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Review Article

Role of dietary intervention in the management of selected skin diseases: A systematic review

Vrusha K. Shah, MPH[1], Theresa Tran, MD[2], Selina J. Chang, BS[1], Alana Sadur, BS[3], Peter A. Lio, MD[4], Sonal Choudhary, MD[5]

[1] Dermatology, University of Pittsburgh Medical Center, [2] Dermatology, Temple University Hospital, [3] Dermatology, George Washington University School of Medicine and Health Sciences, [4] Dermatology, Northwestern University Feinberg School of Medicine, [5] Dermatology, University of Pittsburgh Medical Cente

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Relevance

Dietary intervention in the management of skin disease is underutilized in medical practice and could be a means for patients to optimize skin health as well as overall physical and mental well-being. Summarizing existing literature can serve as a catalyst to increase research efforts focusing on dietary intervention and skin disease management which may inform the way dermatologists provide care to their patients.

Objective

Dietary intervention is a commonly used option to improve physical and mental health with many evidence-based associations in improving prognoses of diabetes, high cholesterol, high blood pressure, depression, among many other conditions. The role of dietary intervention in the management of skin disease remains limited. Understanding its role may improve the options for care dermatologists may provide to their patients.

Methods

A systematic search of PubMed, EMBASE, and Cochrane Central Registrar between January 1st, 1985 and December 31st, 2023 was conducted. Studies included were case reports, clinical trials, controlled studies, comparative studies, systematic reviews, and meta-analyses. Review papers were excluded.

Results

Results showed that dietary intervention improves symptom severity among atopic dermatitis, acne, hidradenitis suppurativa, and psoriasis patients.

Conclusion

While data shows positive associations between use of dietary intervention and decrease in symptom severity, future small and large-cohort randomized controlled trials with placebo and intervention groups are warranted.

INTRODUCTION

Dietary choices have profound effects on overall health. Beyond supplying the body with nutrients including proteins, vitamins, and minerals, nutrition is now considered an important factor for influencing disease risk, triggering health conditions, and offering medicinal and protective qualities.[1] In medicine, evidence-based nutritional advice is part of the gold standard for common diseases such as obesity, diabetes mellitus, hyperlipidemia, and coronary heart disease.[2] However, the impact of nutrition on the progression of dermatological diseases is not similarly regarded as dietary modifications have been underappreciated in terms of dermatological disease therapy. Recent studies, however, have uncovered significant evidence that well-substantiated dietary interventions can influence the course of skin diseases. In learning more about these nutritional recommendations, dermatologists can be more comprehensive in their treatment recommendations to better care for their patients.

On the macro level, the GI tract absorbs nutrients from food, and the circulatory system passes them on to other parts of the body. On the micro level, the gut hosts microbiota comprising prokaryotic and eukaryotic symbiotic microorganisms which support the host in terms of metabolic and immune function. They can metabolize indigestible complex polysaccharides into essential nutrients, protect the host by maintaining the gut's epithelial barrier integrity, and influence immune system development.[3-6] Communication between the microbiota and the host is important for preventing harm to the host, which includes

preventing tissue-damaging inflammatory responses and avoiding infection or uncontrolled growth.[3] Communication is possible via hormone-like compounds produced by the microbiota: short chain fatty acids (SCFAs), secondary bile acids, cortisol, and neurotransmitters including gamma-aminobutyric acid (GABA), serotonin, dopamine, and tryptophan.[7-9] These compounds can locally affect the intestinal mucosal barrier, enter the bloodstream, and thus can impose systemic effects at distant organs and systems as well. These compounds, interacting with skin receptors, can consequently directly affect the skin or modify the skin's commensal bacteria.[7]

The gut and skin are connected through the systemic circulation, where these two systems can communicate via the diet, microbial metabolites, the immune system, neuroendocrine pathways, and the central nervous system. The skin-gut axis is termed from the gut and skin communicating with one another via these gut microbiota metabolite products.[10] Host lifestyle factors including diet and hygiene can impact the proportions of commensal microbiota strains and disrupt mucosal immunological tolerance.[10] If the gut microbiota is perturbed, the quantity of microbial products can change and impact the host accordingly.[10-12] Therefore, an imbalance in gut microbiome, termed intestinal dysbiosis, can affect skin function and integrity through their metabolic activity and immunological impact.[13-15] The dysbiotic state is characterized by an impaired gut barrier, including an imbalanced gut microbiome, reduced mucus layer, intestinal permeation into the bloodstream, and gut inflammation.[8] Specifically, certain neurotransmitters such as GABA, dopamine, serotonin, acetylcholine, as well as short chain fatty acids such as butyrate have important effects such as creation of a robust intestinal barrier with decreased permeability. Absorption of short chain fatty acids is dependent on intake of fiber, intestinal absorptive capacity, and fermentation rate of microbes.[10] Compromise of these factors can lead to decreased short chain fatty acid absorption and decreased epithelial barrier strength. Molecules with potential modulatory effect on the skin and gut are summarized in Table 1. Additionally, dysbiosis leading to inflammatory skin disease is seen in conditions such as acne vulgaris where a decrease in Firmicutes and an increase in Bacteroides bacteria is observed per literature.[10]

Dietary changes play a role in consequent modulation of the gut microbiome, hormonal changes, and neurotransmitter activity which can lead to a wide variety of dermatological disorders, systemic disease, and health outcomes. In regard to alterations of gut microbiome, with nutrient deficiencies, dermatological manifestations are familiar. For example, inadequate protein intake can result in Kwashiorkor, an exfoliative erythroderma dermatitis, while vitamin B3 deficiency, or Pellagra, can lead to a photo-distributed dermatitis.[32] Conversely, nutrient excess may also elicit dermatological manifestations. For example, hypervitaminosis A can manifest with xerosis, cheilitis, and alopecia while insulin resistance and hyperinsulinemia can present as acanthosis nigricans and skin tags.[33] In some cases, dietary interventions may even serve as an aspect of prevention. Alpha-lipoic acid, found in certain meats and vegetables, can prevent glycation seen in the aging process, and a diet rich in fruits and vegetables can reduce the risk of cancer.[34]

In this article, we review common skin disorders and the current literature on the effect of different diets and offer evidence-based nutritional guidance for the everyday practicing dermatologist. The reviewed skin disorders, including acne, atopic dermatitis, hidradenitis suppurativa, and psoriasis are the most common skin conditions clinicians treat.

METHODS

A systematic search of PubMed, EMBASE, and Cochrane Central Registrar was conducted between January 1st, 1985 and December 31st 2023 to identify studies to treat dietary intervention among different diseases. Search terms broadly included the disease of interest ("acne," "hidradenitis suppurativa," "psoriasis," "atopic dermatitis" [OR] "eczema") [AND] ("gut," "diet," "supplement," "inflammation"). Case reports, clinical trials, controlled studies, comparative studies, systematic reviews, and meta-analyses were included. After abstract and title review followed by full-text article review, 46, 9, 39, and 10 articles in the English language were included for acne, hidradenitis suppurativa, psoriasis, and atopic dermatitis respectively. Systematic reviews and meta-analyses were included for reference review. PRISMA flow diagrams for acne, hidradenitis suppurativa, psoriasis, and atopic dermatitis can be seen in Figures 1-4. Level of evidence for included studies was defined as I: systematic reviews of randomized controlled trials, II: RCTs or observational studies with dramatic effect, III: non-randomized controlled cohort/follow-up studies, IV: case series, case-control studies, or historically controlled studies, and V: mechanism-based reasoning. This systematic review did not require IRB approval. The study is registered with PROSPERO and followed PRISMA guidelines.

RESULTS & DISCUSSION

ACNE VULGARIS

Acne vulgaris, a chronic inflammatory skin disease affecting 85% of adolescent individuals globally is influenced by hormonal factors, genetics, diet, stress, and environmental factors. Notably, the prevalence of this dermatological disease can vary across different regions and populations with studies showing increased prevalence and incidence in westernized versus non-westernized societies.[35,36]

ROLE OF DYSBIOSIS WITHIN THIS DISEASE

On the skin surface, disruption of the normal skin flora can contribute to acne pathogenesis. However when looking at the gut-skin axis, increased intestinal permeability and disruptions in the gut microbiota can lead to acne through systemic inflammation.[37] Stress disturbs eubiosis,

Table 1. Cutaneous Effects of Important Dietary Metabolites and Components

Molecule	Source	Documented/ Possible effect on skin
Bacterial metabolites		
SCFAs (short chain fatty acids)	From fermentation of dietary complex carbohydrates by colonic bacteria	Anti-inflammatory effects; promotes keratinocyte differentiation[14,16]
Gamma-aminobutyric acid (GABA)	Bacterial by-product	Anti-itch, anti-inflammatory, anti-allergy[11,12,17,18]
Dopamine	Bacterial by-product	Inhibits human hair growth[12,19]
Phenol and p-cresol	Metabolites of aromatic amino acids produced by colonic bacteria	Disrupts skin barrier integrity and epidermal differentiation, reduces skin hydration, disrupts keratinization[20]
Serotonin		Anti-inflammatory[11]
Dietary components		
Catechins: a polyphenol compound	Green tea	Anti-inflammatory, reductions in pro-inflammatory eicosanoids, novel therapeutics for treatment of melanoma[21-24]
Polyphenols: chemical compounds found naturally in plants. Protect plants from damage caused by ultraviolet radiation from the sun. These are poorly absorbed from the small intestine, and therefore accumulate in the large intestine. Polyphenols then catalyze changes in the gut microbiome that lead to significantly lower levels of inflammation.	Strawberries, blueberries, plums, cherries, apples, black currants, black olives, dark chocolate, black tea, coffee, hazelnuts, pecans, turmeric, cloves, cinnamon, ginger, cumin	Anti-inflammation, anti-oxidant[25,26]
Lycopene	Tomatoes	Protection against photodamage[27,28]
Alpha-lipoic acid	Organ meat (liver, kidney), broccoli, spinach, tomatoes, brussels sprouts, rice bran	Antioxidant, Anti-aging[29,30]
Prolamin	Wheat, rye, barley	Protection against atopic dermatitis[31]

and bacteria *Lactobacillus* and *Bifidobacterium* are particularly sensitive to its effect.[38] Notably, acne patients have increased ratios of *Firmicutes* to *Bacteroides*, with overall decreased levels of *Actinobacteria* and *Proteobacteria* compared to healthy individuals.[38-40] The gut microbiota can affect the metabolism and regulation of hormones, including sex hormones that play a role in acne.[40] There is also a noted gender difference between male and female acne patients and their gut microbiota.[41]

The systematic review search revealed many cross-sectional studies which used questionnaires to assess diet and its impact on acne in populations such as Turkey, China, Korea, Italy, India, USA, Pakistan, and Norway. A systematic review of diet and acne shows acne being linked to diet. While overall positive associations exist between acne and familial dysmetabolism, high body mass indices, and family history of acne, further research is needed to evaluate the true impact of diet on acne.[42,43] A systematic review consisting of 34 articles concluded that a high glycemic index diet and high glycemic load was positively associated with increased acne severity.[44] Diets rich in refined carbohydrates, saturated fat, and trans-fats stimulate the synthesis of sebum triglycerides, promoting the growth of *C. acnes* and cytokines and therefore promoting comedogenesis.[44] Milk consumption has also shown association with acne onset and or aggravation likely attributable to either its high-glycemic index or high insulin index.[45,46] Whey protein has also been seen to worsen acne severity, and increase incidence.[47-49]

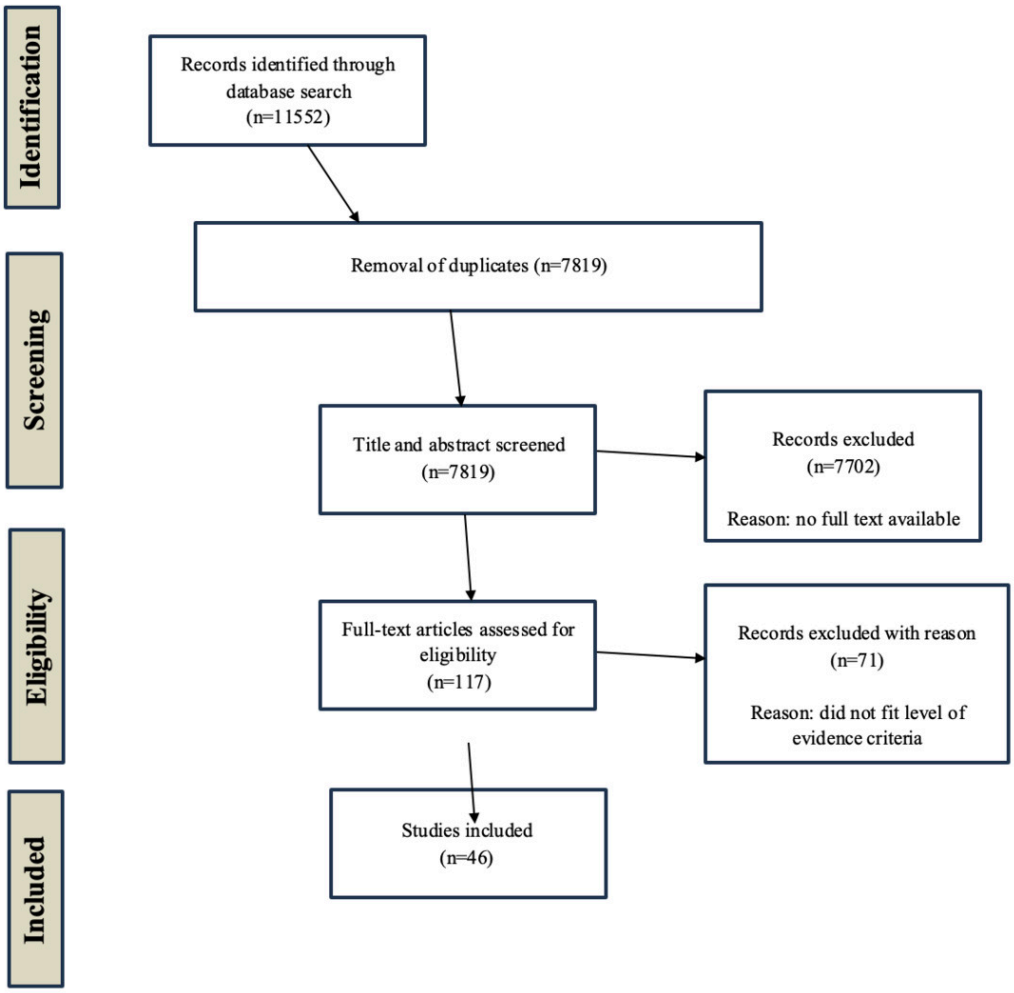

Figure 1. PRISMA flow diagram for acne studies

DIETS

LOW-GLYCEMIC INDEX DIET

With the positive association of high glycemic index, diets and acne, several studies have evaluated the impact of a low-glycemic index diet on acne. These studies have shown significant reductions in noninflammatory and inflammatory lesion counts, smaller sebaceous glands, decreased inflammation, and reduced acne severity grading.[50-54]

