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Original Research

Association between the Frailty Index and psoriasis: a cross-sectional study of the U.S. NHANES 2003–2006

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ABSTRACT

Background: Psoriasis is a chronic inflammatory skin disease often accompanied by various comorbidities, but its relationship with frailty remains understudied. The Frailty Index (FI), calculated based on 49 health deficits across multiple systems (e.g., cognition, function, comorbidities, laboratory values) was used as a continuous measure.

Objectives: We investigated the association between psoriasis and the Frailty Index (FI), providing evidence to support the implementation of frailty screening and potential interventions in patients with psoriasis.

Design and setting: This cross-sectional study used data from the 2003–2006 U.S. National Health and Nutrition Examination Survey (NHANES) including 6532 participants.

Measurements: We analyzed the psoriasis–FI relationship using weighted nested regression, supplemented by subgroup analyses and restricted cubic spline regression to test for nonlinear relationships.

Results: The FI was significantly higher in patients with psoriasis ($n = 162$) than in those without ($n = 6370$; $P < 0.001$). Weighted nested regression analysis showed a significant positive association between FI and psoriasis (OR 2.22; 95% CI 1.14–4.35; $P = 0.02$). The association was stronger for male patients, those with normal body mass index, hypertension, and diabetes. Nonlinear relationships were observed between FI and psoriasis.

Conclusions: The present study validates the association between psoriasis and frailty using a nationally representative sample and provides empirical support for integrating frailty evaluations into psoriasis care. Our findings are consistent with the hypothesis that chronic inflammatory pathways may underlie the association between psoriasis and frailty.

1. Background

As a chronic inflammatory skin disorder mediated by immune mechanisms, psoriasis affects roughly 2 %–3 % of the global population [1]. Psoriasis is a chronic immune-mediated inflammatory disease, characterized not only by cutaneous manifestations (e.g., erythematous, scaly plaques [2,3]) but also by a state of systemic inflammation that links it to numerous comorbidities. The development of psoriasis is closely related to genetic predispositions, immune system abnormalities, environmental triggers, and other factors [4]. Moreover, psoriasis is often accompanied by obesity and obesity-related metabolic disorders such as metabolic syndrome, dyslipidemia, hypertension, type 2 diabetes mellitus, nonalcoholic fatty liver disease, obstructive sleep apnea/hypopnea, and cardiovascular disease, suggesting that it may be a part of a systemic inflammatory disorder [5,6]. Additionally, psoriasis is associated with a variety of comorbidities, such as depression and anxiety [7,8].

Frailty is an age-related clinical syndrome characterized by decreased physiological reserve, multisystem dysfunction, and increased vulnerability to stressful events [9]. Frailty is associated with several adverse outcomes, including reduced quality of life, increased mortality, hospitalization, falls, depression, and dementia [10]. Frailty is strongly associated with a variety of chronic inflammatory diseases, such as cardiovascular disease [11], metabolic syndrome [12], and inflammatory bowel disease [13,14]. Chronic inflammation is considered an important pathological bases of frailty, and psoriasis, a low-grade chronic inflammatory disease, may promote frailty.

Frailty is more prevalent in older patients with psoriasis than in healthy controls [15,16]. However, there is currently a gap in epidemiological research on the relationship between psoriasis and frailty,

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and a particular lack of empirical data based on nationally representative samples. The U.S. National Health and Nutrition Examination Survey (NHANES), a nationally representative database, may help reveal the potential link between the two at a macro level and provide a scientific basis for screening and intervention in patients with psoriasis.

2. Methods

2.1. Study design and population

We employed a cross-sectional research design, and the data were collected from the U.S. NHANES, a national survey conducted by the U. S. National Center for Health Statistics (NCHS) to assess the nutritional status and health of the ambulatory population in the United States of America [17]. The survey employs a stratified, multistage probability sampling design that is highly representative of the health status of the U.S. adult population. NHANES data from 2003 to 2006 were used in this study. Comprehensive documentation regarding the NHANES sampling methodology, including multistage probability sampling design and weighting procedures, is available through the official study protocols [18,19]. The 2003–2006 survey cycles were selected because they provided both the consistent psoriasis diagnosis variable (MCQ160A) and the comprehensive set of clinical and laboratory measures required for the robust construction of the 49-item Frailty Index. The exclusion criteria included: 1) participants with a missing, refused, or 'don't know' response to the psoriasis diagnosis question (MCQ160A); and 2) participants with missing data on any of the key covariates listed in the subsequent subsection. Ultimately, data from 6532 patients were included in this study . The original NHANES protocols were approved by the National Center for Health Statistics Research Ethics Review Board, and written informed consent was obtained from all participants. As this analysis utilized de-identified, publicly available data, additional institutional review board approval was not required.

