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ORIGINAL RESEARCH

The Link Between Weight-Adjusted-Waist Index and Psoriasis in Adults: A Cross-Sectional Study Based on 2009-2014 and 2003-2006 Data

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Purpose: The weight-adjusted-waist index (WWI) is a new indicator that may be used to assess obesity. However, there has never been any prior research indicating a link between psoriasis and WWI. Hence, the aim of this investigation is to search for the correlation between the two.

Patients and Methods: Cross-sectional analyses used National Health and Nutrition Examination Survey (NHANES) data from 2003 to 2006 and 2019 to 2014. Through multivariate logistic regression, the connection between Psoriasis and WWI was explored, while subgroup analyses aimed to identify possible causes. Furthermore, Smoothed curve fitting was also performed to further understand the association. The non-linear connection was examined through the use of threshold effects.

Results: There were 21,916 participants over the age of 20 in the research. Psoriasis and WWI were revealed to be positively correlated [1.25 (1.14, 1.38)] using multivariate logistic regression analysis. This association was observed in both men [1.50 (1.29,1.78)] and hypertensive patients [1.37(1.16,1.62)] in subgroup analysis. Furthermore, we noticed a curvilinear association between WWI and psoriasis, wherein the inflection point was identified as 10.15. To the left of the inflection point, there existed a negative correlation [0.12(0.02,0.91)] while to the right, a positive one [1.68(1.03,2.72)].

Conclusion: According to our findings, psoriasis and WWI are related, although more extensive prospective research is still required to support this conclusion.

Keywords: WWI, obesity, NHANES, cross-sectional study

Introduction

Psoriasis is a prevalent condition that causes skin inflammation. It tends to reoccur and is characterized by scaly, flaky skin with underlying redness. This disease can affect both men and women of all ages, but young people and middle-aged people are more susceptible to the disease. Psoriasis has a chronic course, is prone to relapse, and is severe in winter and mild in summer.[1] The severity of psoriasis varies widely: it might be an infrequent ailment with a few localized skin involvement patches or it can be a significant skin illness that affects a large area of the body, causing intense pruritus, extensive skin involvement, complications, and incapacity.[2] Genetic, immunological, and environmental factors are generally believed to be involved in the disease, but the pathogenesis of psoriasis remains unclear. It is therefore important to explore the risk factors associated with psoriasis.

Obesity has emerged as one of the major public health concerns in recent times, which is a serious global health issue.[3] Obesity is one of the risk factors for a wide range of diseases, and the number of obese people has increased dramatically worldwide, now affecting one-third of the population.[4] Over the past few years, there has been a growing body of research on the correlation between obesity and psoriasis, and these studies have found a higher prevalence and incidence of obesity in people with psoriasis compared to the general population.[5–8] Excessive production of

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inflammatory cytokines such as TNF-α, IL-1, IL-6, and IL-8 in adipose tissue provides chronic levels of low-grade inflammation and is an important feature of obesity that may also contribute to the pathogenesis of psoriasis.[7,9–11] Another study has demonstrated that targets including S100A7, SERPINB4, SPRR3, and CXCL1 may influence psoriasis and obesity at the same time.[12] It has also been shown that psoriasis and obesity are a two-way street and that the two can promote each other.[13] Numerous research have also expanded on the idea that there is a connection between fat and psoriasis. People who were overweight (body mass index 26–29) or obese (body mass index ≥30) had a greater chance of acquiring psoriasis than those of normal weight (odds ratio, OR, 1.6 and 1.9, respectively), according to a case-control research involving 560 psoriasis patients.[14] A study with 2.1 million study participants indicated a higher prevalence and incidence of obesity in people with psoriasis compared to the general population. People with severe psoriasis were more likely to be obese than those with mild psoriasis.[15] In addition to this, through epidemiology, it has been found that in the Chinese Han population, the prevalence of overweight and obesity is higher in people with psoriasis compared to those without psoriasis.[16] And a large prospective cohort study showed that increased obesity and weight gain are important risk factors for the development of psoriasis in women.[7] A systematic review and meta-analysis of observational studies also illustrated that obesity and overweight are associated with an increased risk of psoriatic arthritis in patients with psoriasis.[17] Furthermore, a number of research have demonstrated the connection between obesity and psoriasis.[18–20]