MEDITERRANEAN DIET

Diets such as the Mediterranean diet, emphasize consumption of components such as fish and olive oil which contain omega-3 fatty acids, vegetables such as leafy greens, fruits, nuts, whole grains with a moderate consumption of dairy products as well as a decreased consumption of red meat and processed foods. Omega-3 fatty acids show a protective effect towards acne with an association with decreased sebum production and inhibition of inflammatory cytokines, reducing inflammatory acne lesions.[35,55-58] An epidemiological study found that participants who consumed large amounts of fish and seafood, rich in omega-3 fatty acids, had less oily skin and fewer acne lesions.[35]

SUPPLEMENTS

OMEGA-3 FATTY ACIDS/FISH OIL

Based on how omega-3 fatty acids as a part of the Mediterranean diet are associated with less acneiform lesions, it can be theorized that fish oil supplements, rich in omega-3 fatty acids, may be beneficial for acne. However, only a few studies have been conducted to evaluate this effect. Smaller studies have concluded moderate improvement in acne lesions with supplementation, however the efficacy of fish oil supplementation may depend on the acne severity.[59-61]

PROBIOTICS

In addition, when looking at the gut-skin axis, the use of probiotics as a potential therapy has been considered. The clinical trials completed with oral probiotics have shown positive results.[38-42,62] Oral probiotics are theorized to modify the intestinal microbiota, generating an anti-inflammatory response and restoring intestinal integrity, or

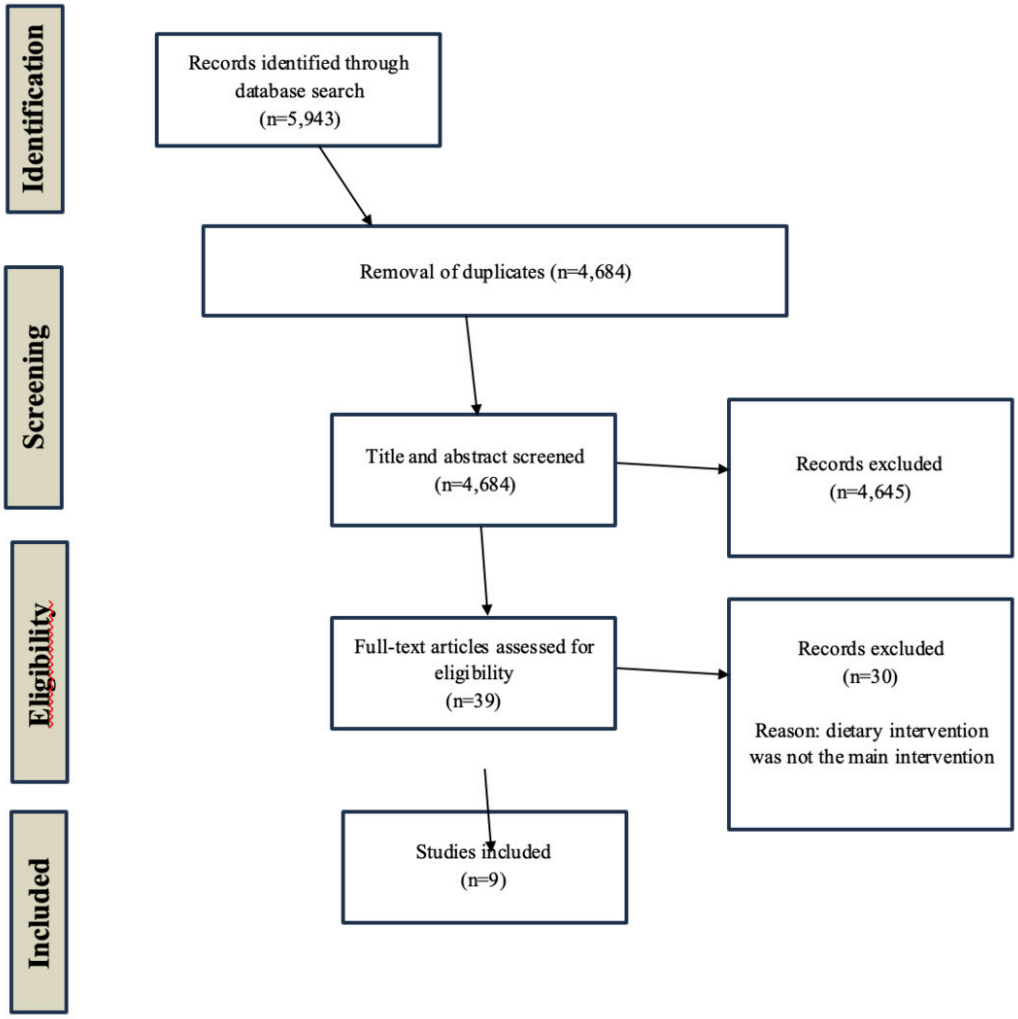

Figure 2. PRISMA flow diagram for hidradenitis suppurativa studies

through metabolic pathways involving insulin-like growth factor I (IGF-1).[63-68] A few specific strains shown to be associated with improvement in acne symptom severity include *Lactobacillus rhamnosus*, *Lactobacillus plantarum*, and *Lactobacillus reuteri*.[64-66,68]

OTHER SUPPLEMENTS

There have also been several randomized controlled trials which evaluate other supplements. Chan et al evaluates lactoferrin with vitamin E and zinc supplementation, which was seen to reduce acneiform lesion counts.[69] Tolino et al evaluated a combination of probiotics, vitamin E, zinc, and nicotinamide with either male or female formulations, which also had significant response.[70] Other supplements studied include vitamin D, vitamin A, berberis vulgaris fruit extract, magnesium, phosphate, herbal syrups, coenzyme Q10, green tea extract, sunflower seeds, soy isoflavones, and more.[71-80] (See Table 2)

HIDRADENITIS SUPPURATIVA

Hidradenitis suppurativa (HS), also known as acne inversa, is a chronic inflammatory skin disorder that causes skin abscesses and sinus tracts in intertriginous regions and has a poorly understood mechanism. HS can cause significant pain, disfigurement, and unpleasant odor, frequently resulting in social isolation and diminished quality of life.[81-84]

HIDRADENITIS SUPPURATIVA AND DYSBIOSIS

Numerous research studies have sought to characterize the cutaneous microbiome in individuals with HS. A systematic review conducted in 2022 identified several studies revealing common patterns, such as an overgrowth of anaerobic bacteria and a reduction in skin commensals, which typically exhibit antimicrobial properties. Two prevalent bacterial skin species, *Staphylococcus aureus* and *Streptococcus pyogenes*, did not seem to play a role in HS.[85] The increased abundance of anaerobic species, such as *Prevotella* or *Porphyromonas*, has been suggested as a potential contributor to HS pathogenesis by promoting the upregulation of antimicrobial peptide secretion (AMP), inducing keratinocyte proliferation and subsequent recruitment of neutrophils and macrophages. This sequence of events may lead to heightened follicular occlusion and increased levels of TNFα.[86]

Table 2. Acne Vulgaris Studies

Study Reference	Level of Evidence	Design Description	Intervention/exposure and comparison group (if applicable)	Main outcome measures	Results/Data pertaining to Acne	Discussion
19	IV	Case study of 5 patients with mild to moderate acne vulgaris	Daily dietary supplementation of 250 mg of EPA obtained from sardines and anchovies, 3.75 mg of zinc gluconate, 50 mcg of selenium, 50 mcg of chromium and 50 mg of EGCG from green tea extract for 2 months	Total lesions count; inflammatory lesions count	Both average total and inflammatory lesion counts decreased significantly	Dietary supplementation with PUFAs may improve acne lesion count
20	II	Observational study of 1200 Kitavan patients		Acne incidence and prevalence	Of the 1200 Kitavan subjects, no cases of acne were observed. Of 115 Aché subjects, over 843 days, no case of acne were observed	The incidence of acne between nonwesternized and westernized societies can have a genetic difference, however Ache and Kitavan diets also differ from typical Western high-glycemic diets in that they are composed of minimally processed plant and animal foods. Low-glycemic load dietary interventions may have therapeutic potential in treating acne
21	IV	Case-control study to assess gut microbiota of 8 acne patients	Oral minocycline	DNA extracted from stool samples and facial skin swabs before and after minocycline treatment	After minocycline treatment, patients had a decreased Firmicutes to Bacteroides ratio	Minocycline induces gut and skin microbiota derangements
22	IV	Case-control study on 43 acne patients with matched controls		Intestinal microbiota	Acne patients have lower Firmicutes and higher Bacteroidiain microbials	Acne patients have gut microbial dysbiosis
23	IV	Case-control study on 8 acne patients with 8 matched controls	Minocycline	Bacterial community profiling	A lower Firmicutes to Bacteroides ratio was associated with a Western diet and with acne; the ratio was significantly reduced following antibiotics in the Asian population	Race and diet have a significant impact on the Firmicutes to Bacteroides ratio in acne patients taking antibiotics
24	IV	Case-control of 31 acne patients with		Gut microbiota evaluation through 16S RNA Sequencing	In acne patients, Actinobacteria is decreased and	Shows a link between gut microbiota changes and acne risk

		31 controls			Proteobacteria is increased	
25	IV	Cross-sectional, case-control study of 43 acne patients and 43 matched controls		Gut microbiota analysis of 16SrDNA and microbial metabolites	Men with acne had lower abundance of 18 types of microbes, and had disordered metabolism of fatty acids. Female acne patients had increased Clostridium and declined Oscillibacter and Odoribacterin, and showed dysbiosis of amino acid metabolism	Gut dysbiosis in acne patients are gender-specific
26	I	Systematic review of 53 articles meeting eligibility criteria			There is growing interest in acne and diet, with acne-promoting factors to include high glycemic index/load foods, dairy, fatty foods, and chocolate	Further research is needed for a more comprehensive outline of the effect of diet on acne
27	I	Systematic review of acne epidemiology, distribution, and causes on Medline and Embase to the end of November 2011			Acne is associated with pre-puberty, a positive family history, and a possible association between dairy food intake and diet	
28	I	Of 410 articles in the literature search, 34 articles met the inclusion criteria in the literature search			High glycemic index and load was positively associated with increased acne severity	Increased carbohydrate intake and higher glycemic load and index have increased acnegenic effect.
29	II	Randomized cross-over	Daily whole milk or low-fat milk	Plasma hormone levels	Mongolian children had higher growth hormone	Milk intake may stimulate endogenous growth hormone

		study of 46 children in Ulaanbaatar and 28 children in Boston			levels	production
30	I	Systematic review, meta-analysis of 14 studies consisting of 78,529 patients, including 23,046 acne patients and 55,483 controls			Increased risk for acne was seen with full-fat dairy, any milk, whole milk, low-fat/skim milk, cheese, and yogurt consumption	Any dairy is associated with an increased odds ratio for acne
31	IV	Case reports of 5 male patients	Stopping whey protein supplementation	Total acneiform lesions	Acneiform lesions cleared in 4 patients after discontinuation of whey protein	Whey protein may promote acne formation
32	II	Observational study of 30 patients	Protein calorie supplements	Onset or exacerbation of acneiform lesions	Those consuming protein calorie supplements, specifically Whey protein extract, had a significant onset of acneiform lesions	This type of supplementation may worsen acne
33	IV	Case series of 6 patients	Whey protein exposure	Acne lesion count	These patients developed truncal acne after consumption of whey protein	This trending supplement may be related to truncal acne
34	II	Randomized controlled cohort study of 43 male acne patients	Low glycemic-index load diet	Acneiform lesion count, insulin sensitivity, androgen and testosterone levels	Experimental diet resulted in greater reduction in weight, less total acne lesion counts, and improved insulin sensitivity	A low-glycemic-load diet can improve acne and insulin sensitivity
35	II	Randomized controlled trial of 43 male acne	Low glycemic-index load diet with the control group having a high glycemic-load diet	Changes in lesion counts, sex hormone binding globulin, free androgen index, insulin-like growth	Experimental diet resulted in reduced weight, reduced free androgen index, and	Nutrition-related lifestyle factors help in acne pathogenesis

		patients		factor-I, and insulin-like growth factor binding proteins	increased insulin-like growth factor binding protein	
36	II	Randomized controlled trial of 32 mild to moderate acne patients with a low glycemic load diet	Histopathological examination of skin samples		Experimental diet showed significant improvement in the number of acne lesions, reduced inflammation, and reduced sebaceous gland size	Reduction in glycemic load diet can lead to improvements in acne
37	II	Observational study with 2,995 respondents		41-item, IRB-approved, anonymous, web-based questionnaire to assess low glycemic South Beach, Florida diet	Most patients noted improvements in their acne condition within 3 months of starting the low-glycemic South Beach, Florida diet	The South Beach Diet could be an additional modality in which to treat acne
38	II	Randomized trial of 58 adolescent males.	High or Low glycemic index diets.	Severity of facial inflammatory lesions, body mass index	Differences between the groups were not significant during the 8-week period	A longer time frame and or weight loss may be necessary to further evaluate acne among adolescent males
39	IV	Case control study of 93 cases and 200 controls		Food-frequency questionnaire	Mediterranean diet showed protective effects against acne; familial hypercholesterolemia, diabetes, and hypertension are strong risk factors for acne	Acne patients were more likely to have familial dysmetabolism history. The Mediterranean diet may play a role in the pathogenesis of acne
40	IV	Case-control study of 40 acne patients and 40 control patients	Adherence to the Mediterranean diet	Global evaluation acne severity score, and PREDIMED (Prevención con Dieta Mediterránea) questionnaire to assess adherence to the Mediterranean diet	Significant negative correlation between the severity of acne and the adherence to Mediterranean diet	It is important to consider a holistic approach for acne management
41	IV	Cross sectional, case control study of 35 patients	Adherence to the Mediterranean diet	IGF-1 serum levels	IGF-1 serum levels were higher in the western diet group compared to the Mediterranean group	The Mediterranean diet can have a protective role in acne pathogenesis through IGF-1