2.2. Definition of variables

2.2.1. Exposure variable

The exposure variable was psoriasis, according to the questionnaire variable MCQ160A ("Ever been diagnosed with psoriasis by a doctor?"). A diagnosis of psoriasis was made if the participant answered 'yes' to MCQ160A. The validity of self-reported physician-diagnosed psoriasis in NHANES and similar large cohorts has been established, showing good specificity and moderate sensitivity when compared to medical record review or dermatologist confirmation [20].

2.2.2. Dependent variable

The Frailty Index (FI) represents a continuous quantitative variable ranging from 0 (absence of frailty) to 1 (maximal frailty), with values reflecting gradations in frailty severity. The FI incorporates 49 diagnostic criteria following Rockwood's standardized procedure [21]. The following systems were assessed: cognitive function (including information integration and memory impairment), dependence status (assessed through activities of daily living), depressive symptoms (measured by the Patient Health Questionnaire-9 scale), comorbid conditions (including but not limited to osteoarthritis, diabetes, and chronic kidney disease), health status indicators and healthcare utilization patterns, physical capacity measures (handgrip strength and body mass index), and laboratory biomarkers (including glycated hemoglobin [HbA_{1c}] and complete blood count parameters [hemoglobin concentration and lymphocyte count]). Cognitive function was assessed using the Digit Symbol Substitution Test (DSST), a validated psychometric tool from the Wechsler Adult Intelligence Scale that measures processing speed, executive function, and working memory [22].The validity of this approach has been established through large-scale population studies [23]. These characteristics were recorded in at least 80 % of the patients. Depending on the severity of the defect, a value between 0 and 1 is assigned, allowing continuous and categorical variables to be combined. Calculation of the FI involves computing the proportion of observed deficits relative to the total possible deficits, producing a continuous scale where 0 represents a complete absence of frailty and 1 indicates the most severe frailty state, with higher values being associated with greater frailty (Supplementary Table 1).

2.3. Covariates

To minimize the impact of confounding variables on study outcomes, our study included the following covariates: sex (male or female), age (years), race (non-Hispanic black/non-Hispanic white/other Hispanic/other race), educational attainment (less than high school/high school and equivalent/high school and above), marital status (living alone/married or cohabitating), poverty-to-income ratio (PIR), body mass index (normal/overweight/obese), alcohol consumption (yes/no), smoking (yes/no), physical activity (yes/no), dyslipidemia (yes/no), hypertension (yes/no), and diabetes (yes/no). We adjusted for known covariates. For demographic data and physical examination data, we adjusted for a variety of confounders, including age group, sex, race, educational attainment, marital status, smoking status, alcohol use, the poverty–income ratio (PIR), hypertension, and diabetes mellitus. Body mass index (BMI) = weight/height^2 (weight in kilograms; height in meters), where underweight/normal ($<$25 kg/m^2), overweight (25–29.9 kg/m^2), or obese ($>$30 kg/m^2). A diagnosis of diabetes mellitus was determined based on the following conditions: glycosylated hemoglobin $\geq$6.5 %, fasting plasma glucose level $\geq$7 mmol/L, self-reported physician diagnosis, or use of oral hypoglycemic agents or insulin. Hypertension was defined as a systolic blood pressure $\geq$130 mm Hg, diastolic blood pressure $\geq$80 mm Hg, self-reported physician diagnosis, or the use of antihypertensive medications.

2.4. Statistical analysis

Statistical analysis was performed using R version 4.3.3. Continuous variables in the survey baseline table are expressed as the means (standard deviations), and categorical data are expressed as the sample size or frequency, n (%). Analytical methods included Welch two-sample *t* and Pearson chi-square tests to assess differences in baseline characteristics. The Boruta algorithm was used to identify significant variables. Three different models were developed using weighted nested regression analysis to assess the correlation between the independent and dependent variables. Model 1 was unadjusted for any potential confounding variables. Model 2 was demographically adjusted for age, sex, and racial composition. Model 3 expanded these covariates by incorporating variables including age, sex, race, BMI, alanine aminotransferase (ALT), aspartate aminotransferase (AST), neutrophil count (NC), hemoglobin (HGB), C-reactive protein (CRP), high-density lipoprotein (HDL), total cholesterol (TC), hypertension, and diabetes. After adjusting for important confounding variables, the relationship between the FI and psoriasis was evaluated using restricted cubic spline (RCS) regression, which allows for nonlinear parametric estimation. The variance inflation factor (VIF) was computed for all variables in the fully adjusted model to assess multicollinearity; all VIF values were below 5, indicating no significant multicollinearity. In addition, we conducted subgroup analyses based on age, BMI, diabetes, and hypertension. For all statistical comparisons, significance was defined a priori as a two-tailed $P < 0.05$.