When it comes to evaluating obesity, the development of WWI is incredibly important. Although WC and BMI have historically been used as measures for calculating obesity, their shortcomings have given rise to a contentious discussion over the so-called obesity conundrum. Now comes the WWI method, which divides the waist circumference by the square root of the weight.[21] Compared to WC and BMI, WWI is more sensitive to fat mass versus muscle mass.[22] In addition, WWI has the best predictive performance over BMI, WC, and WHtR for cardiovascular disease mortality assessment, combining the advantages of waist circumference and suppressing the association with BMI, thereby alleviating the obesity paradox.[23] Consequently, investigating the link between WWI and psoriasis might help us comprehend more fully how fat affects psoriasis.

We used the 2003–2006 and 2009–2014 National Health and Nutrition Examination Survey (NHANES) to examine the association of WWI with psoriasis in a population of adults greater than 20 years of age in this study.

Materials and Methods

Study Population

The National Health and Nutrition Examination Survey (NHANES), which collects data through interviews, standardized tests, and biospecimen collection, is a distinctive repository of national information on the health and nutritional condition of the American people.[24] This research analyzed the US NHANES dataset gathered from consecutive cycles of 2003–2006 and 2009–2014. To ensure accuracy, we omitted 24,895 participants who lacked psoriasis diagnosis data, as well as 2282 individuals with incomplete WWI data. Furthermore, the study excluded 1845 participants below the age of 20, leaving a total of 21,916 participants to examine. Figure 1 shows the sample selection flowchart.

Study Variables

Assessment of Weight-Adjusted-Waist Index

WWI is a new obesity assessment index based on waist circumference and weight calculation. Each participant's WWI was determined by dividing their centimeters of waist circumference by the square root of the weight in kilograms ($\mathrm{WWI} = \mathrm{WC}/\sqrt{\mathrm{Weight}}$).[23] In our study, WWI was the expected independent variable and was designed as an exposure variable.

Assessment of Psoriasis

If a participant responded "yes" to the question, "Have you ever been told that you had psoriasis by a health care provider?" Psoriasis was diagnosed. Or "Have you ever been told by a doctor or other health care professional that you had psoriasis (sore-eye-asis)? Psoriasis was the dependent variable in this study.