42	IV	Case-control study of 51 acne patients and 51 matched controls		Global acne grading system score, PREDIMED (Prevención con Dieta Mediterránea) questionnaire, and body composition	Higher percentage of acne patients had lower Mediterranean diet adherence scores and higher values of fat mass in their body composition	Diet and body composition may be useful in assessing clinical severity of acne
43	IV	Case-cohort study of 13 males with inflammatory acne	Three capsules of fish oil daily for 12 weeks, which contained a total of 930 mg of EPA, 720 mg DHA, and 174 mg DPA	Total inflammatory lesions counts and acne severity grades were determined using the Allen and Smith grading scale; skin redness data obtained using a Konica Minolta CR-400 colorimeter with the L*a*b* color system as defined by the Commission Internationale de L'Eclairage	Inconclusive results, as eight patients showed improved acne, four patients showed worsened acne, and one patient's acne remained unchanged	Fish oil supplementation to improve acne may be dependent on the initial acne severity
44	II	Randomized, double-blind prospective study of 45 patients with mild to moderate acne	Three groups, one which took 2000 mg of EPA and DHA daily, the second group taking borage oil containing 400 mg GLA daily, and a control group not receiving any treatment for 10 weeks	Inflammatory lesion count and non-inflammatory lesion count	Both treatment groups showed a significant decrease in both inflammatory and non-inflammatory acne lesion count	Moderate doses of omega-3 polyunsaturated fatty acids or gamma-linoleic acids could improve acne lesions
45	I	Systematic review of 38 studies			Report benefits for omega-3 fatty acid supplementation in treatment of acne among other dermatologic disorders	Shows well-studied benefits of omega-3 fatty acid supplementation in dermatology
46	II	RCT of 18 patients in the treatment group, 18 patients in the placebo group	Fermented milk with 200 mg of lactoferrin daily	Acne lesion counts and grade	The lactoferrin group showed improvement with significant decreases in inflammatory lesion count, decreased sebum content specifically surface triacylglycerols	Lactoferrin-enriched fermented milk may help treat acne vulgaris through a mechanism of decreasing surface triacylglycerols
47	II	Prospective, open-label	Treatment group A receiving probiotic supplementation, group B receiving	Clinical and subjective assessments	The treatment group receiving both the	Probiotics in adjunct with antibiotics may provide a synergistic anti-

		randomized study with 45 female participants	minocycline, and group C receiving both probiotic and minocycline		probiotic and the antibiotic had a significant decrease in total lesion counts compared to the other groups at 8 and 12 weeks	inflammatory effect
48		RCT of 20 subjects with acne	Supplementation with the probiotic strain Lactobacillus rhamnosus SP1 compared with placebo group which received a liquid lacking probiotic	Paired skin biopsy analysis for insulin-like growth factor 1, and forkhead box protein O1 gene expression involved in insulin signaling	Patients who had taken the probiotic had improved acneiform lesions compared to the placebo group, and had reduced insulin signaling expression	Supplementation with probiotic strain may improve appearance of adult acne
49	III	Non-randomized controlled cohort study of 30 patients	Supplement composed of biotin and 3 strains of lactic ferments in addition to a topical gel composed of azelaic acid, hydroxy pinacolone retinoate, and α-hydroxy acids	Photographic evaluation; GAGS (Global Acne Grading System) Score; SEBUTAPEtm score to assess seborrhea, measurement of the trans epidermal water loss (TEWL), and TBlue test on saliva to measure oxidative stress	Total reduction in the GAGS, SEBUTAPEtm, and TEWL score	Probiotic supplementation in adjunction with topical therapy may help treat acne
50	II	Randomized clinical trial of 44 subjects	Lactobacillus rhamnosus T12 dietary supplement	Dermatological visual score of acne, and instrumental evaluations including hydration, pH, etc	The Lactobacillus supplement group showed a significant improvement in acne appearance and instrumental skin evaluations	Data supports the use of Lactobacillus containing supplements in diseases such as seborrheic dermatitis and acne
51	I	Systematic review of 697 articles				Further studies are needed to evaluate the full effects of probiotics
52	II	Randomized control study of 14 patients per group	Lactobacillus plantarum CJLP55 ingestion or placebo	Acne lesion count and grade, skin sebum, hydration, pH and surface lipid assessment; Metagenomic DNA analysis on urine extracellular vesicles (reflecting systemic bacterial flora)	Those who ingested the supplement had improved acne lesion count and grade, and decreased sebum triglycerides. The supplement also decreased the Bacteroides: Firmicutes	Dietary supplementation with this Lactobacillus strain was beneficial to the skin and gut microbiomes of acne patients

					ratio	
53	II	Randomized clinical trial with 168 participants	Lactoferrin with vitamin E and zinc	Reduction in the number of acne lesions	The intervention group showed a significant reduction in total lesion count	A twice daily supplement of lactoferrin with vitamin E and zinc may reduce acne lesion count in acne patients
54	II	Randomized clinical trial	Oral supplements contain biotin, probiotic, vitamin E, zinc, nicotinamide with the male formulation containing beta sitosterol and Boswellia serrata, and females containing myo-inositol and folic acid compared to topical cream device containing active plant agents (verbascoside, Ocimum gratissimum) and keratolytic molecules (salicylic acid, gluconolactone, complex alpha-hydroxy acids)	Global acne Grading System (GAGs)	Most patients had significant therapeutic response	An association of oral therapeutic supplementation for mild to moderate acne
55	I	Randomized clinical trial with 100 acne patients and 100 controls	0.25 micrograms of alfacalcidol daily	Serum levels of 25-hydroxy-vitamin D	Serum levels of 25-hydroxy-vitamin D were significantly lower in acne patients and were inversely correlated to acne severity. After the intervention, patients had significantly higher serum levels with decreased inflammatory markers IL6 and TNFα	Acne patients may have vitamin D deficiency, and alfacalcidol supplementation may have a beneficial role in acne treatment
56	I	Meta analysis from 1931 to 2021 regarding use of vitamin A in acne treatment, resulting in 9 studies for review			Of the 9 studies, 8 noted improvement in patients' acne with vitamin A supplementation	Oral vitamin A could serve as a therapy for acne management; however side effects must be considered
57	II	Randomized clinical trial of 49 patients	600 mg dried barberry	Counts of acne lesions, Michaelson's acne severity score	At 4 weeks, acne lesion count and acne severity score declined significantly in the intervention group	Barberry can be considered an effective supplemental treatment for acne patients

58	II	Randomized control study of 257 patients in the treatment arm, and 275 patients in the control arm	Dietary supplementation with magnesium, phosphate, omega 6 (linoleic acid calcium salt - C18:2 fatty acid Ca salt), and omega 7 (palmitoleic acid calcium salt - C16:1 fatty acid Ca salt) compared with controls who took isotretinoin	Acne resolution	All patients who took the dietary supplement reported complete regression of symptoms after 6 months of treatment. In the control group, 68% reported complete resolution of symptoms over the same period	The dietary supplementation can promote better regression and or cure of acne symptoms compared to drugs such as isotretinoin
59	II	Randomized clinical trial of 57 patients in each group	Herbal syrup consisting of Prunus domestica L., Tamarindus indica L., Terminalia chebula L., Ziziphus jujube L., and Cassia fistula (Plum, Jujube, Yellow Myrobalan, Golden Shower, Tamarind, Honey) or placebo	Acne severity index and Cardiff acne disability index	From 6 to 12 weeks, there was a significant reduction in the mean number of comedones in the herbal syrup intervention group	The herbal syrup could be an alternative treatment for acne
60	II	Randomized trial of 36 patients with acne	Treatment group received tretinoin 0.025% cream and once-daily coenzyme Q10 supplementation; placebo group only received tretinoin cream treatment	Serum glutathione peroxidase levels and severity of acne	Administration of coenzyme Q10 with tretinoin cream significantly improved acne severity after 8 weeks compared to tretinoin cream only. Serum glutathione peroxidase levels were not significant	Coenzyme Q10 supplementation may improve acne severity
61	II	Randomized clinical trial of 80 participants	1500 mg of decaffeinated green tea extract, or placebo of cellulose daily	Inflammatory lesion counts, fasting glucose levels, and lipid profile	No significant differences between the groups for total lesion counts, however improved acne lesion counts on the nose, perioral area, and chin in the treatment group	Green tea extract may improve lesion counts in certain areas, however more research is needed for total benefit of green tea extract on acne
62	II	Randomized controlled trial of 40 acne patients	Intervention group consumed 25 g sunflower-containing food daily for 7 days, control group were asked to stop eating sunflower seeds	10% increase/decrease in baseline acne severity index	Global acne grading score was not significantly different between groups. A majority of those taking the sunflower food supplement had at least a 10% increase in baseline acne severity	Sunflower seed intake may worsen acne severity

663	II	Randomized test of 25 patients	5 groups: isoflavones 40 mg, 80 mg, 120 mg, 160 mg and placebo, and treated for 4 weeks	Acne lesions	There was significant difference in acne lesions when comparing pre and post-treatment in groups receiving isoflavone supplementation	Soy isoflavones supplementation can lower total acneiform lesions
64	II	Randomized test of 40 patients	2 groups, placebo group and 160 mgs of isoflavone group	Acne lesions	There was significant difference after treatment with 160 mgs of isoflavone compared to placebo	Supplementation with 160 mg of soybean isoflavone can reduce total acneiform lesions

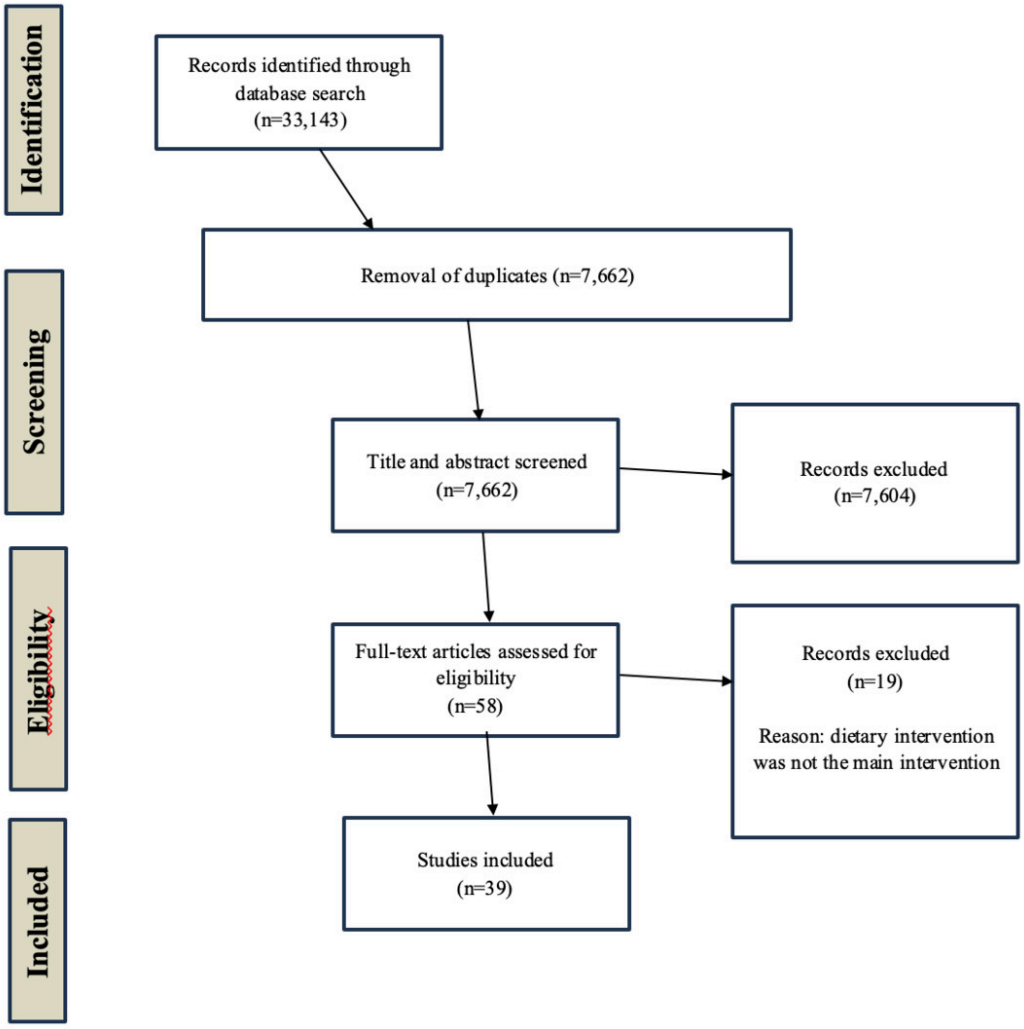

Figure 3. PRISMA flow diagram for psoriasis studies

Changes in gut microbiomes may stimulate inflammation and modify immune responses in HS. HS has been correlated with an elevated risk of inflammatory bowel disease.[87] In a 2022 study, McCarthy et al reported an increased presence of *Ruminococcus gnavus* in the fecal microbiome of HS patients compared to controls. Notably, *R. gnavus* is also more prevalent in individuals with Crohn's disease, suggesting a potential link between the diseases through shared alterations in microbiota.[88]

HIDRADENITIS SUPPURATIVA AND DIETS

OBESITY AND METABOLIC SYNDROME

Elevated rates of obesity and metabolic syndrome are reported among HS patients, with higher BMI correlated with more severe disease activity.[82,89,90] The connection between obesity and HS is attributed to increased mechanical friction, the development of humid microenvironments in skin folds fostering bacterial growth, and systemic low-grade inflammation.[83,91] Despite these associations, engaging in exercise can be challenging and painful, perpetuating a cycle wherein exacerbated symptoms may decrease physical activity.