3. Results

3.1. Baseline characteristics of the patients

We included data from a total of 6532 patients, with a mean age of 37.55 $\pm$ 11.22 years, who had been enrolled in the survey. Of these, 47

% were men and 53 % were women. We categorized the patients into two groups based on their psoriasis status. Table 1 shows that patients with psoriasis had a greater mean age, BMI, and ALT, a higher percentage of non-Hispanic whites, a higher prevalence of hypertension, and a higher prevalence of living alone than did those without psoriasis.

3.2. Feature selection based on the Boruta algorithm

Boruta is a feature selection algorithm based on the random forest model. The algorithm can help identify the features that contribute most to model performance, thereby improving the accuracy and interpretability of the model [24,25]. Fig. 1 shows the results of feature selection using the Boruta algorithm. Variables identified as important features are marked in red, whereas those considered unimportant are marked in green. The variables most strongly associated with psoriasis are ALT, AST, HGB, FI, hypertension, CRP, sex, HDL, age, NC, ethnicity, BMI, diabetes, and TC.

3.3. Correlations between frailty indices and psoriasis

According to the unadjusted model (Model 1), higher FI measurements were significantly associated with a greater likelihood of psoriasis occurrence (OR 1.34; 95 % CI 1.20–1.49; $P < 0.001$). In the partially adjusted model (Model 2), the positive association of FI with psoriasis remained significant (OR 1.31; 95 % CI 1.16–1.48; $P < 0.001$). In the model adjusted for multiple significant variables (Model 3), the positive association between FI and psoriasis remained more significant (OR 1.28; 95 % CI 1.10–1.49; $P = 0.004$). The prevalence of psoriasis was significantly greater in the fourth interval of the FI than in the lowest interval of the FI (OR 2.22; 95 % CI 1.14–4.35; $P = 0.02$), and similar results were found in unadjusted Model 1 and partially adjusted Model 2. In addition, a test for a trend in Model 3 ($P = 0.01$) indicated that psoriasis was associated with a greater FI. The effect estimates remained stable when comparing the fully adjusted model to both the crude (Model 1) and demographic-adjusted (Model 2) specifications. The details are shown in Table 2. The RCS curves (Fig. 2) revealed a statistically significant nonlinear relationship between FI and psoriasis (P (overall) = 0.001, nonlinearity < 0.05). As the FI increased from 0.06 to 0.18, the odds ratio for psoriasis increased from 1 to 2.13 (1.40–3.24), indicating progressively elevated psoriasis risk with higher FI levels.

3.4. Subgroup analysis and interaction effects

Effect modification was assessed through subgroup analyses (Fig. 3) by key clinical variables: age, BMI, diabetes, and hypertension. Significant associations were found for male patients, individuals with a normal BMI, and patients with hypertension or diabetes (all $P < 0.05$). We subsequently conducted an interaction study for each variable and showed that both hypertension and diabetes in the model had an interaction effect on the FI ($P < 0.05$).

4. Discussion

In the present study, we investigated the relationship between the FI and psoriasis using the U.S. NHANES database. The results revealed that the FI was significantly greater in patients with psoriasis than in those without ($P < 0.001$). In weighted nested regression analyses, the FI was significantly and positively associated with the prevalence of psoriasis, and this association persisted even after adjusting for confounders such as age, sex, race, BMI, hypertension, and diabetes (OR 2.22; 95 % CI 1.14–4.35; $P = 0.02$). RCS regression further revealed a nonlinear relationship between the FI and psoriasis, revealing a significant increase in the risk of psoriasis with increasing debilitating indices within a range. Subgroup analyses further revealed that this association was stronger among male patients, those with a normal BMI, and patients with comorbid hypertension and diabetes. These results suggest that

Table 1
The baseline demographic and clinical characteristics of U.S. NHANES 2003–2006 participants ($n = 6532$).