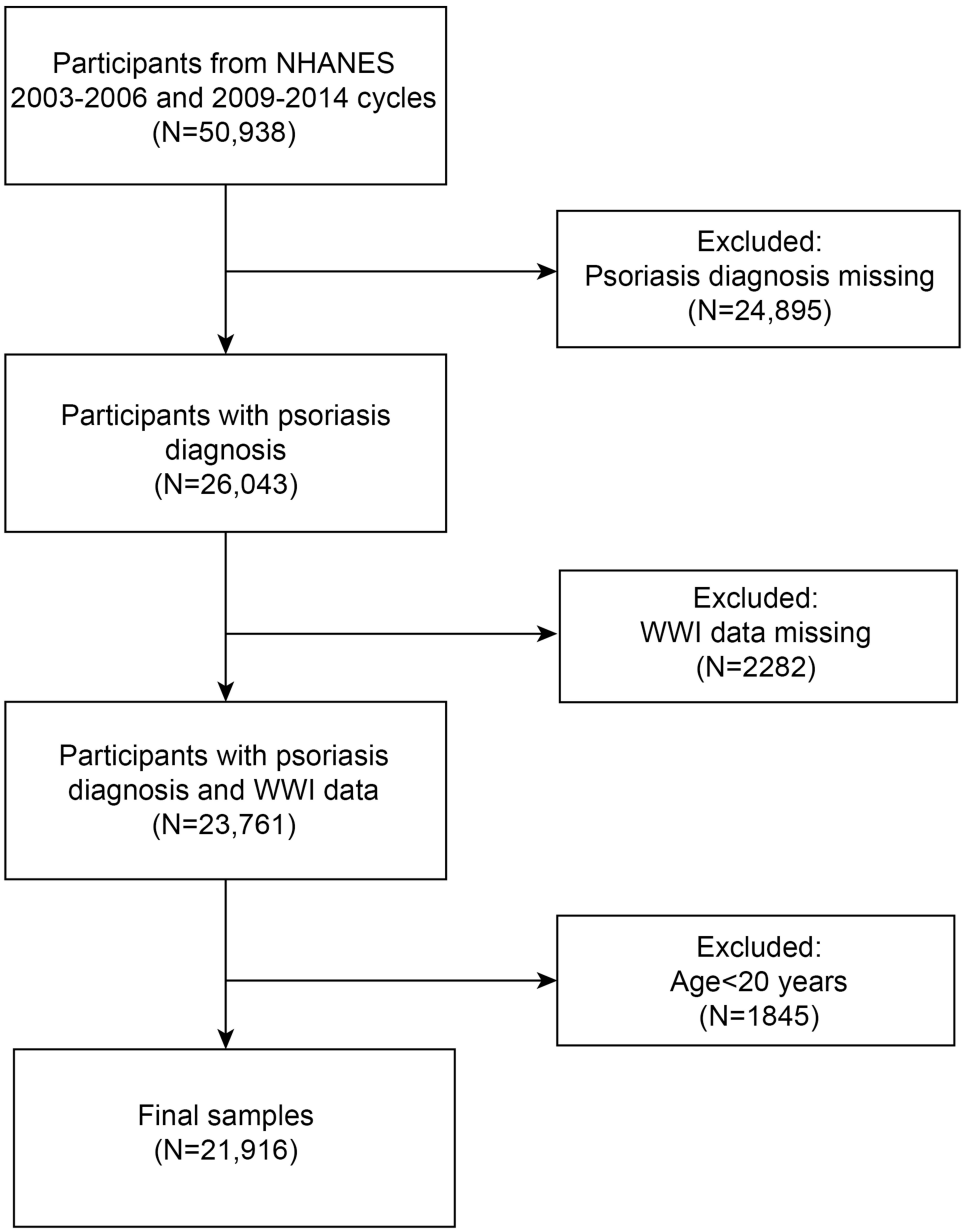

Figure 1 Flowchart of the sample selection from NHANES 2009–2014 and 2003–2006.

Assessment of Covariates

The covariates in this study included sex, age (>20 years old), race, income to poverty ratio, education level, smoked at least 100 cigarettes (yes/no), HDL-C (mmol/L), BMI (Kg/m2), triglyceride (mg/dL), lymphocyte number (1000 cells/uL), neutrophils number (1000 cells/uL), eosinophils number (1000 cells/uL), hemoglobin (g/dL), total cholesterol (mmol/L), hypertension (yes/no).

Statistical Analysis

The investigation's baseline table represented continuous variables as mean plus or minus standard deviation moreover categorical data were listed using either numbers (n) or percentages (%). The link between WWI and psoriasis was evaluated by implementing logistic regression, the results showed an odds ratio (OR) and a 95% confidence interval (CI) that indicated how strong the correlation was. Three models were used, model 1 without adjusting for variables, model 2 included adjustments for gender, race, and age. Lastly, model 3 was adjusted for all covariates, excluding weight and

waist circumference. After stratifying WWI, we further performed sensitivity analyses to assess its robustness. The relationship and turning points between psoriasis and WWI were assessed using a smoothed curve fitting with a threshold effect. It turned out to be statistically significant at $p<0.05$. Statistical studies for this survey were conducted using R (version 4.1.3) and EmpowerStats (version: 2.0).

Results

Baseline Characteristics of Participants

A total of 21,916 participants were involved in this study, with an average age of 45.64±16.77, of which 48.22% were male and 51.78% were female. We divided participants into two groups according to whether they had psoriasis or not.