Interventions focused on weight loss have been demonstrated to alleviate HS disease flares. Documented instances of reduced HS severity following weight loss have been observed post-bariatric surgery.[89,92,93] Kroman et al reported a 35% reduction in patients reporting HS symptoms after weight loss, a decrease in the mean number of involved sites from 1.93 to 1.22, and a significant association between weight loss exceeding 15% and reduced disease severity.[89]

Dietary modifications may play a role in managing HS. Barrea et al found that HS patients displayed poorer body composition and lower adherence to Mediterranean diets compared to healthy controls. In their cross-sectional, case-controlled observational study, HS patients consumed higher quantities of simple carbohydrates, total fat, and foods with a higher n-6/n-3 PUFA ratio. The severity of HS, assessed through the Sartorius score, showed an inverse correlation with adherence to the MedD.[94] Although Lorite-Fuentes et al found a similar correlation of greater MedD adherence with lower HS severity,[95] Velluzzi et al did not observe a significant association.[96]

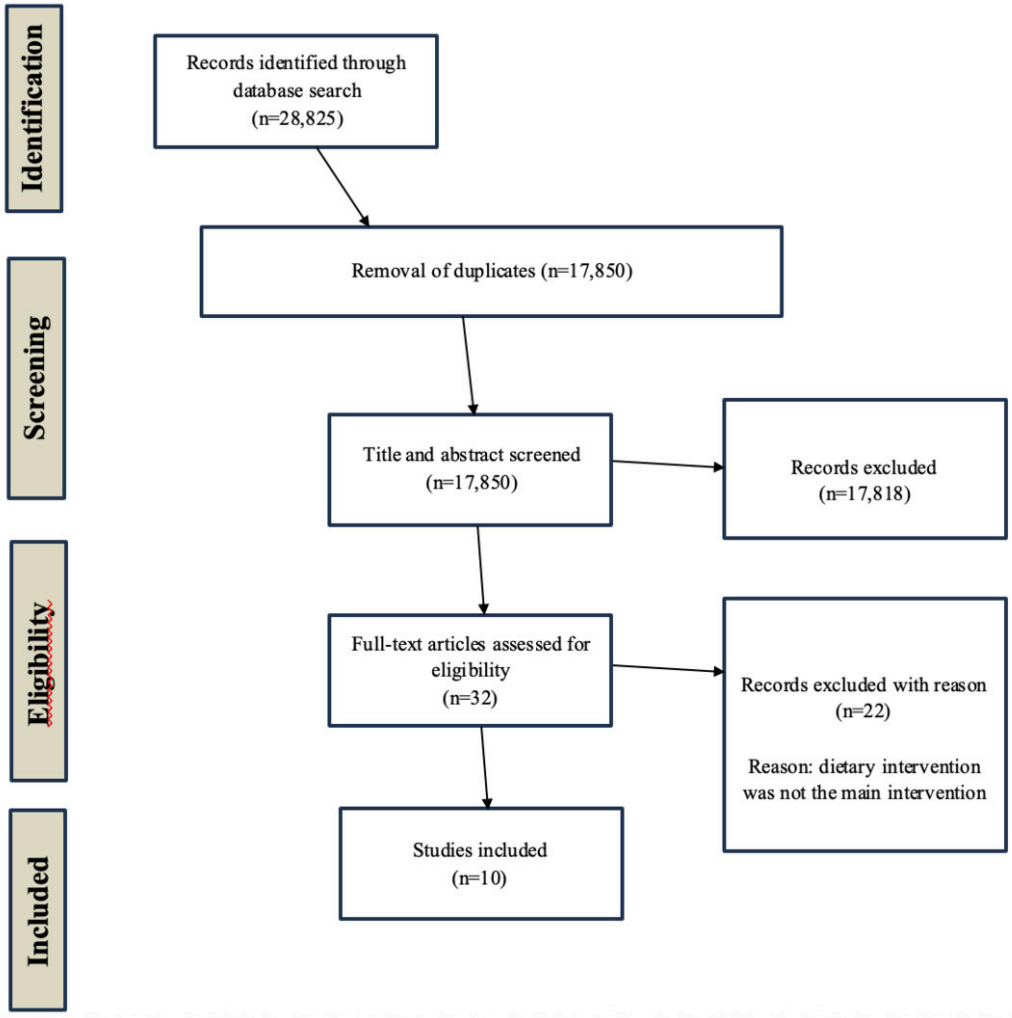

Figure 4. PRISMA flow diagram for atopic dermatitis studies

LOW CARBOHYDRATE/LOW DAIRY

Reducing carbohydrate and dairy consumption has been associated with improved HS symptoms. In an online anonymous survey study from 2020, 237/728 patients identified HS symptom-exacerbating foods, which included sweets (67.9%), bread/pasta/rice (51.1%), dairy (50.6%), and high-fat foods (44.2%).[97] In an online survey study from 2022, individuals reported significant improvements in symptoms when adhering to Paleo and anti-inflammatory diets, which are characterized by reduced emphasis on dairy and grains and increased fruit and vegetable consumption. Reductions in sugar and dairy consumption were noted to lead to greater self-reported symptom improvement.[98] In a small uncontrolled study, Danby reported that 39 out of 47 patients (83%) showed improvement under dairy-free diets, with none experiencing worsening symptoms. However, Danby's study has faced criticism for lacking specificity in self-reported improvements regarding symptoms, potential response bias, and lack of formal or validated assessment methods.[99]

High intake of simple carbohydrates and dairy is theorized to increase follicular obstruction in HS.[99] Casein, whey, natural androgens, and their precursors contribute to the blockage of follicles by inducing cytokeratin overexpression, keratinocyte hyperproliferation, and heightened follicular wall cornification, leading to the leakage and rupture of pilosebaceous units. Moreover, androgen hormones are hypothesized to play a role in activating HS.[100] Casein activates insulin-like growth factor 1 (IGF-1), and whey increases insulin levels; hyperinsulinemia and high IGF-1 can amplify androgen receptor activation.[99,101]

WHEAT AND BREWER'S YEAST

Evidence suggests that brewer's yeast and wheat may exacerbate HS symptoms. Anti-Saccharomyces cerevisiae antibodies (ASCA), traditionally considered specific for Crohn's disease, have been found in elevated levels in patients with other autoimmune conditions such as type 1 diabetes and systemic lupus erythematosus.[102] Assan et al reported that ASCA is associated with systemic inflammation and advanced HS disease.[103]

Elimination diets targeting wheat and brewer's yeast have demonstrated effectiveness in stabilizing HS. In a study involving 12 patients with ASCA antibodies, a 12-month brewer's yeast-free diet combined with surgical excision resulted in symptom stabilization, regression of

skin lesions, and improvements in quality of life. Recurrence was observed upon accidental or intentional ingestion of beer or other foods containing wheat or brewer's yeast.[104] A 6-year follow-up study at the same center found that 26/37 (70%) patients reported improvement in HS symptoms with a brewer's and baker's yeast-free diet and operative intervention. Similarly, 32/37 (82%) patients experienced symptom recurrence after reintroducing restricted foods. 10% of these patients completed serological testing by measuring immunoglobulin G (IgG) antibodies, which identified yeast intolerance in 20%, wheat intolerance in 29%, and cow's milk intolerance in 23%.[105] Both studies, with small sample sizes and lacking control groups, were confounded by the inclusion of surgical excisions performed on all patients. Moreover, it remains unclear whether a similar diet would benefit patients without comparable dietary intolerances.

HIDRADENITIS SUPPURATIVA AND SUPPLEMENTS

Zinc supplementation has been associated with improved HS symptoms. A 2018 case control study highlighted a higher prevalence of low serum zinc levels among HS patients compared to controls. Moreover, low zinc levels were found to be correlated with more severe Hurley staging, increased DLQI scores, and heightened symptom severity.[106] In cases where traditional treatments like systemic antibiotics, isotretinoin, surgery, or antiandrogens proved ineffective, Brocard et al revealed that administering 90 mg of zinc gluconate daily resulted in complete remission for 8/22 (36%) and partial remission for 14/22 (63.6%) patients.[107] Similarly, Molinelli et al and Hessam et al found that zinc supplementation was associated with significant reductions in acute flares, disease severity, and longer disease-free survival.[108,109]

HS patients exhibit a higher prevalence of vitamin D deficiency compared with controls,[110,111] and vitamin D serum levels are inversely correlated with HS disease severity.[112] In HS patients with low vitamin D, Guillet et al revealed that vitamin D supplementation significantly decreased the number of nodules at 6-month follow up, noting a correlation between response to HS therapies and an increased vitamin D levels following supplementation.[113] (See Table 3)

PSORIASIS

Psoriasis is a chronic inflammatory skin disorder with numerous subtypes,[114] most commonly plaque psoriasis which is characterized by well-demarcated erythematous plaques with silvery scaling on extensor surfaces, trunk, and the scalp. Psoriasis appears with a similar frequency in both men and women with a mean onset age of 33 years, although studies indicate that it may present earlier in women.[115] As there is no known cure for psoriasis and given the complex nature with a multifaceted origin that is influenced by both genetic and environmental factors,[114] dietary intervention may be a potential therapeutic option to explore to alleviate symptoms.[116]

PSORIASIS AND DYSBIOSIS

The gut and skin immune systems are interconnected. Research has shown an increased prevalence of intestinal inflammation in individuals with psoriatic arthritis, with gut inflammatory lesions occurring in 16% of psoriasis patients which were identified via ileocolonoscopy.[117,118] Although the exact underlying mechanisms remain unclear, there is a mutual relationship between psoriasis and inflammatory bowel diseases, including Crohn's disease (CD). People with CD are five times more likely to develop psoriasis compared to those without CD, and individuals with psoriasis have an elevated risk of developing CD.[119]

Studies on the gut microbiome consistently report imbalances in individuals with psoriasis, although the specific compositions of intestinal microbiota may vary among psoriasis patients.[120,121] The gut microbiota are known to play a vital role in maintaining host equilibrium and regulating inflammation in the gut and skin, particularly in the context of Th17, a cytokine associated with CD.[122] Th17 cells govern the IL-17A and IL-17F production, which modulates gut inflammation.[123]

A randomized controlled trial (RCTs) demonstrated that dietary interventions can have specific effects on gut microbiota diversity and inflammatory markers. For example, the consumption of fermented foods has been found to reduce IL-6, a mediator of chronic inflammation that is elevated in chronic inflammatory diseases such as rheumatoid arthritis and type 2 diabetes.[124,125] Notably, elevated IL-6 expression has been linked to psoriatic skin lesions and increased keratinocyte proliferation.[126,127]

PSORIASIS AND DIETS

Psoriasis can profoundly impact quality of life. and many patients seek information regarding lifestyle changes that may help with disease management. Studies indicate that individuals suffering from psoriasis display strong motivation to modify their diets, as they view these interventions as natural, safe, and self-empowering.[128,129] While there are numerous dietary suggestions for psoriasis in popular literature, the scientific literature, particularly randomized controlled trials (RCTs), is notably lacking. There is a dearth of studies examining the impacts of widely recommended dietary approaches, such as the Paleolithic or vegetarian diets. This limited body of research on the relationship between diet and psoriasis highlights a significant knowledge gap, making it challenging for both patients and clinicians to engage in informed discussions on this subject.[128] Below are the top dietary interventions and supplements reported in literature.