Variable	Overall $n = 6532$	Psoriasis unweighted n, weighted % (95 % CI) No $n = 6370$	Yes $n = 162$	P
Age (y)	39.09 (11.13)	39.01 (11.15)	41.43 (10.39)	0.003
PIR	3.08 (1.58)	3.08 (1.58)	3.22 (1.61)	0.35
BMI	27.69 (5.44)	27.66 (5.44)	28.71 (5.50)	0.02
ALT	26.81 (17.23)	26.80 (17.35)	27.11 (13.12)	0.04
AST	25.59 (14.75)	25.59 (14.89)	25.42 (9.55)	0.43
NC	58.77 (8.76)	58.75 (8.74)	59.37 (9.29)	0.30
HGB	14.57 (1.45)	14.57 (1.45)	14.56 (1.54)	0.91
CRP	0.42 (0.82)	0.41 (0.81)	0.52 (0.91)	0.10
HDL	53.88 (15.60)	53.92 (15.64)	52.80 (14.44)	0.52
TC	199.42 (41.11)	199.26 (41.14)	204.34 (39.98)	0.25
FI	−0.05 (0.99)	−0.06 (0.99)	0.26 (0.96)	<0.001
Gender				0.38
Male	3070 (49.18 %)	3000 (49.29 %)	70 (45.68 %)	
Female	3462 (50.82 %)	3370 (50.71 %)	92 (54.32 %)	
Race, n (%)				0.001
Mexican American	1373.00 (9.15 %)	1361.00 (9.37 %)	12.00 (2.50 %)	
Non-Hispanic Black	251.00 (4.01 %)	246.00(4.05 %)	5.00 (2.68 %)	
Non-Hispanic White	3066.00 (68.90 %)	2956.00 (68.43 %)	110.00(83.15 %)	
Other Hispanic	1522.00 (12.18 %)	1493.00 (12.33 %)	29.00 (7.52 %)	
Other race	320.00(5.76 %)	314.00 (5.82 %)	6.00 (4.15 %)	
Education, n (%)				0.35
Above high school	986.00 (10.85 %)	968.00 (10.90 %)	18.00 (9.40 %)	
High school	1568.00 (24.95 %)	1536.00 (25.09 %)	32.00(20.81 %)	
Under high school	3978.00 (64.20 %)	3866.00 (64.02 %)	112.00 (69.79 %)	
Marital, n (p %)				0.03
Living alone	3478.00 (56.98 %)	3385.00 (56.72 %)	93.00(64.96 %)	
Living with a partner	3054.00 (43.02 %)	2985.00 (43.28 %)	69.00 (35.04 %)	
PIR group, n (p %)				0.20
<1.30	1198.00 (12.56 %)	1170.00 (12.53 %)	28.00 (13.45 %)	
1.30~3.49	3481.00 (50.93 %)	3404.00 (51.12 %)	77.00 (45.12 %)	
≥3.50	1853.00 (36.51 %)	1796.00 (36.34 %)	57.00 (41.43 %)	
BMI group, n (p %)				0.15
Normal	2080.00 (35.26 %)	2038.00 (35.54 %)	42.00 (26.84 %)	
Obese	2476.00 (34.10 %)	2412.00 (34.02 %)	64.00(36.58 %)	
Overweight	1976.00 (30.64 %)	1920.00 (30.45 %)	56.00 (36.58 %)	
Drink, n (p %)				0.83
No	4697.00 (76.04 %)	4580.00 (76.01 %)	117.00 (76.95 %)	
Yes	1835.00 (23.96 %)	1790.00 (23.99 %)	45.00 (23.05 %)	
Hypertension				0.02
No	1326.00 (21.51 %)	1276.00 (21.18 %)	50.00 (31.39 %)	
Yes	5206.00 (78.49 %)	5094.00 (78.82 %)	3112.00 (68.61 %)	
Dyslipidemia				0.38
No	2247.00 (35.37 %)	2186.00 (35.23 %)	261.00 (39.55 %)	

(continued on next page)

Table 1 (*continued*)

