Clinical, Cosmetic and Investigational Dermatology

Dovepress
Taylor & Francis Group

Open Access Full Text Article

ORIGINAL RESEARCH

Testosterone Deficiency and Sleep Deprivation as Risk Factors for Psoriasis: Insights From the National Health and Nutrition Examination Survey (NHANES) 2011–2014

Yue Zhuo[1,2], Lin Lin[3], Qiran Dong[2], Jianzhou Ye[1,4]

[1]The First Clinical Medical College,Nanjing University of Chinese Medicine, Nanjing, Jiangsu,People's Republic of China; [2]Dermatology,The First Affiliated Hospital of Anhui University of Chinese MedicineHefei, Anhui,People's Republic of China; [3]Dermatology,Zhong Shan Hospital of Traditional Chinese Medicine,Zhongshan, Guangdong,People's Republic of China; [4]Dermatology,Yunnan Provincial Hospital of Traditional Chinese Medicine, Kunming, Yunnan,People's Republic of China

Correspondence: Jianzhou Ye, Email kmyjz63@sina.com

Background: Psoriasis is a chronic, multisystemic immune-mediated inflammatory disorder with a complex etiology involving genetic, environmental, and systemic factors. Testosterone, a key androgen hormone, has immunomodulatory effects, and its deficiency is linked to increased inflammation. Sleep disturbances are also known to exacerbate systemic inflammation. This study investigates the associations between low testosterone levels, short sleep duration, and psoriasis risk using data from the US National Health and Nutrition Examination Survey (NHANES) 2011–2014.

Methods: This cross-sectional study included 4,060 male participants, after excluding individuals with missing data on psoriasis, testosterone, sleep duration, and relevant covariates. Psoriasis status was self-reported, testosterone levels were measured using isotope-dilution liquid chromatography-tandem mass spectrometry (ID-LC-MS/MS), and sleep duration was assessed through a self-reported questionnaire. Multivariable logistic regression models were used to estimate the associations between testosterone levels, sleep duration, and psoriasis risk. Restricted cubic spline (RCS) analysis explored potential non-linear relationships, and subgroup and sensitivity analyses were performed to test the robustness of the findings.

Results: Participants with testosterone levels below 300 ng/dL had a significantly higher risk of psoriasis (OR=2.97, 95% CI: 2.16–4.09, P<0.001) in the fully adjusted model. Short sleep duration (<7 hours) was also associated with increased psoriasis risk (OR=1.76, 95% CI: 1.33–2.35, P<0.001). The RCS analysis revealed a non-linear association between both testosterone levels and sleep duration with psoriasis risk, with risk plateauing at extremely low testosterone levels and sleep durations longer than 8 hours. Sensitivity analysis excluding participants with testosterone levels >1000 ng/dL confirmed the robustness of these associations.

Conclusion: Low testosterone levels and short sleep duration are independently associated with an increased risk of psoriasis in a large, diverse male population. These findings highlight the importance of hormonal and lifestyle factors in the prevention and management of psoriasis, suggesting potential intervention points for improving patient outcomes.

Keywords: psoriasis, testosterone, sleep duration, inflammation, immune modulation

Introduction

Psoriasis is a chronic, immune-mediated inflammatory skin disorder that affects approximately 2–3% of the global population, with notable geographic, ethnic, and socioeconomic variations in prevalence.[1,2] The prevalence of psoriasis is higher in developed countries, particularly in regions with colder climates, such as Northern Europe, where rates can reach up to 11.8% in some populations.[3,4] In contrast, lower prevalence rates are reported in East Asia and sub-Saharan Africa.[5] Psoriasis can occur at any age, but it most commonly manifests in adulthood, with peaks between the ages of

Received: 26 February 2025
Accepted: 18 June 2025
Published: 23 June 2025

15–25 and 50–60.[6] The condition is not only physically burdensome due to its symptomatic nature but also linked to significant psychological distress and reduced quality of life, as patients often experience stigma and discrimination.[7,8]

In addition to skin involvement, psoriasis is increasingly recognized as a systemic disease with associations to various comorbidities, such as cardiovascular disease, metabolic syndrome, diabetes, and psoriatic arthritis.[9,10] The complex pathogenesis of psoriasis involves a dynamic interaction of genetic susceptibility and environmental triggers, such as infections, stress, obesity, and lifestyle factors.[11–13] Central to the disease's pathophysiology is the dysregulation of the immune system, particularly the overactivation of T-cells and the production of pro-inflammatory cytokines like TNF-α, IL-17, and IL-23.[14,15] These molecular pathways not only drive the hyperproliferation of keratinocytes but also foster a pro-inflammatory state that underpins the systemic nature of the disease.[16]

Despite substantial advancements in understanding the immune mechanisms involved in psoriasis, much remains to be explored regarding the role of systemic factors such as hormonal imbalances and lifestyle behaviors, including sleep patterns, in modulating disease risk and severity.[17,18] Understanding these factors is crucial, as psoriasis is associated with long-term health complications, and identifying modifiable risk factors can have a significant impact on prevention and management.[19,20]

In recent years, there has been growing interest in understanding how systemic factors, such as hormonal regulation and sleep behaviors, influence the onset and progression of psoriasis.[21,22] Testosterone, a key androgen hormone, plays a pivotal role in regulating various physiological processes, including immune response and inflammation.[23] Low testosterone levels, commonly observed in aging males and individuals with metabolic disorders, have been linked to increased susceptibility to several inflammatory and autoimmune diseases.[24,25] In the context of psoriasis, testosterone's immunomodulatory properties are believed to influence disease activity by altering cytokine profiles, reducing the body's ability to control inflammatory cascades.[26,27] However, population-based studies specifically examining the relationship between testosterone levels and psoriasis are sparse, leaving a significant gap in our understanding of this potential association.[28]

Simultaneously, sleep has emerged as a critical factor in maintaining immune function and overall health.[29] Sleep deprivation and poor sleep quality are well-established risk factors for systemic inflammation and chronic diseases, including metabolic syndrome, cardiovascular disease, and mood disorders.[30] In particular, insufficient sleep has been associated with increased levels of pro-inflammatory cytokines, similar to those involved in psoriasis pathogenesis.[31] Despite the potential implications of disrupted sleep patterns on skin health, few studies have explored the direct relationship between sleep duration and psoriasis, especially in large-scale epidemiological datasets.[32,33]

Given the significant overlap between the pro-inflammatory states driven by both hormonal imbalance and sleep disturbances, the combined effects of low testosterone and inadequate sleep on psoriasis risk warrant further investigation.[34] Using data from the 2011–2014 NHANES cohort, this study aims to provide novel insights into the role of these modifiable factors in psoriasis development. By assessing testosterone levels and self-reported sleep duration in a nationally representative population, we seek to clarify the independent and interactive contributions of these factors to psoriasis risk.[35] The findings from this study have the potential to inform prevention strategies and clinical management of psoriasis, particularly for patients with hormonal or sleep-related issues.[36]

Methods

Study Design

This cross-sectional study utilized data from the National Health and Nutrition Examination Survey (NHANES) conducted between 2011 and 2014. A total of 19,312 participants were initially included in the survey. After excluding individuals with missing psoriasis data, 12,625 participants remained. Further exclusions were made for those missing data on testosterone levels and sleep duration, leaving 11,244 participants. Finally, after excluding women and participants missing covariate information, the study cohort consisted of 4,060 male participants, comprising 3,880 controls and 180 psoriasis cases (Figure 1).