HYPOCALORIC DIETS

The association between obesity and psoriasis is well-documented. Studies have found a correlation between elevated levels of obesity-related adipokines, such as leptin, and a higher risk of developing psoriasis. Moreover, individuals with psoriasis are more likely to be obese compared

Table 3. Hidradenitis Suppurativa Studies

Study Reference	Level of Evidence	Design Description	Intervention/ exposure and comparison group (if applicable)	Main outcome measures	Results/Data pertaining to HS	Discussion
79	IV	Cross-sectional study with 221 patients with HS, explored potential association between adherence to a Mediterranean diet, physical activity and HS severity		Disease severity, Hurley, and IHS4 (International Hidradenitis Suppurativa Severity Score System)	Higher adherence to a Mediterranean diet was associated with lower disease activity, lower self-reported Hurley and lower IHS4 (International Hidradenitis Suppurativa Severity Score System)	The MD could be an appropriate dietary pattern for patients with HS due to its anti-inflammatory properties, and combining this with increased levels of physical activity could have additional benefits
80	IV	Case-control with 35 patients with HS, 35 healthy subjects, evaluated several anthropometric measures, lifestyle (Mediterranean diet adherence, and physical activity level) and the perceived physical and mental health status were evaluated	35 patients with HS, 35 healthy subjects	Disease severity (via Hurley stage system or Sartorius score)	HS patients showed a significantly lower adherence to the Mediterranean diet than that of controls. Hidradenitis patients showed significantly higher values of body mass index, waist circumference, body composition, fat mass, and lower values of physical and mental health status compared to controls, while both groups showed a similar moderate physical activity level which can be assumed to counteract the negative effects of obesity or poor nutritional pattern in hidradenitis patients. However, none of the evaluated variables were correlated with the severity of the disease, assessed by means of the Hurley stage system or the Sartorius score. Instead, the Sartorius score showed a positive correlation with the duration of hidradenitis, mainly imputable to the diagnostic delay and the consequent long lasting inflammatory status	Although nutritional factors and lifestyle can be important and modifiable factors in the hidradenitis suppurativa course, the detrimental effect of chronic inflammation and delayed management are clearly prevalent and heavily influence the disease burden
88	IV	Studied 12 patients who underwent surgical excision or localized treatments followed by diet modification (controlled brewer's yeast-free diet for 12 months)		Clinical symptoms, skin lesion regression or recurrence	Diet demonstrated stabilization of clinical symptoms; skin lesions regressed over the 12-month treatment period. Similarly, all the patients demonstrated an immediate recurrence of skin lesions following accidental or voluntary consumption of beer or other foods containing brewer’s yeast or wheat	Surgery followed by the elimination of the foods containing or made with the yeast resulted in a rapid stabilization of the dermatologic manifestation and

						a slow, but complete, regression of the skin lesions within a year
89	IV	185 patients with a self-evaluative questionnaire; 37 treated following a protocol (yeast-exclusion diet followed by operative intervention) and 148 were members of a support group for patients with HS treated by other centers	Yeast-exclusion diet followed by operative intervention compared with members of a support group for patients with HS	HS symptomatology	In the diet group, 70% had an improvement of HS symptomatology. 87% of patients demonstrated an immediate recurrence of skin lesions less than a week after consuming a food containing the yeast	Stabilization and regression of hidradenitis suppurativa with protocol diet, presumably by decreasing the local and systemic inflammation, leading to a less invasive operative treatment. These new findings seem to link hidradenitis suppurativa to food intolerance and gut dysbiosis
90	IV	Multicenter, prospective clinical and analytical case–control study with 122 patients with HS and 122 control subjects was designed to assess the possible association between HS and serum zinc levels	122 patients with HS compared to 122 control subjects	Disease severity, Dermatology Life Quality Index, affected sites	Low serum zinc levels were associated with Hurley III, Dermatology Life Quality Index ≥ 9, number of affected sites ≥ 3, genital location, and perineal location	Low serum zinc levels are more prevalent in HS than in a healthy population, an indicator that may also be associated with disease severity
91	IV	22 patients treated with 90 mg of zinc gluconate per day		Clinical response	There was a clinical response with zinc gluconate in all patients, with 8 complete remissions (CR) and 14 partial remissions (PR)	Zinc salts could provide a new therapeutic alternative for the treatment of hidradenitis suppurativa
92	IV	92 patients with Hurley stage I and III HS were evaluated, divided into 2 groups according to treatment received or not received. 47	47 patients treated with oral zinc gluconate and nicotinamide	Number and duration of acute flares, VAS, Dermatology Life Quality	There was a significant reduction in the number and mean duration of acute flares in the treated versus control groups. Patients of the treated group correspondingly reported a marked reduction in mean Visual Analogue Scale, Dermatology Life Quality Index, and International HS Severity Score System scores compared with the control group at 12 and 24 weeks. Disease-free survival was	Zinc and nicotinamide supplementation in patients who have previously been treated with

		patients started oral therapy with capsules containing 90 mg of zinc gluconate and 30 mg of nicotinamide once daily for 90 days, compared to a control group of 45 patients who did not receive any treatment	compared to a control group of 45 patients who did not receive any treatment	Index, International HS Severity Score System	significantly longer in the treated group, and it showed sustained improvement even after discontinuation of oral supplementation. Slightly decreased or stable International HS Severity Score System score and pain Visual Analogue Score during the maintenance treatment was collaterally observed in the treated group with no statistically significant difference at 24 weeks	tetracyclines (minocycline) may be a valuable and a well-tolerated maintenance approach for mild to moderate HS, extending the disease-free survival reducing the rate and duration of flares
93	IV	To evaluate the efficacy of anti-inflammatory oral zinc gluconate, 90 mg/day, combined with topical triclosan, 2% twice daily in 60 patients with HS		Modified HS score and Dermatology Life Quality Index, Number of inflammatory lesions, fistulas, visual analogue scale	After 3 months of combination therapy, The modified HS Score and the Dermatology Life Quality Index improved significantly. The number of inflammatory nodules, new boils or flare-ups, and erythema scores decreased significantly. Fistula count and the visual analogue scale score showed no significant difference	The combination therapy of zinc gluconate and topical triclosan can be considered as an anti-inflammatory treatment for HS patients in Hurley stage I and initial Hurley stage II
97	IV	14 patients supplemented with vitamin D evaluated for number of nodules and frequency of flare-ups at 6 months		Number of nodules and frequency of flare-ups	Supplementation significantly decreased the number of nodules at 6 months and the endpoints (20% decrease in number of nodules and frequency of flare-ups) were achieved in 79% of patients	Disease is associated with a major vitamin D deficiency, correlated with the disease severity. It suggests that vitamin D could significantly improve the inflammatory nodules, probably by stimulating the skin innate immunity

to those without the condition,[130] and a higher body mass index (BMI) is associated with more severe psoriasis symptoms.[131,132] Importantly, obesity has been found to diminish the effectiveness of psoriasis treatments by as much as 50%.[133] These associations may be due to increased adiposity leading to heightened inflammation from overproduction of proinflammatory cytokines such as TNF-α, IL-1, IL-6, and IL-8.[134]

Numerous RCTs have indicated that weight loss through hypocaloric diets is beneficial for individuals with psoriasis who are classified as overweight or obese, which is defined as BMI ⩾ 25.0. When caloric restriction is implemented in conjunction with pharmacologic therapies, these diets lead to significant improvements in dermatology life quality index (DLQI),[135,136] psoriasis area and severity index (PASI),[136-138] body surface area (BSA),[138] and weight loss compared to controls. Serum markers such as triglycerides,[135,139] total cholesterol,[135] plasma glucose, and glycated hemoglobin also significantly decrease.[140] Jensen et al showed that the positive effects on PASI and BSA can last for one year.[140]

Dietary weight loss has been demonstrated to be beneficial in conjunction with multiple systemic treatments, including biologic therapies,[138] cyclosporine,[141] methotrexate,[137] and psoralen ultraviolet A therapy (PUVA). This is particularly important for individuals who have both obesity and psoriasis, as they face an elevated risk of experiencing adverse effects from systemic medications. Weight reduction not only enhances the treatment effectiveness but also reduces the likelihood of drug toxicity.[142]

However, weight reduction alone may not be sufficient to maintain psoriasis remission. In one RCT, patients in remission for 12+ weeks on methotrexate therapy were randomly assigned to receive a hypocaloric diet or free diet after discontinuing their methotrexate. The outcome of this study revealed no significant difference between these two groups in terms of maintaining psoriasis remission.[143]

GLUTEN-FREE DIET

Gluten-free diets have gained popularity in recent decades, and evidence suggests that this may benefit some psoriasis patients. Celiac disease (CD) and psoriasis are hypothesized to have a bidirectional relationship, where people with psoriasis have a higher odd of CD and vice versa.[144,145] Psoriasis patients were observed to have elevated levels of IgA antigliadin antibodies (AGA), which are frequently utilized in diagnosing celiac disease, and increased antibody levels are linked to more severe psoriasis.[146]

Studies indicate that gluten-free diets may be helpful for patients with CD or serologic markers of gluten sensitivity. Adopting a gluten-free diet not only leads to a reduction in the severity of psoriasis but also alleviates gastrointestinal symptoms.[147] In psoriasis patients with AGA antibodies, a 3-month adherence to a gluten-free diet resulted in significant improvements in PASI scores, and symptoms rebounded to pre-diet scores in 60% of patients after resuming a normal diet.[148] Kolchak et al demonstrated that individuals with higher AGA antibodies experienced more substantial reductions in their PASI scores when they maintained a gluten-free diet for one year.[149]

Psoriasis patients without serological markers for gluten sensitivity serum markers do not benefit from gluten-free diets.[148]

MEDITERRANEAN DIET

The Mediterranean diet (MedD) promotes the consumption of healthy fats and plant-based foods, proving beneficial for weight reduction.[150] While there is no conclusive evidence establishing a causal link between MedD and psoriasis severity, numerous observational studies suggest a connection between poor adherence to MedD and increased PsO severity.[151] Korovesi et al revealed that MedD adherence is inversely associated with psoriasis risk, severity, and quality of life,[152] and Barrea et al's case control study revealed that higher percentages of psoriatic patients had lower PREDIMED scores compared to control groups.[153] Similarly, the 2018 NutriNet-Santé Cohort study showed an inverse relationship between MEDI-LITE score and severe psoriasis.

Furthermore, psoriatic arthritis has been inversely linked to MedD adherence. A 2020 multicenter cross-sectional study found a negative association between DAPSA and MedD adherence[154]; Molina-Leyva et al reported that the proportion of patients with PsA was lower in people with greater adherence to MedD.[151] Randomized clinical trials are needed to establish the role of MedD in psoriasis.

PSORIASIS AND SUPPLEMENTS

In the era of biologics, there is an increasing prevalence of complementary and alternative medicine (CAM) use among psoriatic patients,[155] and CAM use is high compared to controls.[156] Common dietary supplements include fish oils, vitamin D, vitamin B12, and selenium.[157]

Although many patients believe that fish oil is helpful to improve their skin health,[128] the results from double-blinded RCT are mixed.[158-167] Many of the RCTs were conducted in the 1980s-1990s and utilized less objective measures or controls. Meta-analyses of RCTs yield similarly controversial findings.[168-170] Additional well-controlled and randomized studies are needed to confirm the relationship between fish oil and psoriasis.

Vitamin D is a popular supplement among patients.[128] There is an increased prevalence of vitamin D deficiency in psoriatic patients compared to the general population,[171] and vitamin D deficiency has been correlated with worse psoriasis severity.[172] Topical vitamin D is a well-established component of psoriasis treatment, but the benefit of oral vitamin D is unclear.[173] RCT results are mixed, but open-label trials have shown beneficial results.[174-177] A 2021 meta-analysis reports a lack of significant evidence for oral vitamin D supplementation and concludes that additional RCTs with larger sample sizes are needed to yield more conclusive data.[178]

Vitamin B12 deficiency has been reported in psoriasis patients.[179,180] However, limited studies have investigated

the efficacy of intramuscular B12 injections in psoriasis treatment. A 2001 intra-individual trial suggested that B12 and avocado oil may be beneficial for long-term therapy.[181] In contrast, Baker and Comaish's double-blinded RCT revealed no statistically significant benefit of vitamin B12 injections compared to placebo.[182]

Selenium has been found to prevent ROS damage, reduce cell proliferation, and catalyze apoptosis in keratinocytes.[183] Decreased selenium levels have been reported in psoriatic patients,[184-186] and selenium supplementation appears to yield varying results in patients with different psoriasis subtypes. Kharaeva et al's double-blinded RCT reported that coenzyme Q(10) 50 mg/d, vitamin E 50 mg/d, and selenium 48 mug/d dissolved in soy lecithin for 30-35 days resulted in significantly decreased psoriasis severity compared to soy lecithin controls.[187] However, selenium did not demonstrate benefit in plaque psoriasis management when used as monotherapy or adjuvant therapy with 5% salicylic acid ointment or phototherapy.[184,187-189] (See Table 4).

ATOPIC DERMATITIS

Atopic dermatitis (AD), commonly referred to as eczema, is a persistent and recurring inflammatory skin condition that constitutes part of the "atopic triad" (atopic dermatitis, asthma, and allergies). Globally, it is estimated that AD impacts approximately 3.4-33.7% of the population, with a higher prevalence among women.[190] The increasing prevalence over the past decades suggests a potential connection to environmental factors triggering the condition in predisposed individuals.[191-194] Diet is proposed as a significant factor in triggering AD, alongside other environmental exposures like pollution, UV radiation, and climate.[193,195] In addition, diet modifications have been proposed as strategies to ameliorate flares or prevent disease. Here, we examine the existing literature regarding the impact of diet on AD.