Table 1 demonstrated that compared to non-psoriasis participants, those with psoriasis had higher mean age, higher rates of non-Hispanic whites, lower income-to-poverty ratio, higher smoking status, higher neutrophil counts and eosinophil counts, lower lymphocyte counts, higher prevalence of hypertension, larger waist circumference, heavier body weight, and higher levels of BMI and WWI.

Table 1 Comparison of Characteristics of Psoriasis Patients and Non-Psoriasis Participants

Characteristics	Non-psoriasis	Psoriasis	*P*-value
Age,(years)	44.28±15.59	47.31±14.59	<0.0001
Gender,%			0.7798
Male	48.72	48.17	
Female	51.28	51.83	
Race,%			<0.0001
Mexican American	8.91	3.83	
Other Hispanic	5.23	4.02	
Non-Hispanic White	67.28	80.81	
Non-Hispanic Black	11.56	5.97	
Other races	7.02	5.37	
Education level,%			0.2700
Less than high school	16.33	13.64	
High school	22.53	21.41	
More than high school	61.08	64.95	
Income to poverty ratio	2.99±1.65	3.16±1.65	0.0173
Smoked at least 100 cigarettes			<0.0001
Yes	44.99	57.30	
No	54.99	42.70	
Lymphocyte number,(1000 cells/uL)	2.13±0.89	2.04±0.67	0.0083
Neutrophils number,(1000 cells/uL)	4.33±1.75	4.52±1.68	0.0068
Eosinophils number,(1000 cells/uL)	0.20±0.16	0.21±0.15	0.0461
Hemoglobin,(g/dL)	14.31 ± 1.47	14.31 ± 1.45	0.9275
Hypertension,%			<0.0001
Yes	27.93	37.59	
No	71.95	62.01	
Total cholesterol (mmol/L)	5.04 ± 1.08	5.09 ± 1.04	0.2869
HDL-C (mmol/L)	1.38 ± 0.42	1.35 ± 0.41	0.0704
Triglyceride (mg/dL)	1.37 ± 1.40	1.37 ± 0.99	0.9737
BMI (Kg/m2)	28.61 ± 6.64	29.79 ± 7.03	<0.0001
Waist circumference(cm)	97.95 ± 16.21	101.37 ± 16.45	<0.0001
Weight(Kg)	82.02 ± 21.02	85.34 ± 21.50	<0.0001
WWI	10.87 ± 0.81	11.03 ± 0.81	<0.0001

Abbreviations: HDL-C, high-density lipoprotein cholesterol; BMI, body mass index; WWI, weight-adjusted -waist index.

Associations Between Psoriasis and WWI

Table 2 described the correlation existing between WWI and psoriasis. In the unmodified model 1 [1.25 (1.14, 1.38)], there was a high correlation between WWI and psoriasis, and after adjusting for sex, age, and race, there was still a significant positive correlation in model 2 [1.19 (1.06, 1.33)], but after adjusting for covariates, this positive correlation was not significant in model 3 [1.43 (0.90, 2.29)]. Sensitivity analysis was performed after categorizing WWI into tertiles. In model 1, the OR in Tertile 2 and Tertile 3 were 1.28 and 1.52, respectively. In model 2, the OR in Tertile 2 and Tertile 3 were 1.21 and 1.35. In model 3, the relationship is not significant.