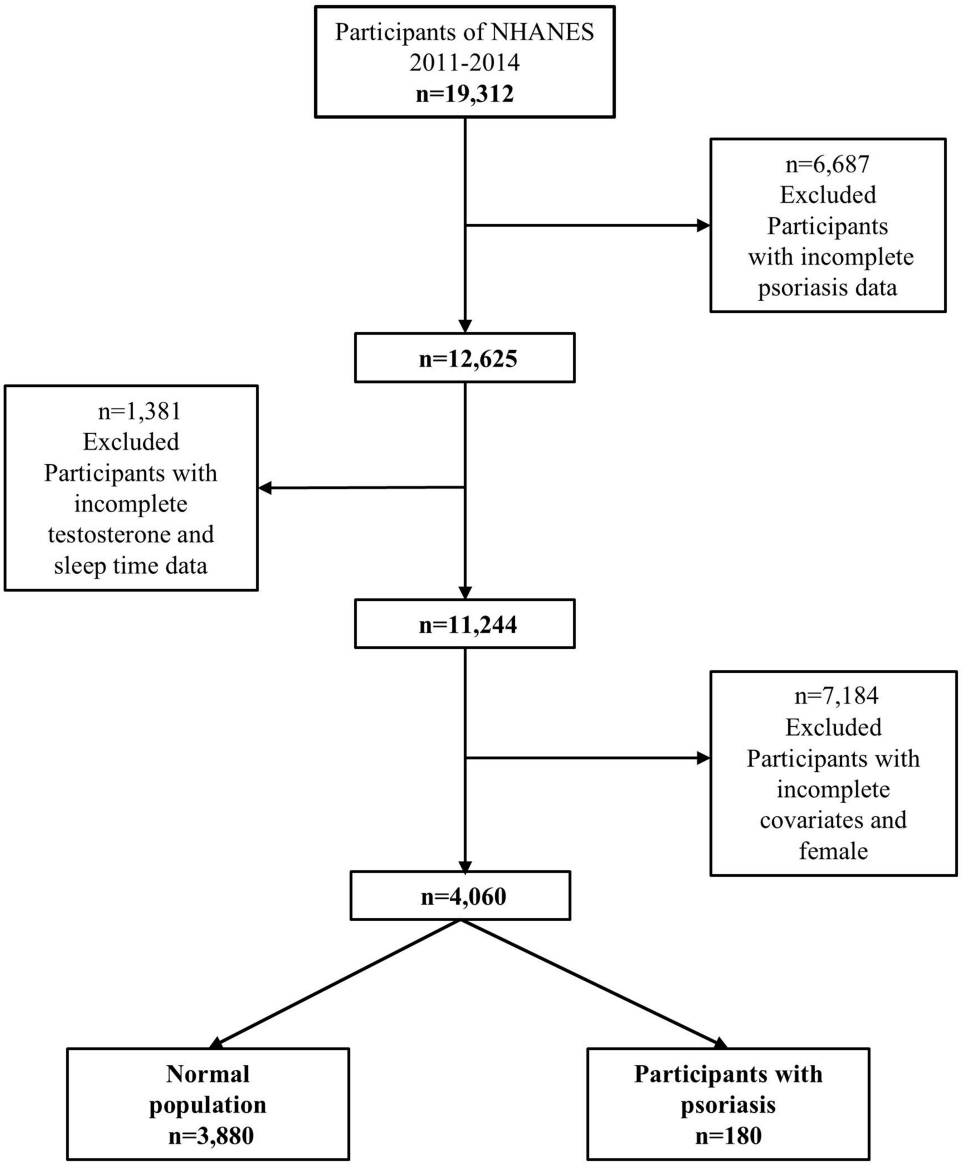

Figure 1 Flow chart of participant selection.Note:Bold sample sizes (n=5,880; n=180) represent the final analytical cohorts included in the study.

Psoriasis

Psoriasis status was self-reported by participants in response to the question: "Have you ever been told by a doctor or other health professional that you have psoriasis?" Participants who answered "yes" were classified as having psoriasis. Psoriasis prevalence was determined based on this self-reported information, which has been used in previous NHANES-based studies to evaluate psoriasis in population-level datasets.[37] Due to data limitations, psoriatic arthritis cases were not excluded.

Testosterone

Total serum testosterone levels were measured using isotope-dilution liquid chromatography-tandem mass spectrometry (ID-LC-MS/MS) following standardized NHANES procedures. Testosterone levels were categorized as low if the value was below 300 ng/dL, a commonly accepted clinical threshold for hypogonadism.[38] This cutoff was used to classify participants into normal and low testosterone groups for subsequent analyses.

Sleep Duration

Sleep duration was assessed through the NHANES sleep questionnaire, where participants reported their average sleep duration over the past month. Sleep duration was assessed via self-report to the question, "How much sleep do you usually get on weekdays or workdays?" Responses were categorized as < 7 (insufficient sleep) or ≥7 hours (normal sleep), in line with guidelines from the American Academy of Sleep Medicine.[39] Sleep duration was analyzed as both a continuous and categorical variable in the statistical models.

Covariates

In our analysis, several covariates were included to control for potential confounding factors that might influence both testosterone levels and psoriasis risk. Age was treated as a continuous variable, given its well-established association with both testosterone levels and psoriasis prevalence. Race/ethnicity was categorized into five groups (Mexican American, Other Hispanic, Non-Hispanic Black, Non-Hispanic White, and Other races) to account for known variations in health outcomes across different racial and ethnic backgrounds. Socioeconomic factors were also considered, including education (categorized into five levels from less than 9th grade to college graduate or above) and poverty-income ratio (PIR, categorized into ≤1, 1–3, and >3), both of which are linked to access to healthcare and overall health status. Marital status was included as it can affect both psychological well-being and health behaviors, with categories such as married, widowed, divorced, separated, never married, and living with a partner. Lifestyle factors, such as smoking (current smoker or non-smoker) and alcohol use (current user or non-user), were also included given their impact on inflammation, hormone levels, and overall health. Additionally, comorbidities like hypertension, hyperlipidemia, and diabetes were treated as binary variables (yes/no) since they are commonly associated with both low testosterone and psoriasis. Finally, body mass index (BMI) was categorized into three groups (<25, 25–30, and ≥30) based on its well-established role as a risk factor for both testosterone deficiency and psoriasis, as well as its significant interaction with sleep duration.[40] These covariates were included in all adjusted models to ensure a comprehensive analysis and to mitigate potential confounding effects.