EPITHELIAL DYSFUNCTION AND DYSBIOSIS

AD pathogenesis is associated with a dysfunctional skin barrier. Loss-of-function mutations in the FLG gene result in impaired filaggrin, a crucial protein that links keratin filaments and interacts with lamellar bodies, consequently compromising the skin barrier function.[196] Filaggrin-poor skin is believed to facilitate greater allergen penetration, thereby heightening allergen sensitivity.[197] Various case-control studies have indicated that mutations in filaggrin are linked to an elevated risk of developing egg or peanut allergies.[198,199] Eczematous skin lesions additionally display increased dendritic cells, which express high-affinity receptors for IgE that facilitate allergen uptake. Increased receptor expression has been associated with greater lesion severity.[196]

Similar to the skin, the intestinal epithelium is integral to the innate immune system, safeguarding the body against environmental threats. The gastrointestinal tract can share analogous "leaky" characteristics with skin epithelium, characterized by heightened permeability and reduced protection.[200] A compromised gut barrier is believed to permit the increased passage of antigens from ingested contents and lead to an inflammatory response.[201] Elevated intestinal permeability has been linked to more severe cases of atopic dermatitis (AD).[202,203]

Microbiota alterations have been associated with AD. Skin dysbiosis is mediated through increased concentrations of *Staphylococcus aureus* during flares, which disrupts normal microbiota and reduces commensal bacteria.[204,205] While the association between gut microbiome diversity and the onset of AD is inconclusive, individuals with AD tend to exhibit higher proportions of C*lostridium difficile, Escherichia coli*, and *Staphylococcus aureus* in the gut microbiome compared to healthy controls. Conversely, there is a decrease in *Bacteroides, Bacteroidetes,* and *Bifidobacteria*.[206]

ATOPIC DERMATITIS AND DIETS

ELIMINATION DIETS

In recent decades, there have been ongoing discussions revolving around the influence of food triggers and elimination diets on AD. The prevalence of food allergies in patients with AD has been reported to be as high as 50.7%.[207] A significant portion of atopic dermatitis (AD) patients report restricting specific foods they suspect might be causing reactions, hoping that modifying their diet will alleviate symptoms. Up to 75% of AD patients have tried dietary modifications to manage their disease, with only half seeking prior consultation from a healthcare professional or dietitian.[208,209]

Numerous studies have explored potential food-related risk factors for the development of atopic dermatitis (AD) or triggers for its symptoms. In a study using the Korean National Health and Nutrition Examination Survey, Park et al reported that the consumption of meat, instant noodles, and processed foods was linked to an increased prevalence of AD.[210] Similarly, Lim et al found a strong association between a high intake of burgers and fast food and an elevated risk of chronic and severe AD, while an increased consumption of fruits and vegetables was associated with a reduced risk.[211] In a 2017 survey focusing on patient-reported outcomes in dietary modifications, the most commonly trialed dietary modifications included junk foods (68%), dairy (49.7%), and gluten (49%). Notably, the most significant skin improvement occurred when removing white flour products (53.6%), gluten (51.4%), and nightshades (51.4%).[212]

Studies on gluten intolerance and gluten-free diets in AD have yielded inconsistent results. A cross-sectional study found that AD was associated with a significantly higher prevalence of celiac disease on multi-variate analysis.[213] However, a cohort study did not find a significant association between amount of dietary gluten intake and atopic dermatitis in adult women.[214] Similarly, in a questionnaire study between celiac and non-celiac controls, there was no significantly increased risk of AD among celiac patients. However, celiac patients with AD most frequently reported positive responses from gluten-free diets.[215] Ap-

Table 4. Psoriasis Studies

Study Reference	Level of Evidence	Design Description	Intervention/exposure and comparison group (if applicable)	Main outcome measures	Results/Data pertaining to Psoriasis	Discussion
117	I	Systematic review and meta-analysis of 6 RCTs	N/A	Weight loss interventions, PsO/PsA in obese patients	Weight loss following lifestyle interventions improves psoriasis compared with controls ($p < 0.001$). 3 studies on pharmacologic interventions yielded conflicting results. 2 cohort studies suggested that gastric bypass reduces the risk of developing psoriasis ($p < 0.01$)	Weight loss can improve pre-existing PsO and PsA, as well as prevent the development of PsO in individuals with obesity
119	II	RCT of 44 obese patients with plaque PsO	Energy-restricted diet (20 kcal/kg/ideal body weight/day) with n-3 PUFAS (2.6 g/day) or usual diet. All patients continued their immuno-modulating therapy throughout the duration of the RCT	PASI, DLQI, body weight, WC, laboratory results (serum triglycerides, serum total cholesterol, n-6/n-3 ratio)	Data was measured at baseline, 3 months, and 6 months. PASI, itch scores, and DLQI decreased significantly compared with baseline ($p < 0.05$). Among patients with an energy-restricted diet, a significant decrease in body weight, waist circumference, serum triglycerides, serum total cholesterol, and n-6/n-3 ratio intake occurred ($p < 0.05$). No significant changes were observed among controls.	In PsO patients with obesity, an energy-restricted diet with immuno-modulating therapy improved clinical outcomes and improved metabolic profiles
120	II	RCT of 60 overweight/obese patients with psoriasis	Intervention group completed energy-restricted diet (800-1000 kcal/day) for 8 weeks, followed by 8 weeks of 1200 kcal/day. Control group continued ordinary healthy foods	PASI, DLQI	At week 16, mean weight loss was greater in intervention group compared with controls ($p < 0.001$). Mean differences in PASI ($p = 0.06$) and DLQR (0.02) were greater in energy-restricted diet group compared with controls	In PsO patients who are overweight, an energy-restricted diet improved PASI scores and reduced DLQI.
121	II	RCT of 303 overweight/obese patients with plaque psoriasis who did not achieve clearance after 4 weeks of systemic therapy	20-week dietary plan + physical exercise for weight loss, or simple counseling about utility of weight loss for controlling psoriatic disease	PASI	Mean PASI reduction was greater in dietary intervention arm than information-only arm ($p = 0.02$), and PASI scores reduction ≥ 50% was more frequent in the intervention group ($p = 0.006$). Weight-loss target (≥ 5% from baseline) was achieved more frequently in the dietary intervention arm ($p = 0.001$).	In systemically treated PsO patients who are overweight/obese, a 20-week dietetic intervention with increased physical exercise reduced PsO severity
122	II	RCT of 262 overweight/obese patients with psoriasis on biologic therapy	Low-calorie (≤ 1000 kcal/day) or normal diet for 24 weeks	PASI	Mean weight loss and PASI score improvement was greater in dietary intervention arm than controls. PASI 75 was achieved more frequently in the diet group ($p < 0.001$), and mean BSA was lower in the diet group compared with controls	Weight reduction in obese PsO patients on biologic therapy may increase drug efficacy
123	II	RCT of 60 men with class I obesity, chronic	Low calorie diet + exercise + immunosuppressive drugs or	PASI, weight, BMI, WC, laboratory results	Low calorie diet group had significant improvement in all measured variables, including: BMI, waist circumference, AST, ALT, triglycerides, PASI, and	For male patients with chronic plaque psoriasis and non-alcoholic fatty

		plaque psoriasis, and non-alcoholic fatty liver disease	immunosuppressive drugs only for 12 weeks	(triglycerides, liver enzymes), DLQI	DLQI). No significant improvements were achieved in control group	liver disease, dietary interventions control BMI, increase psoriasis responsiveness to immunosuppressive therapy, improves quality of life, controls hepatic enzymes, and reduces triglycerides.
124	II	RCT of 32 patients with psoriasis	Two phases: low-energy diet or control phase for 16 weeks, followed by weight maintenance for 48 weeks	PASI, DLQI	PASI, DLQI, and weight were reduced after the 16-week low energy diet period. At week 64, there was an average regain in weight compared with week 16, but PASI and DLQI were maintained	Long-term weight loss in patients with psoriasis reduced psoriasis severity
125	II	RCT of 61 obese patients with chronic plaque psoriasis	Cyclosporine + low-calorie diet or cyclosporine alone) for 24 weeks	PASI	At week 24, the mean body weight reduction and PASI 75 response was greater in the intervention group compared with controls ($p < 0.001$). More patients from the control group withdrew from the study compared with the intervention group ($p < 0.001$)	For obese patients with moderate-to-severe psoriasis, response to low-dose cyclosporine was increased if low-calorie diet is included in the treatment regimen
127	II	Questionnaire to 200 patients with moderate-to-severe chronic plaque psoriasis about perception of diet on psoriasis severity. RCT of 42 obese patients with PASI 75 ≥ 12 weeks after methotrexate therapy	Hypocaloric diet or free diet for 24 weeks, with subsequent follow-up for 12 weeks	Questionnaire, body weight, PASI	Most patients believed that a dietary modification can influence psoriasis. Obese patients in psoriasis remission had significant body weight reduction after 12 weeks, which was maintained at 24 weeks. No significant differences in maintenance of psoriasis remission were observed	Weight reduction only may be insufficient for maintaining remission for moderate-to-severe psoriasis in obese patients
131	IV	Multicenter cross-sectional study of 218 PsO patients and 264 controls	N/A	Celiac screening; positive celiac serology prompted histologic evaluation	More PsO patients had positive anti-tissue transglutaminase antibodies compared with controls ($p < 0.05$). CD diagnosis was confirmed histologically in all patients with positive antibodies. A 6-month GFD was associated with significantly improved skin lesions in the patients with celiac and psoriasis	There is a high prevalence of CD in psoriasis, and GFD can improve skin lesions in CD and psoriasis
132	III	Cohort study of 33 AGA-positive	3-month GFD + 3 months of ordinary diet	PASI, duodenal biopsy histology	AGA-positive PsO patients had significantly decreased mean PASI following GFD, whereas AGA-negative	AGA-positive PsO patients may improve on

		and 6 AGA-negative PsO patients			patients did not improve. When ordinary diet resumed, PsO symptoms resumed in 18/30 patients with AGA who had completed the GFD	a GFD
133	III	Cohort study of 97 PsO patients + 91 healthy controls	Strict GFD for 2 years	Gliadin IgA antibodies, PASI	Patients who had high gliadin IgA antibodies were placed on a GFD without change to ongoing psoriasis treatment. Psoriasis lesions improved in all patients, with the most significant decline in PASI and reduction in pharmacologic treatment in patients with strongly positive gliadin IgA	AGA positivity is significant among psoriatic patients who are not diagnosed with celiac disease or gluten sensitivity, and AGA testing can identify patients who may benefit from GFD
135	IV	Cross-sectional study of 89 psoriasis patients	N/A	PREDIMED compared with severity of psoriasis, cardiovascular profile, and CRP	Higher adherence to MedD is asssociated with reduced psoriasis severity. Higher frequency of hypertension, diabetes, and large waist were observed in patients with greater adherence to MedD	Mediterranean diet should be implemented for PsO patients as part of their ongoing treatment
136	IV	Cross-sectional study of 69 mild-to-severe psoriasis and 69 healthy matched controls	N/A	Med Diet Score, PASI, and DLQI	MedD diet was inversely associated with risk of psoriasis, PASI, and DLQI. PASI was inversely correlated with fish, extra virgin olive oil, and legumes while positively correlated with dairy products	There is an inverse association between MeD dietary adherence and psoriasis severity, occurance, and quality of life
137	IV	Cross-sectional case-control study of 62 mild-to-severe PsO patients and 62 matched controls	N/A	PREDIMED compared with PASI, CRP, and bioelectrical impedance analysis for body composition	More psoriatic patients had lower PREDIMED scores compared to controls. PASI score was positively associated with fat mass percentage and CRP, and PASI and CRP were associated with PREDIMED scores. Extra virgin olive oil and fish consumption had inverse relationship with PASI and CRP levels	There is an inverse association between MeD dietary adherence and psoriasis severity. Psoriatic patients had significant differences in body composition compared with BMI-matched controls, and MedD dietary interventions may be a safe adjuvant treatment
138	IV	Cross-sectional study of 211 PsA patients	N/A	DAPSA, CPDAI, BMI, and PREDIMED	DAPSA was negatively correlated with Mediterranean diet adherence and positively associated with BMI	Since higher disease activity (DAPSA) is correlated with MedD dietary adherence, the MedD diet may have a potential anti-inflammatory benefit

