease symptoms. The most commonly reported include fish oil/omega-3 polyunsaturated fatty acids (PUFAs), fruits and vegetables, vitamin D supplementation, and probiotics. A systematic review identified 15 trials evaluating fish oil supplementation and found an overall moderate reduction in

psoriasis symptoms [51]. There was moderate evidence of benefit for the use of fish oil supplements in psoriasis among twelve trials (six controlled, six uncontrolled) [52–63] and three trials (two controlled, one uncontrolled) showing no benefit [64–66]. PUFAs are thought to reduce the conversion of free arachadonic acids to leukotriene B4, which is elevated in psoriatic lesions [67, 68]. Additionally, PUFAs reduce the production of tumor necrosis factor (TNF)-alpha, interleukin (IL)-1β, and IL-1α in healthy adults and rheumatoid arthritis patients [69–72].

Previous cross-sectional, case–control, and case studies have suggested an inverse relationship between psoriasis and fruits and vegetable intake [73–76]. Fruits and vegetables provide a wealth of antioxidants such as carotenoids, flavenoids, vitamins, and minerals that have been inversely correlated with TNF-alpha, C-reactive protein (CRP), and IL-6 [77–79]. Vitamin D may have antiproliferative and immunomodulatory effects. Among clinical studies, data on vitamin D supplementation have been equivocal. A systematic review identified significant improvements in psoriasis area severity index (PASI) score following oral vitamin D supplementation in eight uncontrolled studies; however, one RCT demonstrated only a slight, statistically insignificant improvement [51, 80–87]. Probiotics aim to restore balance to the host gut microbiome; however, current evidence regarding the role of probiotics in psoriasis is limited. An RCT of oral probiotics in spondyloarthritis patients, including those with psoriasis and psoriatic arthritis, found no significant change in disease severity [88]. The true effect of probiotics may be influenced by factors such as probiotic composition, dose, route of administration and interaction with dietary habits.

Special Diets

Survey respondents self-reported appreciable symptom improvement with Mediterranean, Pagano, Paleolithic, vegan, gluten-free, and low carbohydrate–high protein diets. A case report documented significant improvement in psoriasis lesions in all five patients following a 6-month diet regimen analogous to the Pagano diet, which entails an increase in fruits and vegetables and a decrease in nightshades and junk food among various other recommendations [75, 89]. An observational study found improvement in a subset of psoriasis patients following a 2-week fast and a subsequent 3-week vegetarian diet [90]. Additionally, in patients with rheumatoid arthritis and atopic dermatitis, vegan and vegetarian diets have been shown to alleviate symptoms and promote weight loss, which may decrease adipocyte-mediated inflammation [91, 92]. Similarly, many respondents reported concomitant weight loss with a trial of special diets, possibly contributing to the reported benefits. A case–control study of mild-to-severe psoriasis found extra virgin olive oil and fish oil, typical components of a Mediterranean diet, to decrease PASI scores and CRP levels [93]. In addition to improvement in psoriatic lesions, many of these diets are also advantageous in improving the cardiometabolic profile of patients with psoriasis, as many respondents reported a benefit of overall health as the motivation behind attempting dietary changes. Evidence suggests that the Mediterranean and Paleolithic diets can reduce the risk of cardiometabolic comorbidities in psoriasis, which are a predominant cause of reduced life expectancy and an important aspect of disease management [94–97].

Demographic Variables Associated with Dietary Changes

Favorable dietary changes were more commonly reported in respondents who were younger, non-white, and positive for celiac disease. Chronic inflammation has been shown to be a characteristic of an aging immune system; specifically, evidence has shown an increase in cytokines and inflammatory markers in older compared to younger adults [98–101]. One can speculate that the possible increase in baseline inflammation in older subjects could dampen the anti-inflammatory influences of dietary changes.

The association of non-white race with a favorable response to dietary changes was

intriguing. The effect of race could relate to genetics or the environment or both. Several studies have reported racial and ethnic variations in genes implicated in the pathogenesis of psoriasis [102]. These differences in immunological-related genes may result in variations in response to environmental insults such as diet.

Removal of gluten from the diet in patients with celiac disease had a beneficial effect in our survey respondents, which parallels findings from other studies [11, 50]. Interestingly, celiac patients in our study tended to rank diet as more important for controlling their psoriasis than prescription, over-the-counter, and complementary medications.

Demographic Variables Associated with Attitudes and Perceptions

Managing psoriasis using dietary interventions was viewed as more important by respondents who were younger and those self-reporting mild/moderate disease activity. However, respondents who report having severe psoriasis were more prone to discuss dietary changes with their dermatologist, likely reflecting information-seeking behavior due to the severity of their disease. Difficulty with following a diet was more likely to be reported by respondents who were younger, female and with psoriatic arthritis. Factors underlying this association include the cost and labor involved in purchasing and preparing healthier meals, as well as the physical burden of cooking among those with psoriatic arthritis.

Cluster Analysis

Results from the cluster analysis identified two distinct clusters of patients based on dietary behavior. Cluster 1 was composed of older patients with higher BMI who engaged in broad dietary changes aligned with achieving global health and minimizing cardiovascular and/or cancer risk (e.g., avoidance of red meat, pork, sodium, high fat foods, caffeine, alcohol and tobacco and the addition of fruits, vegetables organic foods, probiotics, fish and vitamin D). Cluster 2 was composed of younger patients who selectively avoided or minimized specific foods from their diet (e.g., gluten, white flour, junk food, and shellfish). These patients may approach dietary change with the intention of reducing dietary triggers of their psoriasis and may be less concerned with diets involving improved global health and cardiovascular risk. Given the increased cardiovascular risk in patients with psoriasis, all patients should be counseled on the importance of sustaining a healthy overall diet in light of their increased risk for cardiovascular disease, while also considering dietary habits that may improve their skin condition.

Limitations

Study limitations include the potential for responder bias and a predominance of female gender, white race, respondents with moderate to severe disease, and urban-living respondents, restricting generalizability. Time lapse may be a concern in that the NPF psoriasis data were collected in 2014 while control data were collected in 2010. Substantial changes in diet have not been reported from the 2010 to 2014 NHANES dataset, suggesting a valid comparison of the two nutrition datasets. An article search also did not identify any dietary trends or changes based on NHANES datasets from 2010 to 2014.

Additionally, limitations of the survey instrument include lack of validation for part two of the survey. Duration of dietary modifications was not assessed, neither were the quantitative reduction nor addition of the specific dietary modification, all of which may be contributing factors to the variation in skin responses reported among respondents. However, the study purpose was not to provide evidence-based guidelines, rather the information presented is primarily to understand the role of diet in managing psoriasis among a large cohort of psoriasis patients.

CONCLUSIONS

This is the first study to better understand the patient experience regarding the role of diet in the management of psoriasis. Importantly, the

majority of respondents report the motivation for trialing dietary modifications is to improve their overall health. Therefore, when discussing with patients interested in dietary management of their psoriasis, physicians can use this opportunity to encourage dietary changes with the intention of benefiting both psoriatic lesions and the cardiometabolic risk factors associated with psoriasis. Future prospective RCTs are needed to identify and validate optimal dietary interventions for psoriasis as well as the length of intervention needed to yield results.

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Compliance with Ethics Guidelines. All procedures followed were in accordance with the ethical standards of University of California, San Francisco Institutional Review Board, and with the Helsinki Declaration of 1964, as revised in 2013. Informed consent was obtained from all patients for being included in the study.

Data Availability. Some data generated or analyzed during this study are included in this published article/as supplementary information files. All other datasets generated during and/or analyzed during the current study are available from the corresponding author on request.

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