Statistical Analysis

Descriptive statistics were used to summarize the baseline characteristics of the study participants, with continuous variables reported as mean ± standard deviation (SD) and categorical variables presented as frequencies and percentages. For comparisons between the psoriasis and control groups, independent t-tests were performed for continuous variables, while chi-square tests were used for categorical variables to assess statistical significance. A P-value of <0.05 was considered statistically significant.

To examine the association between testosterone levels, sleep duration, and psoriasis, multivariable logistic regression models were employed. Three models were constructed: Model 1 was unadjusted, serving as a crude comparison; Model 2 was adjusted for key demographic variables, including age and race; and Model 3 was further adjusted for a range of potential confounders, including education level, marital status, poverty-income ratio, smoking status, alcohol use, hypertension, hyperlipidemia, diabetes, and body mass index (BMI). The inclusion of these covariates aimed to control for confounding factors that may influence both testosterone levels and psoriasis risk, ensuring more accurate estimates of the association.

To explore potential non-linear relationships between testosterone, sleep duration, and psoriasis risk, restricted cubic spline (RCS) regression models were used. This allowed for a more flexible modeling approach to assess dose-response relationships and potential threshold effects. The results of the spline models were presented graphically to illustrate the shape of these associations.Subgroup analyses were conducted to explore the modifying effects of key covariates, including age, BMI, and smoking status. Interaction terms were added to the logistic regression models to assess whether these covariates altered the association between testosterone, sleep duration, and psoriasis risk. Sensitivity analyses were also performed by excluding participants with testosterone levels greater than 1000 ng/dL to evaluate the robustness of the results.

All statistical analyses were conducted using SPSS version 27.0 and R version 4.4.1. A two-tailed P-value of <0.05 was considered statistically significant for all analyses.

Results

Characteristics of the Participants

A total of 4,060 male participants were included in the final analysis, after excluding individuals with missing data on psoriasis, testosterone, sleep duration, and relevant covariates. Among them, 180 participants (4.4%) reported having a physician-diagnosed psoriasis, while the remaining 3,880 participants (95.6%) served as the control group. The mean age of participants was 48.65±17.74 years, with the psoriasis group being significantly older than the control group (53.69±16.71 vs 48.42±17.76 years, P=0.038). No significant differences were observed in the distribution of race/ethnicity, educational attainment, marital status, or smoking and alcohol consumption habits between the two groups. Notably, the psoriasis group had a higher prevalence of diabetes (P=0.029), although the prevalence of other comorbidities such as hypertension and hyperlipidemia was not significantly different. This baseline demographic and clinical profile highlights that psoriasis in this cohort may be associated with certain age-related or metabolic risk factors (Table 1).

Table 1 Baseline Characteristics of the Study Participants

Characteristics	Overall	Psoriasis		*P*-value
		No	Yes	
n	4060	3880	180	
Age, years	48.65±17.74	48.42±17.76	53.69±16.71	0.038
Race, n (%)				0.435
Mexican American	458(11.3%)	438(10.8%)	20(0.5%)	
Other Hispanic	346(8.5%)	330(8.1%)	16(0.4%)	
Non-Hispanic Black	1782(43.9%)	1693(41.7%)	89(2.2%)	
Non-Hispanic White	881(21.7%)	854(21.0%)	27(0.7%)	
Other races	593(14.6%)	565(13.9%)	28(0.7%)	
Education, n (%)				0.848
Less than 9th grade	304(7.5%)	286(7.0%)	18(0.5%)	
9–11th grade	533(13.1%)	511(12.6%)	22(0.5%)	
High school graduate	952(23.5%)	910(22.4%)	42(1.1%)	
Some college or AA degree	1182(29.1%)	1132(27.9%)	50(1.2%)	
College graduate or above	1089(26.8%)	1041(25.6%)	48(1.2%)	
Marital Status, n (%)				0.801
Married	2235(55.0%)	2129(52.4%)	106(2.6%)	
Widowed	167(4.1%)	159(3.9%)	8(0.2%)	
Divorced	368(9.1%)	351(8.7%)	17(0.4%)	
Separated	111(2.7%)	107(2.6%)	4(0.1%)	
Never married	858(21.1%)	826(20.3%)	32(0.8%)	
Living with partner	321(7.9%)	308(7.6%)	13(0.3%)	
PIR, n (%)				0.771
<=1	830(20.4%)	796(19.6%)	34(0.8%)	
1–3	1616(39.8%)	1542(38.0%)	74(1.8%)	
>3	1614(39.8%)	1542(38.0%)	72(1.8%)	
Smoke, n (%)				0.410
Yes	2129(52.4%)	2024(49.8%)	105(2.6%)	
No	1931(47.6%)	1856(45.7%)	75(1.9%)	

(*Continued*)

Table 1 (Continued).

Characteristics	Overall	Psoriasis		*P*-value
		No	Yes	
Alcohol Use, n(%)				0.328
Yes	3429(84.5%)	3272(80.6%)	157(3.9%)	
No	631(15.5%)	608(15.0%)	23(0.5%)	
Hypertension, n(%)				0.732
Yes	1461(36.0%)	1382(34.0%)	79(2.0%)	
No	2599(64.0%)	2498(61.5%)	101(2.5%)	
Hyperlipidemia, n(%)				0.500
Yes	1473(36.3%)	1390(34.2%)	83(2.1%)	
No	2587(63.7%)	2490(61.3%)	97(2.4%)	
Diabetes, n(%)				0.029
Yes	526(13.0%)	481(11.9%)	45(1.1%)	
Borderline	71(1.8%)	67(1.7%)	4(0.1%)	
No	3463(85.2%)	3332(82.0%)	131(3.2%)	
BMI				0.705
<25	1233(30.4%)	1188(29.3%)	45(1.1%)	
25–30	1628(40.1%)	1555(38.3%)	73(1.8%)	
≥30	1199(29.5%)	1137(28.0%)	62(1.5%)	

Note:n, number of participants. For categorical variables, values are expressed as frequency counts with percentages in parentheses. For continuous variables (eg, Age), values are expressed as mean ± standard deviation.

Associations Between Testosterone, Sleep Duration, and Psoriasis

In multivariable logistic regression analyses, both low testosterone levels and short sleep duration were significantly associated with an increased risk of psoriasis. As shown in Table 2, in the unadjusted model (Model 1), participants with testosterone levels below 300 ng/dL had an odds ratio (OR) of 3.18 (95% CI: 2.35–4.30, P<0.001) for psoriasis compared to those with normal testosterone levels. After adjusting for age and race (Model 2), this association remained significant (OR=2.99, 95% CI: 2.20–4.05, P<0.001). In the fully adjusted model (Model 3), which controlled for a comprehensive set of covariates including education, marital status, poverty-income ratio, smoking status, alcohol use, hypertension, hyperlipidemia, diabetes, and BMI, the association between low testosterone and psoriasis persisted with an OR of 2.97 (95% CI: 2.16–4.09, P<0.001). Similarly, short sleep duration (<7 hours per night) was independently associated with an increased risk of psoriasis, with an OR of 1.76 (95% CI: 1.33–2.35, P<0.001) in the fully adjusted model. These results suggest that both hormonal imbalances and inadequate sleep may contribute to the onset of psoriasis, potentially via pathways involving immune dysregulation and systemic inflammation.