142	II	RCT of 20 hospitalized acute guttate PsO patients	Daily infusions with n-3 FA lipid emulsion (100 mL/day of 2.1 g eicosapentanenoic [EPA] and 21 g docosahexaenoic acid [DPA]) or n-6 lipid emusion (EPA + DHA < 0.1 g/100 mL)	Clinical disease characteristics, leukotrienes, and platelet-activating factors	Disease severity significantly improved in all patients of the n-3 group ($p < 0.05$), whereas moderate improvement was observed in the n-6 group. A ten-fold increase in 5-lipoxygenase products was observed in the n-3 group but not the n-6 group, whereas platelet activating factor generation decreased in the n-3 group but increased in the n-6 group	IV n-3 FA supplementation can modulate eicosanoid metabolism and appears to rapidly benefit inflammatory skin lesions in acute guttate psoriasis
143	II	RCT of 83 hospitalized chronic plaque-type PsO patients	Daily infusions of n-3 FA lipid emulsion (omegavenous; 200 mL/day with 4.2 g of EPA and DHA)) or n-6 lipid emulsion (lipovenous; EPA + DHA < 0.1 gm/100 mL) for 14 days	Changes in PASI and self-assessments by patient	PASI score reduced more in the u-3 group than u-6 group ($p < 0.05$), as well as severity of psoriasis, reduction in erythema, and scaling. Response was observed more frequently in u-3 than u-6 group. An increase in EPA concentration, leukotriene B5, and thromboxane B3 generation occurred in the u-3 group but not then u-6 group	IV n-3 FA supplementation can effectively treat chronic plaque-type psoriasis
144	II	RCT of 18 plaque PsO patients	Fish oil or placebo olive oil capsules for 15 weeks, with UVB in weeks 3-11 for both groups	BSA, scaling, erythema, thickness	After phototherapy and 4 weeks later, the fish oil group had a greater decrease in total BSA and greater improvement compared with patients in the olive oil group	Given its safety and health-promoting features, fish oil could serve as an ideal adjunctive therapy for psoriasis treatment
145	II	RCT of 28 PsO patients	10 fish oil or placebo olive oil capsules daily for 8 weeks	BSA, scaling, erythema, pruritus	In the fish oil group, there were significant reductions in itching, erythema, and scaling. No significant change was observed in the placebo group	Fish oil may serve as a treatment for psoriasis
146	II	RCT of 145 PsO patients	3 g n-3 PUFA/day or 3 g olive oil/day for 24 weeks	Disease activity, analgesic use, leukotriene formation	Compared with controls, the n-3 PUFA group had non-significant reductions Disease Activity Score (DAS28-CRP), 68 tender joint count, enthesitis score, and PASI. There was significantly reduced NSAID and paracetamol usage compared with controls, and the n-3 PUFA group had reduced formation of leukotriene B4 and higher formation of leukotriene B5 compared with controls	The n-3 PUFA group showed improvement in outcome measures for disease activity, although not statistically significant
147	II	RCT of 38 PsA patients	12 Efamol Marine (evening primrose oil + fish oil) or placebo capsules daily for 9 months, followed by placebo capsules for 3 months. At month 3, patients were instructed to reduce NSAID intake	Skin disease activity (BSA, severity, pruritus), NSAID usage, arthritis disease activity (morning stiffness duration, Ritchie articular index, number of active joints, ESR,	Skin disease activity measures were unchanged by the Efamol Marine, and NSAID requirements remained the same for both treatment and control groups. No changes were observed in arthritis activity. In the treatment group, a decrease in leukotriene B4 was observed in the active phase, followed by a rise in serum leukotriene B4 and TXB2 during the placebo phase	Efamol Marine may modify prostaglandin metabolism in PsA patients, although it did not provide clinical benefit or reductions in NSAIDs. A larger dose of essential FA may be required

				CRP)		
148	II	RCT of 145 moderate-to-severe PsO patients	6 g fish oil/day with 5 g of eicosapentaenoic and docosahexaenoic acid or corn oil with mostly n-6 FA. All patients were instructed to reduce saturated FA intake	PASI; patient's subjective assessment of erythema, iscaling, pruritus, and effect on daily living; selected 10-cm^2 area representing moderate-to-severe psoriasis evaluated for erythema, scaling, and cellular infiltration	In the fish oil group, serum phospholipids had an increase in n-3 FA, decrease in arachidonic acid to eicosapentaenoic acid, and decrease in n-6 FA. PASI did not significantly change in both groups, although scaling was reduced in both. For the fish oil group, there was no correlation between clinical improvement and increased serum n-3 FA. For the corn oil group, there was a correlation between clinical improvement and increase in eicosapentaenoic acid and total n-3 FA	There was no significant difference between n-3 FA and corn oil supplementation in PsO treatment. Increase in serum n-3 FA was not correlated with clinical improvement
149	II	RCT of 25 plaque PsO patients	10 fish or olive oil capsules 3x daily for the whole study, in addition to betamethasone diproprioinate to their psoriatic plaques for the first 3 weeks. Study was completed after 9 weeks of capsules, or when global severity score had worsened to pre-treatment level	Total BSA, scaling, erythema, thickness	Most patients worsened after discontinuing steroids. There was no significant difference found between fish and olive oil groups through survival analysis	Fish oil is minimally effective as a monotherapy when used in high doses with dietary control
150	II	RCT of 145 plaque PsO patients	10 g fish oil daily with 1.8 g eicosapentaenoic acid or isoenergetic amount of olive oil for 8 weeks	PASI; patient's subjective assessment of erythema, scaling, pruritus, and effect on daily living; selected 10-cm^2 area representing moderate-to-severe psoriasis evaluated for erythema, scaling, and cellular infiltration	There were no significant differences in clinical manifestations in either group. For the fish oil group, the amount of n-3 FA in serum phospholipids was significantly increased at the end of the trial	Increased n-3 FA was not correlated with clinical improvement in plaque psoriasis
151	II	RCT of 43 PsA patients	Seal or soy oil for 2 weeks. Patients continued NSAIDs and DMARDs	Joint pain intensity, patient's global assessment of	The seal oil group had a significant improvement in patient's global disease assessment 4 weeks post-treatment. Both groups had improved tender joint	Seal oil treatment was followed by improved global assessment of

			during the study period	disease, PASI, laboratory assessments	counts but the differences between groups was not significant. The n-6 : n-3 FA ratio, arachidonic acid, and eicosapentaenoic acid reduced after seal oil	disease. Serum FA composition shifted towards an anti-inflammatory profile
152	I	Systematic review and meta-analysis of 10 u-3 PUFA RCTs		PASI, erythema, scaling, pruritus	u-3 FA had a significant reduction in PASI score, erythema, scaling and correlated with higher dosage of u-3 supplementation. Changes in itching and percentage of total body surface area were not significant	Current evidence indicates that u-3 PUFA supplementation can improve PASI, erythema, and scaling for psoriasis patients
153	I	Systematic review and meta-analysis of 13 u-3 PUFA RCTs		PASI	3 RCTs had usable data for meta-analysis. Fish oil supplementation did not significantly reduce PUFA	Current evidence indicates that fish oil supplements are not beneficial for psoriasis
154	I	Systematic review and meta-analysis of 18 u-3 PUFA RCTs		PASI, lesion, pruritus	Fish oil monotherapy did not significantly change PASI, pruritus, or lesion area. Fish oil/u-3 PUFAS in combination with conventional treatments resulted in reduced PASI and lesion area. Fish oil reduced risk factors for metabolic disease, cardiovascular disease, and obesity while regulating inflammatory mediators	Current evidence indicates that fish oil may have benefits on psoriasis and its comorbidities when combined with conventional treatments
158	III	Open-label study of 40 PsO patients	3 groups: 1 alpha, hydroxyvitamin D3 orally 1.0 μgs/day for 6 months; 1 alpha,25-dihydroxyvitamin D3 orally 0.5 μg/day for 6 months; or 1 alpha,25-dihydroxyvitamin D3 topically 0.5 μg/g for 8 weeks		Improvement was observed in all groups. The most rapid response was observed in Group 3, with improvement noted in 84% patients when applied for 3.3 ± 1.2 weeks. No side effects were observed in any groups	Active vitamin D3 metabolites may treat psoriasis lesions. Psoriasis pathogenesis may involve abnormalities in vitamin D metabolism or response
159	III	Non-randomized trial of 25 patients with psoriasis or vitiligo	Both patient groups (psoriasis and vitiligo) received 35,000 IU vitamin D3 daily with low-calcium diet for 6 months	PASI, repigmentation, laboratory assessments	Though all patients presented with low baseline 25(OH)D3, 25(OH)D3 levels increased significantly after 6 months of treatment. PTH levels significantly decreased in both groups. PASI score improved significantly in all 9 patients with psoriasis, and 14/16 vitiligo patients experienced 25-75% repigmentation	High-dose vitamin D3 may be an effective therapy for psoriasis and vitiligo
160	II	RCT of 65 PsO patients	23 vitamin D3 100,000 IU monthly or placebo for 12 months	PASI, Physicians Global Assessment (PGA), DLQI, and PsO Disability Index (PDI)	There were no significant differences between the intervention and control for all outcome measures	Vitamin D3 supplementation at 100,000 IU/month is not an effective treatment for psoriasis

161	II	RCT of 41 PsO patients	Vitamin D3 1 µg/day or placebo		Improvement was observed in both intervention (45% patients) and control (38%) patients	Vitamin D3 supplementation at 1 µg/day is not an effective treatment for psoriasis
162	I	Systematic review and meta-analysis of 7 RCTs (4 qualitative analysis, 3 quantitative analysis)		PASI	Vitamin D supplementation for 6 months was effective for reducing PASI. However, results became non-significant after the Hartung-Knapp adjustment	Vitamin D supplementation could not be verified as a treatment for psoriasis
165	II	RCT of 13 chronic plaque PsO patients	Vitamin D3 analog calcipotriol or vitamin B12 cream with avocado oil in intraindividual R/L-comparison for 12 weeks	PASI score, subjective evaluation of patient & investigator, and 20-MHz sonography	Both PASI and 20-MHz showed no significant differences between treatments. Effects of calcipotriol peaked within first 4 weeks and subsided. Effects of B12 cream with avocado oil remained at constant level throughout observation period, and patients & investigators assessed B12 cream with avocado oil as significantly better tolerated than calcipotriol	Vitamin B12 cream with avocado oil has potential as a long-term and well-tolerated topic therapy for psoriasis
168	II	RCT of 69 PsO patients	600 µgs of selenium-enriched yeast, 600 µgs of selenium-enriched yeast + 600 IU vitamin E, or placebo for 12 weeks	Laboratory evaluations (selenium concentrations in whole blood and plasma, red cell glutathione peroxidase activity, plasma vitamin E), skin selenium concentration, psoriasis severity	At baseline, psoriasis patients' mean concentrations of selenium were reduced compared to matched healthy controls, but red cell glutathione peroxidase (GSH-Px) activity was normal. After 12 weeks, the patients' mean whole blood, plasma, and platelet selenium concentrations, platelet GSH-Px activity, and plasma vitamin E levels increased significantly. However, mean skin selenium concentration and red cell GSH-Px activity were unchanged. Neither supplementation group reduced the severity of psoriasis	Psoriasis lesions may not experience any improvement with selenium-enriched yeast, with or without vitamin E. This absence of improvement may be attributed to the lack of increased selenium content in the skin despite supplementation
171	II	RCT of 58 PsO patients	Groups EP1 and PsA1 received coenzyme Q, vitamin E, selenium with soy lecithin for 30-35 days. Groups EP2 and PsA2 (placebo) received soy lecithin	Oxidative stress markers, PASI, Severity Score (SS)	At baseline, patients had increased superoxide release from granulocytes, increased copper/zinc-superoxide dismutase and catalase activity in granulocytes in EP patients and decreased in PsA patients, decreased copper/zinc-superoxide dismutase activity, and altered catalase activity in the psoriatic epidermis. Dietary supplementation resulted in improvement of clinical conditions and faster normalization of oxidative stress markers compared with controls	Antioxidant supplementation with coenzyme Q, selenium, and vitamin E may be useful for managing severe psoriasis
172	II	RCT of 37 PsO patients and 20	Narrowband UVB 5x weekly and 200 mug	PASI, selenium, sTNF-R1, and CRP	Baseline sTNF-R1 was correlated to PASI ($p < 0.05$). Treatment resulted in nearly parallel decreases in PASI	In active psoriasis patients, levels of sTNF-

		healthy controls	selenium daily or placebo for 4 weeks		in both groups	R1 and CRP and increased. Selenomethionine supplementation for 4 weeks is ineffective for psoriasis
173	II	RCT of 22 inpatient plaque PsO patients and 10 healthy controls	Topical 5% salicylic acid ointment, 0.1-0.3% dithranol ointment, and 200 μgs daily of selenomethionine or placebo for 4 weeks	PASI, selenium, sTNF-R1	There was a positive correlation between PASI and sTNF-R1. Nearly complete remission of skin lesions was achieved in both psoriasis groups after 4 weeks, but PASI score was higher in the intervention group ($p < 0.05$). Correlation between PASI score and TNF-R1 reversed	Increased sTNF-R1 may indicate active psoriasis. Selenomethionine supplementation was ineffective for plaque psoriasis and may contribute to high TNF-R1 despite skin lesion remission

propriate testing for adverse food reactions is important, albeit challenging. Despite the frequent implementation of dietary changes, research indicates that 50-90% of patient-perceived food reactions are not allergies.[216] To minimize subjective influences on observed outcomes, double-blind placebo-controlled oral food challenges are the gold standard for diagnosing food allergies.[216] Patients are recommended to avoid food triggers if true IgE-mediated allergies are found.[217]

Historically, empiric elimination diets were proposed as a beneficial approach to diminish AD flare-ups. However, more recent studies and guidance documents have increasingly discouraged the use of elimination diets. A 2008 Cochrane review noted some benefits in employing an egg-free diet for infants with suspected egg allergies and positive IgEs to eggs. Nevertheless, limited evidence supports the use of exclusion diets in individuals with atopic eczema, possibly due to the absence of true food allergies to the excluded foods.[218] Excessively restrictive diets have led to nutritional deficiencies and malnutrition.[219] Unnecessary food elimination diets may lead to iatrogenic food allergies, causing the emergence of new IgE-mediated sensitivities to previously tolerated foods and posing the risk of anaphylaxis.[220]

OBESITY AND WEIGHT REDUCTION

There is a growing body of literature suggesting a reciprocal relationship between obesity and AD. Both conditions exhibit common pathologic features, including inflammation, insulin resistance, and leptin resistance.[221] Obesity has been shown to predispose individuals to AD development and worsen AD symptoms, whereas AD is associated with an increased risk of obesity.[221-224] Furthermore, obesity is linked to heightened resistance to anti-inflammatory treatments.[225]