Variable	Overall $n = 6532$	Psoriasis unweighted n, weighted % (95 % CI) No $n = 6370$	Yes $n = 162$	*P*
Yes	4285.00 (64.63 %)	4184.00 (64.77 %)	101.00 (60.45 %)	
Diabetes				0.069
No	364.00 (5.10 %)	359.00 (5.20 %)	5.00(2.10 %)	
Yes	6168.00 (94.90 %)	6011.00 (94.80 %)	157.00 (97.90 %)	
Smoke				0.04
No	2935.00 (48.17 %)	2852.00 (47.94 %)	83.00 (55.31 %)	
Yes	3597.00 (51.83 %)	3518.00 (52.06 %)	79.00 (44.69 %)	
PA				0.80
No	3684.00 (61.66 %)	3589.00 (61.70 %)	95.00 (60.35 %)	
Yes	2848.00 (38.34 %)	2781.00 (38.30 %)	67.00 (39.65 %)	
FI, n (p %)				0.01
Q1	1633.00 (26.05 %)	1609.00 (26.41 %)	24.00(15.02 %)	
Q2	1633.00 (26.19 %)	1591.00 (26.31 %)	42.00 (22.54 %)	
Q3	1633.00 (24.41 %)	1590.00 (24.28 %)	43.00 (28.37 %)	
Q4	1633.00 (23.35 %)	1580.00 (23.00 %)	53.00 (34.07 %)	

Values in parentheses are weighted percentages derived using the NHANES sampling weights to adjust for the complex survey design.
Abbreviations: CI, confidence interval; BMI, body mass index; PIR, poverty–income ratio; ALT, alanine aminotransferase; AST, aspartate aminotransferase; CRP, C-reactive protein; FI, frailty index; HGB, hemoglobin; HDL, high-density lipoprotein; NC, neutrophil count; PA, physical activity; TC, total cholesterol.
Data presentation and analysis methods: n (%) and Pearson's chi-square for categorical variables; mean (SD) and Welch's *t*-test for continuous variables.
$P < 0.05$ was considered significant.

systemic physiologic dysregulation, as reflected by the frailty index, may be a key pathway between psoriasis and adverse health outcomes.

The results of the present study are consistent with those of previous studies of psoriasis, systemic inflammation, and comorbidities. Psoriasis, a chronic inflammatory disease, is associated with a variety of systemic disorders (e.g., cardiovascular disease, metabolic syndrome, and depression) [1]. However, few epidemiological studies have investigated the relationship between psoriasis and severity of frailty. A Brazilian cross-sectional study [16] comparing indicators of physical debility (grip strength, standing sit-up test, fatigue, weight loss) in 64 patients with psoriasis over 60 years old, 64 patients with psoriasis under 50 years old, and 64 controls without psoriasis revealed that older (>60 years old) patients with psoriasis presented significant physical debility (27 % decline in grip strength, 59 % fatigue). However, this study did not use the debility index as an assessment tool. A Dutch study [15] assessed the prevalence of frailty and functional dependence in older (≥65 years) patients with psoriasis and its impact on treatment using 3 scales, namely, the Geriatric-eight (G8) scale, the Groningen Frailty Indicator (GFI), the Clinical Frailty Scale (CFS) to assess frailty, and the prevalence of frailty (42.2 % for G8, 26.0 % for GFI, and 13.7 % for CFS), confirming the prevalence of frailty and functional dependence in elderly psoriasis patients. Another study explored the causal relationship between the FI and psoriasis via Mendelian randomization analysis [26]. The results of the present study are consistent with a combination of genomic, transcriptomic, and proteomic multiomics analyses, which revealed that an elevated FI significantly increased the risk of psoriasis. The present study fills a gap in this field by validating the association between psoriasis and debility using a nationally representative sample (U.S. NHANES).

Several possible mechanisms may explain the association between psoriasis and frailty:

Chronic inflammatory pathways: The association between psoriasis and frailty may be mediated through chronic inflammatory pathways. The cutaneous and systemic inflammatory state in psoriasis patients leads to elevated levels of proinflammatory cytokines (e.g., tumor necrosis factor (TNF)-α, interleukin (IL)-6, and IL-17), which not only exacerbate cutaneous lesions but also may contribute to the development of frailty by affecting muscular, skeletal, and neurologic functions [27].Our finding of a higher FI in psoriasis patients, which incorporates inflammatory markers like CRP, offers direct evidence consistent with this chronic inflammation hypothesis.