Table 2 Weighted logistic Regression Analyses of Association Between Psoriasis and Testosterone and Sleep Duration

	Model 1		Model 2		Model 3	
	OR 95% CI	P value	OR 95% CI	P value	OR 95% CI	P value
Normal Testosterone<300	Reference 3.18(2.35,4.30)	 <0.001	Reference 2.99(2.20,4.05)	 <0.001	Reference 2.97(2.16,4.09)	 <0.001
Normal Sleep duration p for trend	Reference 1.51(1.15,1.98)	 0.003 <0.001	Reference 1.73(1.30,2.29)	 <0.001 <0.001	Reference 1.76(1.33,2.35)	 <0.001 <0.001

Notes: Model 1: Unadjusted Model 2: Adjusted for age and race. Model 3: Additionally, adjusted for marital status, education, poverty-income ratio smoke, alcohol Use, hypertension, hyperlipidemia, diabetes and BMI.

Non-Linear Associations Between Testosterone, Sleep Duration, and Psoriasis Risk: RCS Analysis

To further investigate the potential non-linear relationships between testosterone levels, sleep duration, and psoriasis risk, restricted cubic spline (RCS) regression models were applied. The RCS analysis for testosterone (Figure 2) revealed a steep increase in psoriasis risk as testosterone levels dropped below 300 ng/dL. The risk plateaued at lower testosterone levels, indicating that extremely low levels of testosterone might not provide additional risk beyond a certain threshold. Interestingly, testosterone levels above 700 ng/dL did not appear to offer any protective effect against psoriasis, suggesting a potential ceiling effect in the relationship between testosterone and psoriasis risk.

In the case of sleep duration, the RCS analysis (Figure 3) indicated a strong non-linear association between sleep duration and psoriasis. Participants who reported sleeping less than 7 hours per night had a substantially higher risk of psoriasis, with a steep increase in risk observed as sleep duration decreased. Conversely, sleep durations longer than 8 hours showed diminishing returns, with little additional risk reduction beyond 8 hours of sleep. These findings highlight the importance of both sufficient sleep and balanced hormonal levels in mitigating psoriasis risk.

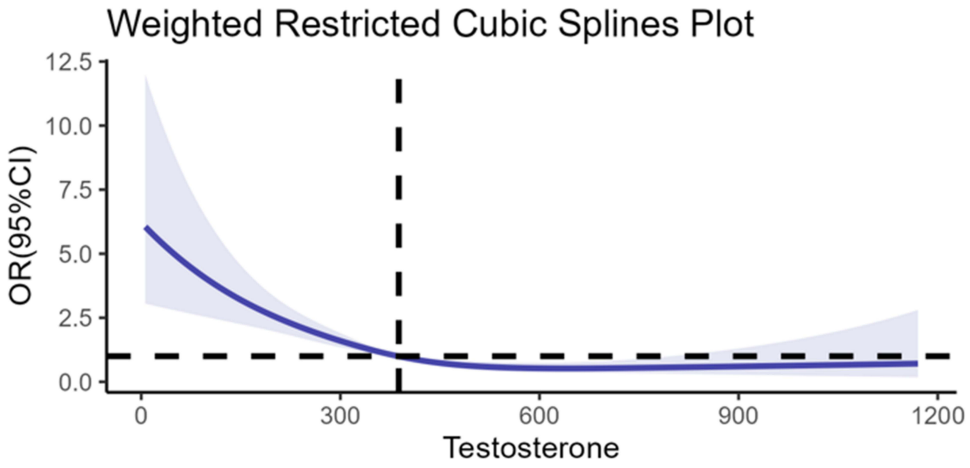

Figure 2 Weighted restricted cubic splines plot showing the relationship between testosterone levels and the odds ratio (OR) with 95% confidence interval (CI). A reference line is included at testosterone = 388. P total < 0.0001; P for nonlinear = 0.0017.

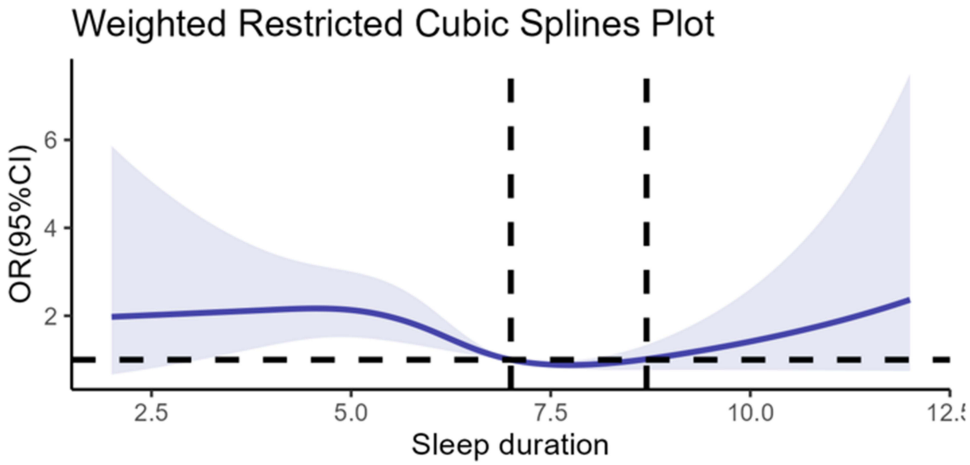

Figure 3 Weighted restricted cubic splines plot depicting the relationship between sleep duration and odds ratio (OR) with 95% confidence interval (CI). Reference lines are included at sleep duration = 7.0 and 8.7. P total < 0.0001; P for nonlinear = 0.0063.

https://doi.org/10.2147/CCID.S521594

Impact of Testosterone and Sleep Duration on Psoriasis Risk: Subgroup and Interaction Analyses

Subgroup analyses were conducted to examine the consistency of the associations between testosterone, sleep duration, and psoriasis across different demographic and clinical strata. The associations between low testosterone levels and psoriasis risk were generally consistent across subgroups defined by age, BMI, and smoking status (Figure 4). However, significant interactions were observed in certain subgroups. For example, the association between low testosterone levels and psoriasis was stronger in participants aged 50 years or older (P for interaction = 0.023), suggesting that age may amplify the effect of hormonal imbalances on psoriasis risk. Similarly, the association between short sleep duration and psoriasis was more pronounced in participants with higher BMI (P for interaction = 0.032), indicating that obesity may exacerbate the effects of sleep disturbances on psoriasis development. No significant interactions were found for smoking status. These interaction effects suggest that older adults and individuals with obesity may represent high-risk populations where hormonal imbalances and sleep disturbances are particularly impactful in driving psoriasis risk.