Subgroup Examination

To determine the persistent association between WWI and psoriasis in different population settings, subgroup analysis and interaction tests were employed, stratified by gender, education level, hypertension, and smoking status. Table 3 revealed that there was a significant interaction between the two relationships in the gender subgroup and the hypertension subgroup and

Table 2 The Association Between Psoriasis and WWI

	Crude Model Model 1	**Minimally Adjusted Model Model 2**	**Fully Adjusted Model Model 3**
	OR(95% CI), *P*-value	OR(95% CI), *P*-value	OR(95% CI), *P*-value
Continuous	1.25 (1.14, 1.38), <0.0001	1.19 (1.06, 1.33), 0.0027	1.43 (0.90, 2.29), 0.1298
Categories			
Tertile 1	**Reference**	**Reference**	**Reference**
Tertile 2	1.28 (1.03, 1.58), 0.0241	1.21 (0.97, 1.51), 0.0864	0.49 (0.18, 1.37), 0.1739
Tertile 3	1.52 (1.23, 1.86), <0.0001	1.35 (1.07, 1.70), 0.0116	1.35 (0.53, 3.40), 0.5267
P for trend	1.28 (1.14, 1.45), <0.0001	1.20 (1.04, 1.38), 0.0125	1.50 (0.84, 2.69), 0.1700

Notes: The Weight-adjusted-waist index was converted from a continuous variable to a categorical variable (tertiles). Model 1: No covariates were adjusted. Model 2: Adjusted for gender, age, and race. Model 3: Adjusted for gender, age, race, education level, income to poverty ratio, smoked at least 100 cigarettes, lymphocyte number, neutrophils number, eosinophils number, hemoglobin, hypertension, total cholesterol, HDL-C, triglyceride, body mass index.

Abbreviations: OR, Odds ratio; 95% CI,95% confidence interval.

Table 3 Subgroup Analysis for the Association Between WWI and Psoriasis

Subgroup	**OR(95% CI)**	***P***	***P* for Interaction**
Gender			0.0026
Male	1.50(1.29,1.78)	<0.0001	
Female	1.10(0.96,1.26)	0.1523	
Education level			0.2049
Less than high school	1.23(0.99,1.54)	0.0664	
High school	1.54(1.25,1.89)	<0.0001	
More than high school	1.24(1.09,1.41)	0.0011	
Hypertension			0.0337
Yes	1.37(1.16,1.62)	0.0002	
No	1.05(0.92,1.20)	0.4816	
Smoked at least 100 cigarettes			0.118
Yes	1.34(1.17,1.53)	<0.0001	
No	1.14(0.99,1.32)	0.0671	