Inflammation pathways: The psoriasis-driven activation of Th17/IL-23 [28] elevates systemic inflammatory factors (e.g., CRP and IL-6) [29], and TNF-α is a proinflammatory cytokine that has been implicated in the pathogenesis of psoriasis through activation of the nuclear factor (NF)-κB signaling pathway [30]. IL-6, along with other cytokines, such as TNF-α and IL-1β, which have profound effects on energy and protein metabolism, may contribute to the development of psoriasis. IL-6 and other cytokines, such as TNF-α and IL-1β, which have profound effects on energy and protein metabolism, have been referred to by Roubenoff as "muscle-activating factors" [31]. A study of 3075 healthy older adults aged 70–79 years revealed a general elevation of inflammatory markers (IL-6, TNF-α, and CRP) in the elderly population, which was associated with decreased muscle mass and strength. Elevated IL-6, CRP, and TNF-α levels are significantly associated with decreased muscle mass [32]. Basic research suggests that chronic inflammation promotes muscle catabolism and mitochondrial dysfunction, which in turn lead to cellular senescence, accelerating the process of frailty [33]. These are core features of debility [34]. Thus, the association between psoriasis and frailty may reflect the cumulative impairment of multisystem function by chronic inflammation. The data from the present study support this mechanism: CRP levels ($P = 0.10$) and FI scores ($P < 0.001$) were higher in patients with psoriasis.The stronger association observed in subgroups with hypertension and diabetes, conditions characterized by heightened inflammatory and oxidative stress states, provides indirect epidemiological support for this shared pathway.

The amplification of metabolic comorbidities: Another possible mechanism is the amplification of metabolic comorbidities. Psoriasis is often associated with metabolic abnormalities (e.g., insulin resistance and dyslipidemia) and cardiovascular disease [35,36], which further increase the risk of frailty [37]. Hyperglycemia, through the accumulation of advanced glycation end products (AGEs) and activation of the receptor for AGEs (RAGE), and angiotensin II (Ang II) further increase reactive oxygen species (ROS) and deplete antioxidant enzymes (e.g., superoxide dismutase and reduced form glutathione). The accumulation of ROS leads to mitochondrial DNA damage in muscle (accelerated sarcopenia) and apoptosis in neurons (cognitive decline). Additionally, hyperglycemia and Ang II directly damage endothelial cells, exacerbating microcirculatory deficits. Inadequate tissue perfusion (e.g., muscle, brain, kidney) leads to a decline in functional reserve, a core feature of debility, suggesting that a common pathway of oxidative stress and endothelial dysfunction may exacerbate multisystem functional decline [38,39]. The present study revealed that hypertension and diabetes enhanced the association between frailty and psoriasis (interaction $P < 0.05$), suggesting that routine screening for FI in psoriasis patients ≥40 years of age (especially those with comorbid cardiovascular–metabolic disease) is warranted for early intervention (e.g., resistance exercise, protein supplementation).

A strength of this study lies in the use of the NHANES, a stratified, multistage probability sample designed to represent the health status of the U.S. adult population. In addition, this study utilized the FI as an assessment tool, the FI-49 Integration of Clinical/Laboratory Indicators, which encompasses health deficits across multiple systems and provides a comprehensive picture of the severity of frailty. Reducing misclassification [40]. Comprehensive adjustment for confounders: controlling