Sensitivity Analysis: Testing the Robustness of Findings After Excluding High Testosterone Levels

To test the robustness of the observed associations, a sensitivity analysis was conducted by excluding participants with testosterone levels greater than 1000 ng/dL, which represent potential outliers or individuals with abnormally high testosterone levels. As shown in Table 3, the results of the sensitivity analysis were consistent with the main analysis. Even after excluding these participants, low testosterone levels remained significantly associated with an increased risk of psoriasis (OR=2.98, 95% CI: 2.18–4.09, P<0.001), as did short sleep duration (OR=2.10, 95% CI: 1.54–2.86, P<0.001). The sensitivity analysis confirmed that the associations observed in the primary analysis were not driven by

Subgroup	n	OR(95%CI)	P value	P for interaction
Age				**0.466**
≤50	2189	3.56(2.20-5.76)	<0.001	
＞50	1871	2.83(1.92-4.21)	<0.001	
Race				**0.417**
Mexican American	458	2.80(1.12-5.02)	0.026	
Other Hispanic	346	3.23(1.17-6.26)	0.023	
Non-Hispanic Black	1782	2.75(1.79-4.25)	<0.001	
Non-Hispanic White	881	2.65(1.15-6.86)	<0.001	
Other races	593	3.43(1.58-7.52)	0.002	
BMI				**0.016**
<25	1233	8.26(4.48-15.4)	<0.001	
25-30	1628	2.07(1.27-3.34)	0.003	
≥30	1199	2.97(1.74-5.24)	<0.001	
Hypertension				**0.689**
Yes	1461	2.99(1.89-4.81)	0.006	
No	2599	3.30(2.20-4.94)	<0.001	
Diabetes				**0.437**
Yes	526	2.44(1.31-4.72)	0.006	
Borderline	71	1.29(0.78-1.62)	0.783	
No	3463	3.16(2.22-4.51)	<0.001	

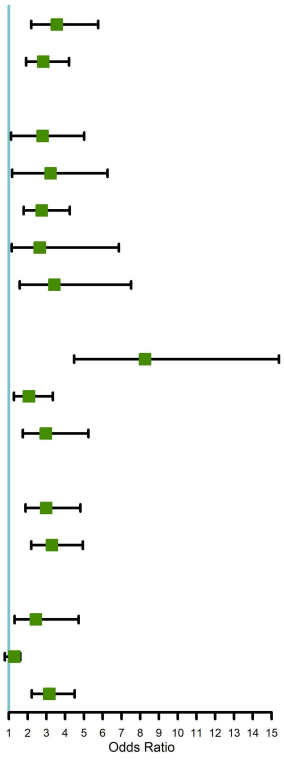

Figure 4 Verification of the association between testosterone, sleep duration and psoriasis by subgroup analyses and interaction analyses.Note:Bold column headers denote variable categories. Bold P values indicate statistical significance ($P < 0.05$). Bold interaction P values highlight significant subgroup effect modifiers. n represents the number of participants in each subgroup.

Table 3 Sensitivity Analysis of the Association Between Psoriasis, Testosterone, and Sleep Duration After Excluding Participants with Testosterone Levels >1000 ng/dL

	Model 1		Model 2		Model 3	
	OR 95% CI	**P value**	**OR 95% CI**	**P value**	**OR 95% CI**	**P value**
Normal Testosterone<300	Reference 3.24(2.40–4.41)	 <0.001	Reference 3.04(2.24–4.13)	 <0.001	Reference 2.98(2.18–4.09)	 <0.001
Normal Sleep duration p for trend	Reference 2.05(1.51–2.78)	 <0.001 <0.001	Reference 2.14(1.58–2.92)	 <0.001 <0.001	Reference 2.10(1.54–2.86)	 <0.001 <0.001

Notes: Model 1: Unadjusted Model 2: Adjusted for age and race. Model 3: Additionally, adjusted for marital status, education, poverty-income ratio smoke, alcohol Use, hypertension, hyperlipidemia, diabetes and BMI.

extreme values of testosterone, reinforcing the robustness and generalizability of the findings. These results suggest that even within a more conservative range of testosterone levels, the associations between low testosterone, inadequate sleep, and psoriasis remain significant and clinically relevant.

Discussion

In this study, we investigated the association between testosterone levels, sleep duration, and psoriasis risk in a nationally representative cohort from the NHANES dataset (2011–2014). Our findings indicate that low testosterone levels and insufficient sleep are both significantly associated with an increased risk of psoriasis. These results align with existing literature on hormonal imbalances, sleep disturbances, and psoriasis, while also providing new insights into the combined effects of these factors in a large, diverse population.

Our findings on the association between low testosterone levels and increased psoriasis risk are consistent with previous studies that have explored the role of hormonal factors in autoimmune diseases.[41,42] Testosterone is known for its immunomodulatory effects, and previous research has indicated that lower testosterone levels may contribute to an inflammatory environment that exacerbates psoriasis.[43] For example, a study by Guarneri et al found that male psoriasis patients had lower serum testosterone levels compared to healthy controls,[44] a finding that resonates with our results. Similarly, research by Eltaweel et al demonstrated that testosterone replacement therapy in men with hypogonadism could improve psoriasis symptoms, further suggesting a protective role of testosterone.[45]

The association between sleep duration and psoriasis risk observed in our study is also supported by previous research that highlights the role of sleep in immune function and chronic inflammation.[46,47] Studies have shown that insufficient sleep is associated with elevated levels of pro-inflammatory cytokines, which play a key role in psoriasis pathogenesis.[48] A recent cohort study by Gupta et al found that individuals with shorter sleep durations had a higher risk of developing psoriasis, similar to our findings.[49] Collectively, these studies emphasize the importance of both hormonal balance and adequate sleep in managing psoriasis risk.