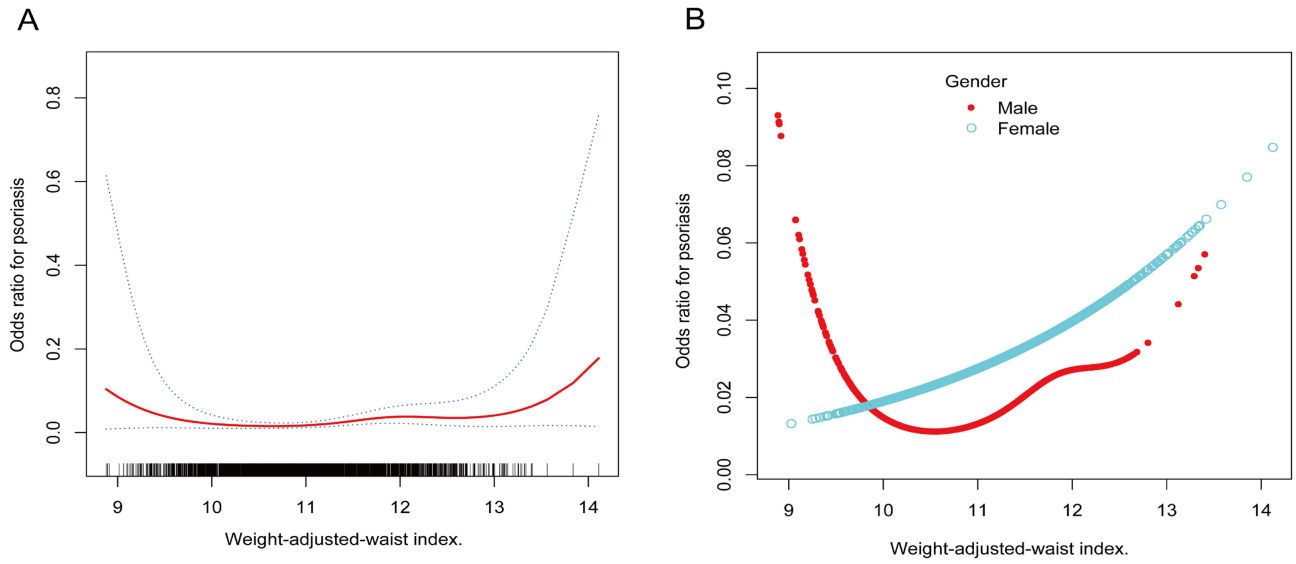

Figure 2 (**A**) Detected Smooth Curve Fitting With the use of the generalized additive model, a nonlinear positive connection between WWI and psoriasis was found. (**B**) The association between WWI and psoriasis stratified by gender.

that there was no meaningful interaction in smoking attainment or level of education. We detected that the positive association was also present in males [1.50(1.29,1.78)] and in patients with hypertension [1.37(1.16,1.62)].

A Nonlinear Link Between WWI and Psoriasis

Using the smoothed curve fitting approach, we were able to determine the U-shaped of the complex non-linear relationship that exists between psoriasis and WWI (Figure 2). As shown in Table 4, the inflection point was further calculated to be 10.15, with a negative correlation [0.12(0.02,0.91] between WWI and psoriasis on the left side of the inflection point and a positive correlation [1.68(1.03,2.72)] on the right side of the inflection point, with a log-likelihood ratio of 0.042. Males exhibited a U-shaped curve when categorized by gender, featuring an inflection point of 10.11. Below the inflection point [0.07 (0.00, 0.99)], there remained a negative correlation, while above it [3.53 (1.22, 10.23)]

Table 4 Threshold Effect Analysis of WWI on Psoriasis

Psoriasis	OR (95% CI)	*P*-value
WWI		
Inflection point (K)	10.15	
WWI<10.15	0.12(0.02,0.91)	0.0402
WWI>10.15	1.68(1.03,2.72)	0.0358
Log likelihood ratio	0.042	
Male		
Inflection point (K)	10.11	
WWI<10.11	0.07(0.00,0.99)	0.0491
WWI>10.11	3.53(1.22,10.23)	0.0201
Log likelihood ratio	0.025	
Female		
Inflection point (K)	10.11	
WWI<10.11	0.21(0.00,16.88)	0.4827
WWI>10.11	1.41(0.81,2.47)	0.2257
Log likelihood ratio	0.468	

there was a positive one. On the other hand, Table 4 demonstrated that females show no discernible association between WWI and psoriasis.

Discussion

Our research revealed a positive link between psoriasis and WWI. With an inflection point of 10.15, the connection was notably U-shaped. At a WWI of 10.15, the risk of psoriasis was at its lowest.

As far as our current understanding goes, this is a new investigation to explore the relationship between WWI and psoriasis. Dagfinn Aune noticed that higher BMI had relevance to a growth incidence of psoriasis,[6] additionally to Arnd Jacobi who used BMI to measure overweight and obesity to investigate the higher prevalence of obesity in psoriasis patients relative to the general population.[5] In a countrywide retrospective survey of Israeli adolescents, the prevalence of psoriasis was found to be higher in heavier adolescents and lower in those with a body mass index (BMI) of less than 20.[25] Besides BMI, other indexes of obesity assessment have also been linked with a higher risk of psoriasis.[6,26] BMI is the most widely used index for the assessment of obesity, but recently many studies have raised the paradox of obesity due to BMI.[27,28] One of the main reasons for the misclassification of individuals lies in BMI's inability to differentiate between muscle mass and fat mass. Those who possess higher levels of muscularity are particularly prone to being misidentified by this method.[29,30] Similarly, as waist circumference (WC) is highly correlated with BMI, it is not an indicator of obesity independent of BMI.[31] Therefore, the use of BMI or WC alone to assess obesity is not reliable. To solve the obesity paradox caused by BMI, Yousong Park proposed the weight-adjusted-waist index (WWI), which is a novel physical indicator that standardizes waist circumference (WC) and has a weaker correlation with BMI,[23] in addition to WWI's ability to reflect both fat and muscle mass components.[22,23,32] Our study's research revealed an intense positive link between psoriasis and WWI, put another way, there may be a strong positive correlation between obesity and psoriasis. Not only that, this positive correlation may also apply to male and hypertensive populations; in addition to gender and hypertension, covariates such as cholesterol and eosinophils may influence the link between WWI and psoriasis, and the fact that the association was not significant in Model 3 of our analysis could be explained by the interaction of other variables. A strong threshold impact for psoriasis and WWI was proposed by the study's non-linear connection, which had a cut-off point of 10.15.