Existing literature indicates that weight reduction can alleviate AD symptoms. In 2020, Jung et al conducted a prospective randomized controlled study focusing on the therapeutic effects of weight loss and serum adipokine levels in AD. Obese patients (BMI > 25 kg/m^2, n = 20) were randomly assigned to either weight maintenance and weight reduction groups, while non-obese (n = 20) AD patients served as controls. Significantly different serum adipokine levels were observed between obese and non-obese patients, and there was a positive correlation between AD severity (EASI score) and pruritus visual analog score (VAS). BMI and EASI also exhibited a positive correlation, and weight reduction decreased EASI scores among obese AD patients.[226]

Similarly, a 2018 case report highlighted how dietary control and exercise contributed to symptomatic improvement in a patient with refractory symptoms despite one-year treatment with antihistamines, topical steroid, and cyclosporine. After 12 weeks, the patient's BMI reduced from 26.81 kg/cm^2 to 20.64 kg/cm^2, waist circumference decreased from 82 cm to 65 cm, EASI score decreased from 16.8 to 6.6, and VAS score decreased from 7 to 4. These changes were accompanied by visible improvements in skin lesions.[227]

VEGETARIAN DIET

Research evaluating the impact of vegetarian diets on AD has yielded conflicting results. A 2023 questionnaire study involving young adults from Singapore and Malaysia (aged 19-22, n = 13,561) found a negative association between moderate-to-high intake of plant-based foods with chronic or moderate-to-severe AD.[228] Conversely, a 2022 Dutch questionnaire study (n = 56,896) found no associations between AD and physical activity, diet quality, and vegetarian or vegan diets. Interestingly, the Dutch study reported a positive association between moderate-to-severe AD and Class I obesity, a condition linked with dietary factors.[229]

In 2001, Tanaka et al conducted an open-trial study on the effects of a standardized vegetarian diet on AD improvement, utilizing the SCORAD method for symptomatic changes while measuring serologic and immunologic parameters (n = 20). Following a two-month treatment period, significant reductions were observed in the SCORAD index, LDH5 activity, and peripheral eosinophils. Moreover, there was a significant decrease in PGE2 production from mononuclear cells, although serum IgE levels remained unchanged.[230]

In 2017, Nosrati et al conducted a cross-sectional survey investigating dietary modifications, perceptions, and patient-reported outcomes among individuals with AD. The findings revealed that 79.9% of patients incorporated new foods into their diets. Of the 63 respondents (37.3%) who reported trialing a specific diet, the most implemented diets were a gluten-free diet (n = 25, 39.7%), vegetarian diet (n = 17, 27%), and Paleo diet (n = 11, 17.5%). The most frequently added items were vegetables (62.2%) and fruits (57.8%), and the greatest improvement in skin occurred when adding vegetables (40/84, 47.6%) and organic foods (17/43, 39.5%).[212]

Intrauterine sensitization and exposure during pregnancy has been suggested to influence the early development of immune systems in infants, thereby playing a role in the etiology of childhood allergic diseases.[231,232] Consequently, studies have been conducted to evaluate the effects of maternal diets on the development of AD during childhood. In 2023, Su et al reported that children of mothers who adhered to a vegetarian diet during pregnancy exhibited a reduced risk of developing AD before reaching 18 months of age (OR 0.65, 95% CI 0.45-0.93, p = 0.018).[233] Long-term follow-up studies are needed to better characterize the impact of a mother's diet on allergic conditions.

ATOPIC DERMATITIS AND SUPPLEMENTS

Probiotics have been suggested for AD management based on observations of distinct differences in the intestinal microbiota between individuals with and without AD. However, studies have found mixed evidence to support their use as a treatment. Recently, a 2022 meta-analysis suggested that use of probiotics decreased Scoring Atopic Der-

matitis scores significantly in adults with atopic dermatitis.[234,235]

Fish oil has additionally been suggested for AD management, as essential fatty acid deficiencies were postulated to be a factor involved in AD pathogenesis.[236] Mendelian randomization studies have indicated an association between lower levels of n-3 fatty acids and a reduced risk of AD.[237] Nevertheless, randomized controlled trials have produced varying outcomes, underscoring the need for larger and more robust studies on the role of oral fatty acid supplementation in AD.[238]

Hempseed oil, recognized as a source for omega-6 and omega-3 PUFAs, has been evaluated for possible benefits in AD. In a randomized single-blinded crossover study, 20 adults (aged 25-60 years) were allocated to either the hempseed oil or olive oil (placebo) groups. Results revealed improvements in skin dryness and itchiness, reduced usage of dermatologic medications, and decreased skin transepidermal water loss in the hempseed oil group. Furthermore, essential fatty acids such as linoleic acid, alpha-linolenic acid, and gamma-linolenic acid increased in the hempseed oil group, without a corresponding increase in arachidonic acid.[239] Larger randomized controlled trials are needed to evaluate the potential benefits of hempseed oil in treating AD. (See Table 5).

CONCLUSION

Overall, the promising yet limited body of literature regarding dietary intervention and its effects on symptom severity and management of inflammatory skin diseases including psoriasis, atopic dermatitis, hidradenitis suppurativa, and acne vulgaris suggests a positive outlook for its use as a primary or adjuvant treatment modality for these selected skin diseases. We conclude that dietary intervention may be an effective treatment for reducing symptom severity related to skin disease. Future studies should compare dietary intervention versus placebo for selected skin diseases to establish more robust associations.

This paper highlights an exciting topic of research with further prospective research necessitated by both community and academic dermatologists. As such, small and large-cohort randomized controlled trials are warranted in order to establish dietary intervention as a treatment option for dermatologists caring for patients with psoriasis, atopic dermatitis, hidradenitis suppurativa, and acne vulgaris. Subsequent research may focus on a personalized approach to dietary intervention. Currently, use of Mediterranean diet is one of the most evidence-based diets used as an adjunct to medical therapy for management of inflammatory dermatoses. For dermatologists recommending dietary intervention as a potential adjunct treatment, it is important to first ask patients about their individual needs as well as their attitudes/perceptions towards use of dietary intervention in the management of their skin disease. Dermatologists should recommend evidence-based dietary regimens and take an interdisciplinary approach, involving a dietician if deemed necessary along with setting realistic expectations for patients.

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DISCLOSURES

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CONTRIBUTION STATEMENT

V.K.S contributed to idea curation, data curation, data analysis, manuscript writing and reviewing. S.J.C. contributed to data curation, data analysis, manuscript writing. T.T. contributed to data curation, data analysis, manuscript writing. A.S. contributed to data curation, data analysis, manuscript writing. P.A.L. contributed to manuscript reviewing. S.C. contributed to idea curation and manuscript reviewing.

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Table 5. Atopic Dermatitis Studies

Study Reference	Level of Evidence	Design Description	Intervention/ exposure and comparison group (if applicable)	Main outcome measures	Results/Data pertaining to Atopic Dermatitis	Discussion
194	III	Investigated association between dietary habits and AD in 17,497 adults in the 2009-2011 Korean National Health and Nutrition Examination Survey (KNHANES)		Atopic dermatitis	The meat and processed food pattern was associated with a significantly higher OR for atopic dermatitis than the low consumption group. Increased atopic dermatitis was most closely associated with instant noodles, whereas the groups with high intake of rice and kimchi exhibited lower ORs compared to the low intake group	Consuming instant noodles, meat and processed foods was associated with increased prevalence of atopic dermatitis, whereas consuming rice and kimchi, and coffee was associated with decreased prevalence of atopic dermatitis
195	III	Association between the dietary intake of 16 food types and AD manifestations using Singapore/ Malaysia Cross-sectional Genetics Epidemiology Study (SMCGES) population. Dietary habits profiles of 11,494 young Chinese adults were assessed by an investigator-administered questionnaire		Severity of atopic dermatitis	A moderate Quality of Diet based on Glycaemic Index Score (QDGIS) class was significantly associated with a lower odd of AD and moderate-to-severe AD. A good QDGIS class was only significantly associated with a lower odds of chronic AD. Among high GI foods, frequent consumption of burgers/fast food was strongly associated with an increased risk of chronic and moderate-to-severe AD. Among low GI foods, increased intake frequencies of fruits, vegetables, and pulses decreased the odds of AD. Also identified significant associations between frequent seafood, margarine, butter, and pasta consumption with an increased odds of AD despite them having little GI values	While genetic components are well-established in their risks associated with increased AD prevalence, there is still a lack of a focus epidemiology study associating dietary influence with AD
196	IV	169 AD patients were surveyed with a 61-question survey about dietary modifications, perceptions, and outcomes		Skin improvement	Eighty seven percent of participants reported a trial of dietary exclusion. The most common were junk foods (68%), dairy (49.7%) and gluten (49%). The best improvement in skin was reported when removing white flour products (53.6%), gluten (51.4%) and nightshades (51.4%). 79.9% of participants reported adding items to their diet. The most common were vegetables (62.2%), fish oil (59.3%) and fruits (57.8%). The best improvement in skin was noted when adding vegetables (47.6%), organic foods (39.5%), and fish oil (35%)	Since dietary modifications are extremely common, the role of diet in AD and potential nutritional benefits and risks need to be properly discussed with patients
198	III	63,443 participants, food frequency questionnaires were used to calculate gluten content		Risk of atopic dermatitis	Increased gluten intake was not associated with increased risk of AD	Findings do not support the amount of dietary gluten intake as a risk

		of participants' diet every 4 years (1995-2013)				factor for atopic dermatitis in adult women
210	IV	40 AD outpatients, obese patients divided into a weight maintenance and weight reduction group, collected data including BMI, Eczema Area and Severity Index (EASI), and visual analogue scale for pruritus.		Eczema Area and Severity Index (EASI) and visual analogue scale for pruritus	In the weight reduction group, there was a significant improvement in the EASI score, however, no significant improvement was determined in the weight maintenance group. BMI and EASI showed positive correlation	Weight reduction was associated with significant improvement of AD symptoms
211	IV	20-year-old obese F with AD prescribed Lorcaserin 10 mg BID and exercise and followed for 12 weeks recording BMI, waist circumference, EASI, VAS for pruritus, and physical exam		EASI, visual analogue scale for pruritus, skin lesions on physical exam	At first visit, body mass index (BMI) was 26.81 kg/cm2 (73 kg, 165 cm), waist circumstance was 82 cm, Eczema Area and Severity Index (EASI) score was 16.8, and visual analogue scale (VAS) for pruritus was '7.' After 12 weeks, BMI was 20.64 kg/cm2 (56.2 kg), waist circumstance was 65 cm, and symptoms had improved. EASI score was 6.6, VAS was '4,' and skin lesions improved	Weight loss decreased severity of AD
212	III	Standardized questionnaire following the International Study of Asthma and Allergies in Childhood (ISAAC) guidelines was investigator-administered to a clinically and epidemiology well-defined allergic cohort of 13,561 young Chinese adults aged 19–22. Four corresponding dietary scores were derived to examine the association of identified dietary patterns with allergic sensitization and AD exacerbations		Atopic dermatitis exacerbation	Moderate-to-high intake of plant-based foods conferred a negative association for chronic and moderate-to-severe AD. Meat and rice and probiotics, milk and eggs were not significantly associated with AD exacerbation. While frequent adherence to high-calorie foods increased the associated risks for moderate-to-severe AD, having a higher adherence to plant-based foods diminished the overall associated risks	Frequent adherence to plant-based foods was associated with reduced risks for AD exacerbation in young Chinese adults from Singapore/Malaysia. This provides the initial evidence to support the association between dietary factors and AD. Further research is needed to better understand the mechanisms underlying diet and AD exacerbations
214	IV	20 patients with AD, evaluated SCORAD index and serological and immunological parameters after 2 months of treatment with a certain vegetarian diet		Severity of dermatitis	After a 2-month treatment, the severity of dermatitis was inhibited, as assessed by SCORAD index and serological parameters including LDH5 activity and a number of peripheral eosinophils. A sharp reduction in eosinophils and neutrophils was observed prior to improvement in the skin inflammation. In addition, PGE2 production by peripheral blood mononuclear cells was reduced by this treatment. In contrast, serum IgE levels did not change during the same period	This treatment may be useful for treatment of adult patients with severe AD
217	IV	Case control using Taiwan Birth	408 mothers	Risk of	292 (1.8%) mothers who adhered to lacto-ovo	A vegetarian diet during

		Cohort Study database with 4,200 mother–child pairs in the database, 20,172 completed face-to-face interviews at 6 and 18 months. Employing a 1:10 matching strategy based on maternal age, education level, and child sex, 408 mothers who followed a vegetarian diet during pregnancy were matched with 4080 nonvegetarian mothers. This resulted in a final dataset of 4488 subjects.	following a vegetarian diet during pregnancy compared to 4080 nonvegetarian mothers	developing AD	vegetarianism and 116 (0.7%) mothers who adhered to veganism, totaling 408 (2.4%) vegetarians during pregnancy. Compared to children of nonvegetarian mothers, children of mothers who followed a vegetarian diet during pregnancy showed a lower risk of developing AD before 18 months of age	pregnancy may lower the risk of AD in children
223	II	20-week randomized single blind crossover study with atopic patients comparing dietary hempseed oil and olive oil, measuring fatty acid profiles and skin dryness, itchiness, usage of dermal medications, and TEWL		Fatty acid profiles, skin dryness, itchiness, use of dermal medications, TEWL	levels of both essential fatty acids (EFAs), linoleic acid and alpha-linolenic acid, and gamma-linolenic acid increased in all lipid fractions after hempseed oil, with no significant increases of arachidonic acid in any lipid fractions after either oil. Intra-group TEWL values decreased, qualities of both skin dryness and itchiness improved and dermal medication usage decreased after hempseed oil intervention	Dietary hempseed oil caused significant changes in plasma fatty acid profiles and improved clinical symptoms of atopic dermatitis

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