Testosterone's role in modulating immune responses may provide insight into its relationship with psoriasis. Testosterone acts on various immune cells, including T-cells, macrophages, and dendritic cells, to regulate the production of pro-inflammatory cytokines such as tumor necrosis factor-alpha (TNF-α), interleukin-17 (IL-17), and interleukin-23 (IL-23), all of which are critical in psoriasis pathogenesis.[50,51] Low testosterone levels are associated with an over-activation of the Th17 pathway, leading to excessive production of IL-17 and IL-23, which are key drivers of the chronic inflammation observed in psoriasis.[52,53] Furthermore, testosterone deficiency has been linked to altered skin barrier function, making the skin more susceptible to environmental triggers that can initiate or exacerbate psoriasis.[54,55]

Sleep deprivation exacerbates this inflammatory state by disrupting the hypothalamic-pituitary-adrenal (HPA) axis, leading to increased cortisol production and systemic inflammation.[56] Sleep disturbances can also impair the body's ability to regulate immune responses, further amplifying the pro-inflammatory environment that contributes to psoriasis.[57,58] Our study contributes to the growing body of evidence suggesting that hormonal dysregulation and sleep deprivation may act synergistically to promote psoriatic inflammation.[45,59]

One of the key strengths of our study is the use of a large, nationally representative sample from NHANES, which enhances the generalizability of our findings. The diversity of the NHANES cohort allows us to examine the association between testosterone, sleep, and psoriasis across different racial, ethnic, and socioeconomic groups.[60] Additionally, our use of restricted cubic spline (RCS) regression analysis enabled us to explore non-linear relationships between testosterone levels, sleep duration, and psoriasis risk, offering a more nuanced understanding of these associations.[61]

Another strength lies in the comprehensive adjustment for potential confounders, including age, race, BMI, education, smoking status, and comorbid conditions such as hypertension and diabetes. By controlling for these variables, we were able to more accurately estimate the independent effects of testosterone and sleep on psoriasis risk.[62,63]

Despite these strengths, there are several limitations to our study that warrant consideration. First, the cross-sectional nature of NHANES data limits our ability to establish causal relationships between testosterone, sleep duration, and psoriasis. Longitudinal studies would be necessary to confirm the directionality of these associations.[64] Second, the reliance on self-reported data for psoriasis diagnosis and sleep duration may introduce recall bias, potentially leading to misclassification of psoriasis status or inaccurate reporting of sleep habits.[65,66]

Additionally, while our study adjusted for a wide range of covariates, residual confounding cannot be completely ruled out. Factors such as stress levels, dietary habits, and physical activity, which may influence both testosterone levels and psoriasis risk, were not accounted for in our analysis.[67] Lastly, the exclusion of women from our analysis means that our findings may not be generalizable to female populations, where hormonal dynamics differ significantly from men.[68]

Our findings highlight the need for future research to explore the interplay between hormonal regulation, sleep, and immune function in psoriasis. Longitudinal studies could help clarify the causal pathways linking testosterone and sleep to psoriasis risk. Additionally, investigating the effects of testosterone replacement therapy and sleep interventions in psoriasis patients could provide valuable insights into potential therapeutic strategies.[69] Finally, exploring sex differences in these associations may offer a more comprehensive understanding of how hormonal and lifestyle factors contribute to psoriasis risk in both men and women.

However, self-reported psoriasis and sleep data may introduce recall bias, although NHANES protocols mitigate this limitation through standardized questionnaires.

Conclusion

In conclusion, our study demonstrates that low testosterone levels and insufficient sleep are independently associated with an increased risk of psoriasis in a large, diverse population.These findings highlight the potential for targeted interventions, such as testosterone replacement in hypogonadal males and sleep hygiene programs, to mitigate psoriasis risk. Longitudinal studies are warranted to confirm causality and explore sex-specific mechanisms.

Ethics Statement

The studies involving humans were approved by Ethics Review Committee of the National Center for Health Statistics. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study. In accordance with Article 32 of the Measures for Ethical Review of Life Science and Medical Research Involving Human Subjects (China, February 18, 2023), this analysis of de-identified, publicly accessible data is exempt from requiring additional approval from an Institutional Review Board.

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.