Many studies have now demonstrated the link between obesity and psoriasis. A previous observational study of 147 patients with psoriasis found overweight and obesity clinically significant factors associated with psoriasis.[33] The release of inflammatory mediators from adipocytes in obese individuals might be connected to the appearance of psoriasis. Adipocytes in obese individuals release several inflammatory mediators, which stimulate the growth of keratinocytes, leading to the production of excess keratin in the skin, which results in the formation of psoriatic scales.[10,34] Insulin resistance is common in obese individuals, and insulin resistance leads to the overproduction of inflammatory factors and cytokines, which affects the normal functioning of skin cells and promotes the formation of psoriasis.[35] However, the mechanism between WWI and psoriasis is unclear. It has been shown that obesity may cause T-helper 17 cells (Th17) to be induced. Th17 cells are known to have a role in the etiology of autoimmune disorders, such as psoriasis, and they release IL-17.[36] According to a notion, visceral obesity may lead to decreased levels of serum adiponectin since the hormone is inversely connected with BMI and the waist-to-hip ratio and positively correlated with weight loss. Adiponectin decreases TNF-α production and raises insulin sensitivity.[37,38] Psoriasis and obesity are linked to both local and systemic TNF-α levels. We are aware of the connection between obesity and HLA-Cw6, a significant gene implicated in psoriasis susceptibility. Compared to individuals of normal weight lacking the HLA-Cw6 gene, obese patients carrying the gene had a 35-fold increased risk of developing psoriasis. The risk of psoriasis was 8.33 times higher in normal-weight people with HLA-Cw6 positive than in people with HLA-Cw6 negative.[39]

Although the high sample size and appropriate covariate adjustment have advanced the credibility and representativeness of our study, certain limitations still exist. Firstly, because it was cross-sectional, it limited our ability to establish causality. Secondly, because of restrictions on our use of the NHANES public database, we were unable to completely rule out the influence of other correlates. A few correlates were not gathered, which might have an impact on our conclusions. Even though possible covariates and confounding variables were adjusted, there are still some factors that may affect the results of this study. The association between WWI and psoriasis, for instance, may be influenced by lifestyle variables (such as foods, emotions, and stress levels), genetic susceptibility, and the regular use of different drugs. Third, the self-reported

questionnaire used to select the psoriasis individuals may have included some false information. Because the diagnosis of psoriasis relies on participants' self-reports, introducing subjectivity and inevitable recall bias.

Conclusion

According to our findings, psoriasis and WWI are related, although more extensive prospective research is still required to support this conclusion.

Data Sharing Statement

In this study, publicly accessible datasets were evaluated. The following website has the data: www.cdc.gov/nchs/nhanes/.

Ethics Statement

The research was examined and permitted by the NCHS Ethics Review Board. The patients/participants provided written, informed permission to participate in this study. Our study did not require further ethics committee approval as it did not involve animal or human clinical trials and was not unethical. In accordance with the ethical principles outlined in the Declaration of Helsinki, all participants provided informed consent before participating in the study. The anonymity and confidentiality of the participants were guaranteed, and participation was completely voluntary.

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Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work. Min Jia proposed this study through her clinical experience and received funding.

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Disclosure

The authors indicate that there were no financial or commercial relationships that might be construed as having a conflict of interest in the research.

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