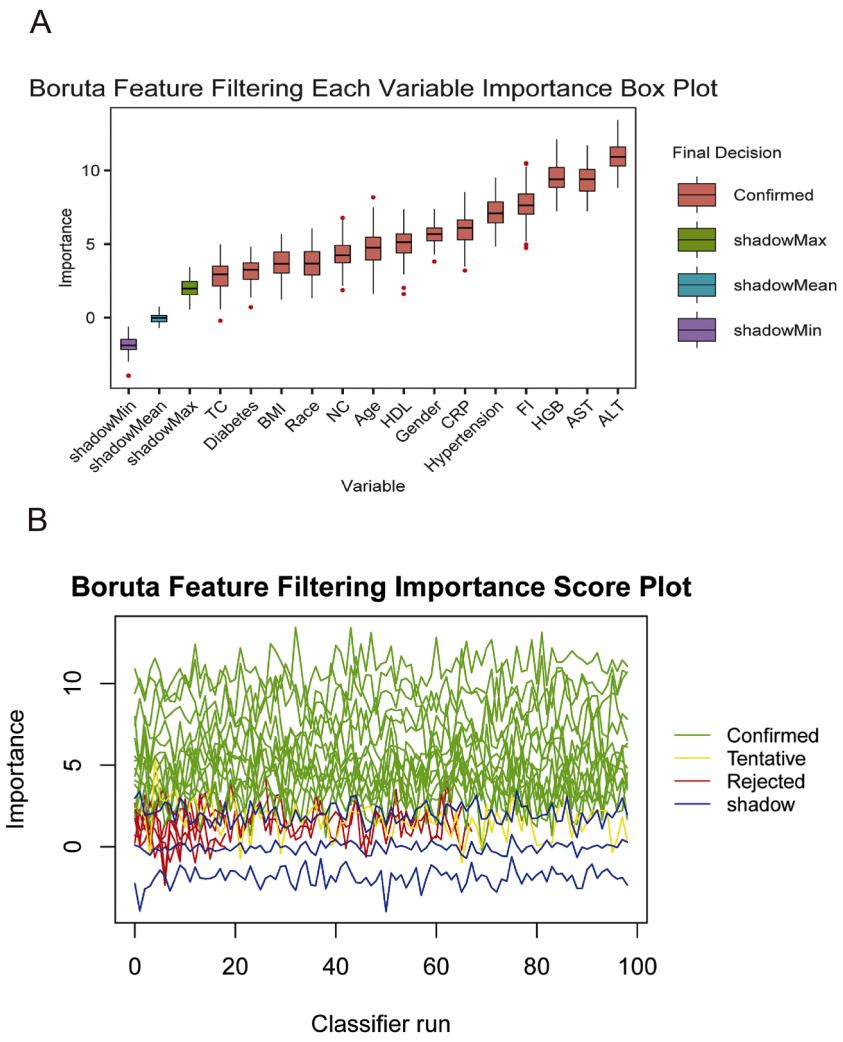

Fig. 1. Variable importance ranking for psoriasis prediction derived from Boruta algorithm analysis.

Table 2
Correlations between frailty indices and psoriasis.

Variable	OR (95 % CI), P-value		
	Model 1	Model 2	Model 3
Frailty index	1.34 (1.20–1.49), $P < 0.001$	1.31 (1.16–1.48), $P < 0.001$	1.28 (1.10–1.49), $P = 0.004$
Stratified by frailty index quartiles			
Q1	Reference	Reference	Reference
Q2	1.51 (0.73–3.11), $P = 0.26$	1.46 (0.69–3.06), $P = 0.31$	1.38 (0.63–3.00), $P = 0.38$
Q3	2.05 (1.09–3.86), $P = 0.03$	1.95 (1.01–3.75), $P = 0.047$	1.80 (0.94–3.46), $P = 0.07$
Q4	2.60 (1.49–4.55), $P = 0.002$	2.44 (1.32–4.53), $P = 0.007$	2.22 (1.14–4.35), $P = 0.02$
P for trend	<0.001	0.002	0.01

Model 1: adjusted for none.
Model 2: adjusted for gender, age, and race.
Model 3: adjusted for Model 2 combined with BMI, ALT, AST, NC, HGB, CRP, HDL, TC, hypertension, and diabetes.

for variables such as inflammation (CRP), metabolism (lipids), and body composition (BMI, neck circumference). However, there are several limitations to this study. First, owing to the cross-sectional design, it was not possible to determine a causal relationship between psoriasis and frailty. Second, based on self-reports (MCQ160A), there was a lack of data on disease severity; unconfirmed cases may have led to bias, and unmeasured confounders, such as duration of psoriasis, treatments (e.g., biologics to suppress inflammation), and dietary data, were missing. Although the analysis accounted for multiple potential confounders, the possibility of residual confounding due to unaccounted variables (e.g., genetic factors or environmental exposures) that influence the results cannot be excluded. Future studies should employ a longitudinal design to evaluate the impact of psoriasis treatment on the progression of debilitating symptoms and incorporate biomarkers (e.g., inflammatory factor levels) to validate this association further. Fourth, we utilized a cumulative deficit model (FI) to measure frailty; other operational definitions (e.g., Fried phenotypic model [41]) might yield different insights. Fifth, the data are from 2003–2006, preceding the widespread adoption of highly effective anti-inflammatory biologic therapies for psoriasis [42]. It is possible that the relationship between psoriasis and frailty may be modulated in patients receiving modern treatment regimens, a hypothesis that future studies with contemporary data should investigate.

This study has several clinical implications; for example, the potential value of screening for frailty in psoriasis patients should be investigated, e.g., through metabolic markers (e.g., BMI), inflammatory markers (e.g., CRP). Future longitudinal studies are needed to confirm this association and establish its utility in clinical practice before firm recommendations can be made.