Disclosure

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

References

1. Boehncke WH, Mp S. Psoriasis. *Lancet*. 2015;386(9997):983–994. doi:10.1016/S0140-6736(14)61909-7
2. Kamiya K, Kishimoto M, Sugai J, Komine M, Ohtsuki M. Risk factors for the development of psoriasis. *Int J Mol Sci*. 2019;20(18):4347. doi:10.3390/ijms20184347
3. Zabotti A, De Marco G, Gossec L, et al. EULAR points to consider for the definition of clinical and imaging features suspicious for progression from psoriasis to psoriatic arthritis. *Ann Rheum Dis*. 2023;82(9):1162–1170. doi:10.1136/ard-2023-224148
4. Parisi R, Iskandar IYK, Kontopantelis E, et al. National, regional, and worldwide epidemiology of psoriasis: systematic analysis and modelling study. *BMJ*. 2020;369:m1590. doi:10.1136/bmj.m1590
5. Foley P, Tsai TF, Rodins K, et al. Effectiveness and safety of secukinumab for psoriasis in a real-world clinical setting in the Asia-pacific and middle east regions: results from the realia study. *Dermatol Ther*. 2022;12(2):511–527. doi:10.1007/s13555-021-00675-w
6. Mahé E, Tubach F, Jullien D, et al. PSOBIOTEQ registry investigators. impact of childhood onset psoriasis on addictive behaviours, socioeconomic and educational data in adulthood. *Acta Derm Venereol*. 2022;102:adv00733. doi:10.2340/actadv.v102.2484
7. Founta O, Adamzik K, Tobin AM, Kirby B, Hevey D. Psychological distress, alexithymia and alcohol misuse in patients with psoriasis: a cross-sectional study. *J Clin Psychol Med Settings*. 2019;26(2):200–219. doi:10.1007/s10880-018-9580-9
8. Blackstone B, Patel R, Bewley A. Assessing and Improving psychological well-being in psoriasis: considerations for the clinician. *CDATA Psoriasis: Targets and Therapy*. 2022;12:25–33. doi:10.2147/PTT.S328447
9. Zhang L, Wang Y, Qiu L, Wu J. Psoriasis and cardiovascular disease risk in European and East Asian populations: evidence from meta-analysis and Mendelian randomization analysis. *BMC Med*. 2022;20(1):421. doi:10.1186/s12916-022-02617-5
10. Gisondi P, Fostini AC, Fossà I, Girolomoni G, Targher G. Psoriasis and the metabolic syndrome. *Clin Dermatol*. 2018;36(1):21–28. doi:10.1016/j.clindermatol.2017.09.005
11. Takeshita J, Grewal S, Langan SM, et al. Psoriasis and comorbid diseases: epidemiology. *J Am Acad Dermatol*. 2017;76(3):377–390. doi:10.1016/j.jaad.2016.07.064
12. Yeung J, Bunce PE, Lynde CW, Turchin I, Vender RB. Review and practical guidance on managing fungal infections in patients with psoriasis receiving anti-IL-17 Therapies. *J Cutan Med Surg*. 2022;26(1_suppl):3S–23S. doi:10.1177/12034754221111111
13. Jensen P, Skov L. Psoriasis and Obesity. *Dermatology*. 2016;232(6):633–639. doi:10.1159/000455840
14. Sachen KL, Arnold Greving CN, Towne JE. Role of IL-36 cytokines in psoriasis and other inflammatory skin conditions. *Cytokine*. 2022;156:155897. doi:10.1016/j.cyto.2022.155897
15. Aleem D, Tohid H. Pro-inflammatory cytokines, biomarkers, genetics and the immune system: a mechanistic approach of depression and psoriasis. *Rev Colomb Psiquiatr*. 2018;47(3):177–186. doi:10.1016/j.rcp.2017.03.002
16. Hao Y, Zhu YJ, Zou S, et al. Metabolic syndrome and psoriasis: mechanisms and future directions. *Front Immunol*. 2021;12:711060. doi:10.3389/fimmu.2021.711060
17. Marek-Jozefowicz L, Czajkowski R, Borkowska A, et al. The brain-skin axis in psoriasis-psychological, psychiatric, hormonal, and dermatological aspects. *Int J Mol Sci*. 2022;23(2):669. doi:10.3390/ijms23020669
18. Musumeci ML, Nasca MR, Boscaglia S, Micali G. The role of lifestyle and nutrition in psoriasis: current status of knowledge and interventions. *Dermatol Ther*. 2022;35(9):e15685. doi:10.1111/dth.15685
19. Wu JJ, Kavanaugh A, Lebwohl MG, Gniadecki R, Merola JF. Psoriasis and metabolic syndrome: implications for the management and treatment of psoriasis. *J Eur Acad Dermatol Venereol*. 2022;36(6):797–806. doi:10.1111/jdv.18044
20. Korman NJ. Management of psoriasis as a systemic disease: what is the evidence? *Br J Dermatol*. 2020;182(4):840–848. doi:10.1111/bjd.18245
21. Gudu T, Gossec L. Quality of life in psoriatic arthritis. *Expert Rev Clin Immunol*. 2018;14(5):405–417. doi:10.1080/1744666X.2018.1468252
22. Cassalia F, Belloni Fortina A. Psoriasis in women with psoriatic arthritis: hormonal effects, fertility, and considerations for management at different stages of life. *Reumatismo*. 2024;76(3). doi:10.4081/reumatismo.2024.1775
23. Goldman AL, Bhasin S, Wu FCW, Krishna M, Matsumoto AM, Jasuja R. A reappraisal of testosterone's binding in circulation: physiological and clinical implications. *Endocr Rev*. 2017;38(4):302–324. doi:10.1210/er.2017-00025
24. Storer TW, Basaria S, Traustadottir T, et al. Effects of testosterone supplementation for 3 years on muscle performance and physical function in older men. *J Clin Endocrinol Metab*. 2017;102(2):583–593. doi:10.1210/jc.2016-2771
25. Pencina KM, Travison TG, Cunningham GR, et al. Effect of testosterone replacement therapy on sexual function and hypogonadal symptoms in men with hypogonadism. *J Clin Endocrinol Metab*. 2024;109(2):569–580. doi:10.1210/clinem/dgad484
26. Mohamad NV, Wong SK, Wan Hasan WN, et al. The relationship between circulating testosterone and inflammatory cytokines in men. *Aging Male*. 2019;22(2):129–140. doi:10.1080/13685538.2018.1482487
27. Barbosa LP, da Silva Aguiar S, Santos PA, et al. Relationship between inflammatory biomarkers and testosterone levels in male master athletes and non-athletes. *Exp Gerontol*. 2021;151:111407. doi:10.1016/j.exger.2021.111407
28. Özer İ, Temiz SA, Ataseven A, Dursun R, Uyar M, Özer M. Is prenatal testosterone-estrogen balance associated with psoriasis? *Dermatol Ther*. 2020;33(6):e14213. doi:10.1111/dth.14213
29. Chasens ER, Imes CC, Kariuki JK, et al. Sleep and metabolic syndrome. *Nurs Clin North Am*. 2021;56(2):203–217. doi:10.1016/j.cnur.2020.10.012
30. Smiley A, King D, Bidulescu A. The association between sleep duration and metabolic syndrome: the NHANES 2013/2014. *Nutrients*. 2019;11(11):2582. doi:10.3390/nu11112582
31. Fullagar HH, Skorski S, Duffield R, Hammes D, Coutts AJ, Meyer T. Sleep and athletic performance: the effects of sleep loss on exercise performance, and physiological and cognitive responses to exercise. *Sports Med*. 2015;45(2):161–186. doi:10.1007/s40279-014-0260-0
32. Vlami K, Pantelidi K, Dalamaga M, et al. Psoriatic insomnia: a subjective and objective sleep evaluation. *Acta Derm-Venereol*. 2023;103:adv00864. doi:10.2340/actadv.v103.4507