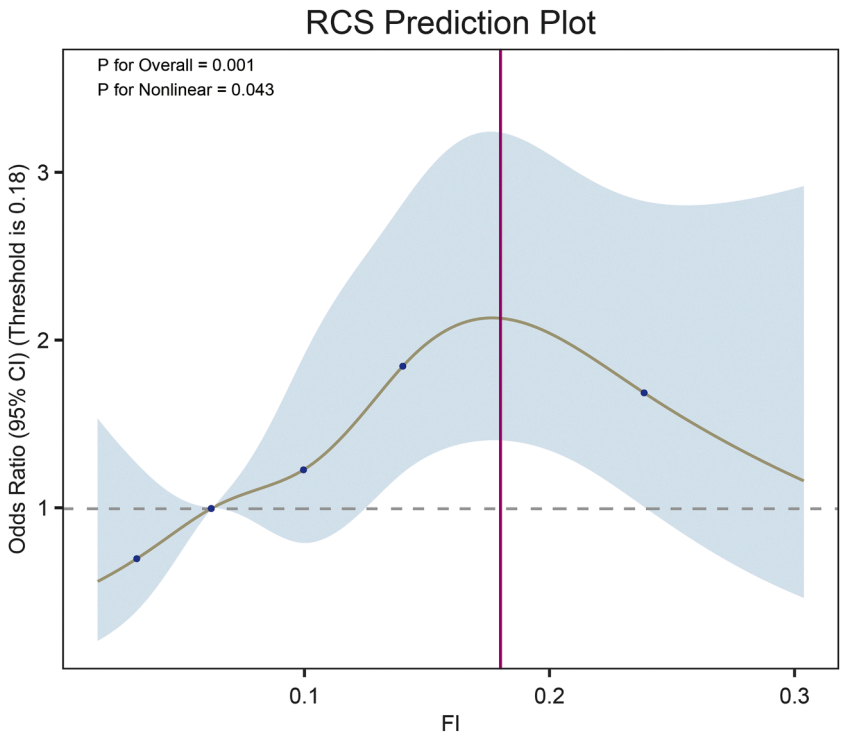

Fig. 2. Relationship between the Frailty Index and psoriasis modeled by restricted cubic spline regression.

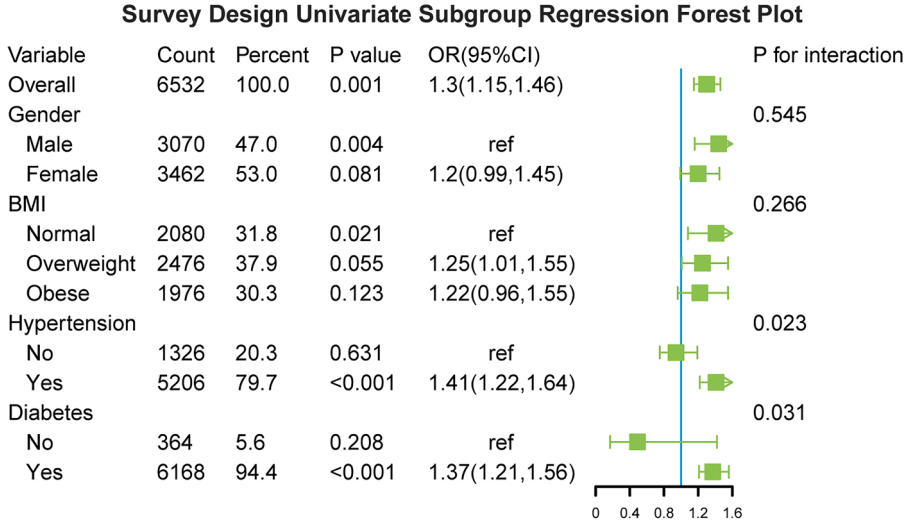

Fig. 3. Stratified analyses of Frailty Index and psoriasis association across clinically relevant subgroups.

Ethical standards disclosure

This study was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki. The original NHANES protocols were approved by the National Center for Health Statistics Research Ethics Review Board, with written informed consent obtained from all participants. As this analysis utilized de-identified, publicly available data from the official NHANES repository (https://www.cdc.gov/nchs/nhanes/index.htm), additional institutional review board approval was not required.

Declaration of generative Al and al-assisted technologies in the writing process

During the preparation of this manuscript, the authors utilized Deepseek for language refinement purposes only. The authors carefully reviewed, edited, and assume full responsibility for all content in this publication.

CRediT authorship contribution statement

Xiaodan Wang: Writing – original draft, Methodology, Resources. **Wenjia Weng:** Data curation. **Zhenzhen Yan:** Resources, Methodology. **Ming Zhang:** Methodology. **Juan Li:** Supervision, Project administration. **Bingbing Song:** Supervision. **Yanqing Gao:** Writing – review &

editing, Funding acquisition.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.tjfa.2025.100102.

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