33. Halioua B, Chelli C, Misery L, Taieb J, Taieb C. Sleep disorders and psoriasis: an update. *Acta Derm Venereol*. 2022;102:adv00699. doi:10.2340/actadv.v102.1991
34. Controne I, Scoditti E, Buja A, et al. Do sleep disorders and western diet influence psoriasis? A scoping review. *Nutrients*. 2022;14(20):4324. doi:10.3390/nu14204324
35. Takeshita J, Grewal S, Langan SM, et al. Psoriasis and comorbid diseases: implications for management. *J Am Acad Dermatol*. 2017;76(3):393–403. doi:10.1016/j.jaad.2016.07.065
36. Ruan Z, Lu T, Chen Y, et al. Association between psoriasis and nonalcoholic fatty liver disease among outpatient US adults. *JAMA Dermatol*. 2022;158(7):745–753. doi:10.1001/jamadermatol.2022.1609
37. Lu J, Li H, Wang S. Interaction effect of psoriasis and chronic kidney disease on the risk of all-cause mortality: a prospective cohort study of NHANES data. *Nephrol Dial Transplant*. 2023;38(11):2474–2484. doi:10.1093/ndt/gfad089
38. Huang D, Ma R, Zhong X, et al. Positive association between different triglyceride glucose index-related indicators and psoriasis: evidence from NHANES. *Front Immunol*. 2023;14:1325557. doi:10.3389/fimmu.2023.1325557
39. Ortona E, Pierdominici M, Maselli A, Veroni C, Aloisi F, Shoenfeld Y. Sex-based differences in autoimmune diseases. Ann Ist Super Sanita. *Annali dell'Istituto Superiore Di Sanita*. 2016;52(2):205–212. doi:10.4415/ANN_16_02_12
40. Watson NF, Badr MS, Belenky G, et al. Recommended amount of sleep for a healthy adult: a joint consensus statement of the American Academy of Sleep Medicine and Sleep Research Society. *SLEEP*. 2015;38(6):843–844. doi:10.5665/sleep.4716
41. Jaiswal SJ, Quer G, Galarnyk M, et al. Association of sleep duration and variability with body mass index: sleep measurements in a large US population of wearable sensor users. *JAMA Intern Med*. 2020;180(12):1694–1696. doi:10.1001/jamainternmed.2020.2834
42. Kravchenko V, Zakharchenko T. Thyroid hormones and minerals in immunocorrection of disorders in autoimmune thyroid diseases. *Front Endocrinol*. 2023;14:1225494. doi:10.3389/fendo.2023.1225494
43. Nolasco-Pérez TJ, Cervantes-Candelas LA, Buendía-González FO, et al. Immunomodulatory effects of testosterone and letrozole during Plasmodium berghei ANKA infection. *Front Cell Infect Microbiol*. 2023;13:1146356. doi:10.3389/fcimb.2023.1146356
44. Eltaweel AEAI, Ai M, El-Shimi OS, Algaod FA. Sex hormones, erectile dysfunction, and psoriasis; a bad friendship! *Int J Dermatol*. 2018;57(12):1481–1484. doi:10.1111/ijd.14178
45. Besedovsky L, Lange T, Haack M. The sleep-immune crosstalk in health and disease. *Physiol Rev*. 2019;99(3):1325–1380. doi:10.1152/physrev.00010.2018
46. Krueger JM, Frank MG, Wisor JP, Roy S. Sleep function: toward elucidating an enigma. *Sleep Med Rev*. 2016;28:46–54. doi:10.1016/j.smrv.2015.08.005
47. Nobari H, Banihashemi M, Saedmocheshi S, Prieto-González P, Oliveira R. Overview of the impact of sleep monitoring on optimal performance, immune system function and injury risk reduction in athletes: a narrative review. *Sci Prog*. 2023;106(4):368504231206265. doi:10.1177/00368504231206265
48. Anderson MS, Chinoy ED, Harrison EM, Myers CA, Markwald RR. Sleep immune function, and vaccinations in military personnel: challenges and future directions. *Mil Med*. 2023;188(11–12):296–299. doi:10.1093/milmed/usad119
49. Gupta MA, Simpson FC, Gupta AK. Psoriasis and sleep disorders: a systematic review. *Sleep Med Rev*. 2016;29:63–75. doi:10.1016/j.smrv.2015.09.003
50. Shepherd R, Cheung AS, Pang K, Saffery R, Novakovic B. Sexual dimorphism in innate immunity: the role of sex hormones and epigenetics. *Front Immunol*. 2021;11:604000. doi:10.3389/fimmu.2020.604000
51. Lakshmikanth T, Consiglio C, Sardh F, et al. Immune system adaptation during gender-affirming testosterone treatment. *Nature*. 2024;633(8028):155–164. doi:10.1038/s41586-024-07789-z
52. Sheikh-Ahmad M, Nakhleh A, Riskin A, et al. The correlation between testosterone, inflammation and cytokine status in type-2 diabetes men. *Andrologia*. 2022;54(10):e14526. doi:10.1111/and.14526
53. Yang Y, Xia J, Yang Z, Wu G, Yang J. The abnormal level of HSP70 is related to Treg/Th17 imbalance in PCOS patients. *J Ovarian Res*. 2021;14(1):155. doi:10.1186/s13048-021-00867-0
54. Brackin T, Gayes H, Johnson I, Fox D, Roper C. Skin barrier function for regulatory skin absorption tests and effects on testosterone and sucrose absorption. *Toxicol in Vitro*. 2024;95:105735. doi:10.1016/j.tiv.2023.105735
55. Salminen AT, Davis KJ, Felton RP, et al. Parallel evaluation of alternative skin barrier models and excised human skin for dermal absorption studies in vitro. *Toxicol in Vitro*. 2023;91:105630. doi:10.1016/j.tiv.2023.105630
56. Nicolaides NC, Vgontzas AN, Kritikou I. *Endotext [Internet]*. South Dartmouth (MA): MDText.com, Inc; 2000. PMID: 25905298.
57. Nollet M, Wisden W, Franks NP. Sleep deprivation and stress: a reciprocal relationship. *Interface Focus*. 2020;10(3):20190092. doi:10.1098/rsfs.2019.0092
58. Gao T, Wang Z, Dong Y, et al. Role of melatonin in sleep deprivation-induced intestinal barrier dysfunction in mice. *J Pineal Res*. 2019;67(1):e12574. doi:10.1111/jpi.12574
59. Eissa N, Mujawar Q, Alabdoulsalam T, Zohni S, El-Matary W. The immune-sleep crosstalk in inflammatory bowel disease. *Sleep Med*. 2020;73:38–46. doi:10.1016/j.sleep.2020.04.020
60. Iranpour S, Sabour S. Inverse association between caffeine intake and depressive symptoms in US adults: data from National Health and Nutrition Examination Survey (NHANES) 2005-2006. *Psychiatry Res*. 2019;271:732–739. doi:10.1016/j.psychres.2018.11.004
61. Liu X, Liu X, Wang Y, Zeng B, Zhu B, Dai F. Association between depression and oxidative balance score: national Health and Nutrition Examination Survey (NHANES) 2005-2018. *J Affect Disord*. 2023;337:57–65. doi:10.1016/j.jad.2023.05.071
62. Shen R, Zou T. The association between cardiovascular health and depression: results from the 2007-2020 NHANES. *Psychiatry Res*. 2024;331:115663. doi:10.1016/j.psychres.2023.115663
63. Tan Y, Fu Y, Yao H, et al. Relationship between phthalates exposures and hyperuricemia in U.S. general population, a multi-cycle study of NHANES 2007-2016. *Sci Total Environ*. 2023;859(Pt 1):160208. doi:10.1016/j.scitotenv.2022.160208
64. Wilson FC, Icen M, Crowson CS, McEvoy MT, Gabriel SE, Kremers HM. Incidence and clinical predictors of psoriatic arthritis in patients with psoriasis: a population-based study. *Arthritis Rheum*. 2009;61(2):233–239. doi:10.1002/art.24172
65. Ma J, Sun X, Wu Z, Qi R, Niu J. Correlation between the systemic immune inflammation index and risk of psoriasis: results from NHANES. *Eur J Dermatol*. 34(1):31–39. doi:10.1684/ejd.2024.4610

66. Hu M, Wang Y, Xu W, Bai J, Tang X. The impact of serum uric acid on psoriasis: NHANES 2005-2014 and Mendelian randomization. *Front Genet*. 2024;15:1334781. doi:10.3389/fgene.2024.1334781
67. Liu N, Zhang C, Hua W. Dietary inflammatory potential and psoriasis: a cross-sectional study. *J Dermatol*. 2023;50(5):692–699. doi:10.1111/1346-8138.16731
68. Gu Y, Ye X, Zhao W, He S, Zhang W, Zeng X. The circadian syndrome is a better predictor for psoriasis than the metabolic syndrome via an explainable machine learning method - the NHANES survey during 2005-2006 and 2009-2014. *Front Endocrinol*. 2024;15:1379130. doi:10.3389/fendo.2024.1379130
69. Xu JR, Zheng DX, Ahn AB, et al. Psoriasis and chronic kidney disease among the United States adult population. *J Am Acad Dermatol*. 2023;89(4):834–837. doi:10.1016/j.jaad.2023.06.011