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ORIGINAL ARTICLE

The importance of illness severity and multimorbidity in the association between mental health and body weight in psoriasis: Cross-sectional and longitudinal analysis

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Abstract

Background: High body weight is common in psoriasis and is associated with depression and anxiety. Past studies are mostly cross-sectional and may underestimate the role of demographic and illness-related factors in the association between mental health and body weight in psoriasis.

Objectives: This study explored the association between depression and anxiety with waist circumference and body mass index (BMI) cross-sectionally and at 12 months follow-up, adjusting for demographic and illness-related factors in people with psoriasis.

Method: Routine psoriasis care data were combined with data on depression and anxiety from a large specialist psoriasis centre. The analytical samples consisted of patients with complete data on either waist circumference ($N = 326$ at time 1; $N = 191$ at follow-up) or BMI ($N = 399$ at time 1; $N = 233$ at follow-up) and corresponding mental health, demographic, and illness-related information. Associations between weight-related outcomes and mental health variables were assessed at time one and at 12 months follow-up, after adjusting for demographic and illness-related factors.

Results: We found no evidence of associations between mental health and waist circumference or BMI, after adjusting for age, gender and illness-related factors. Higher age, male gender and illness-related factors, specifically multimorbidity and psoriasis severity, were positively associated with waist circumference and BMI at both time points.

Conclusion: This study revealed the important role of factors related to illness severity in body weight in psoriasis. The contribution of depression and anxiety to weight was not observed here likely due to the sample and methodology used. Future work should explore other psychosocial factors such as weight-related attitudes and emotional eating in the context of weight in psoriasis, to help inform the development of successful weight-management treatments.

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1 | INTRODUCTION

Psoriasis is a chronic debilitating inflammatory systemic condition that affects 2%–9% of the world's population.¹ One-third of people living with psoriasis have comorbid obesity,² defined as a body mass index (BMI) of ≥ 30 kg/m.³ Psoriasis and obesity frequently co-occur with depression and anxiety in a bi-directional fashion, where obesity may drive mental health issues and vice versa.^{4–8} This co-occurrence may be due to the physical and emotional toll that psoriasis and comorbid obesity have on patients' lives.^{9,10} Pain, discomfort, difficulty performing daily tasks and low self-esteem are common symptoms of both psoriasis and obesity.^{10,11}

Obesity is frequently considered in the context of high BMI, an index for relating weight to height, as means of determining whether a person's weight is healthy.¹² To date, it is the main indicator of healthy weight considered by studies that investigated the relationship between obesity and mental health in psoriasis.⁷ However, BMI does not differentiate between body fat mass and muscle mass.¹³ Hence, it is not a reliable indicator of actual body fat mass.¹⁴ This is crucial because a higher percentage of visceral fat is associated with poor physical and mental health outcomes.¹⁵ Incorporating a more accurate indicator of body fat such as waist circumference, alongside BMI, may allow for more precise monitoring of the association between obesity and comorbid medical and mental health conditions, including anxiety and depression.^{6,7}

Common psoriasis- and obesity-associated comorbidities such as cardiometabolic, kidney and gastrointestinal diseases are also overlooked in the association between mental health and obesity in psoriasis.^{16,17} These co-morbid conditions may increase the psychological burden on patients' lives.¹⁰ They ought to be considered when determining the association between mental health and obesity in psoriasis. Important nuances related to demographic factors should also be factored in. Depression and anxiety affect disproportionately women with psoriasis compared to men.¹⁸ Higher BMI has been linked to depression in females (24.5%, 95% CI = 17.2, 33.5), but not in males (11.6%, CI = 6.5, 19.7).^{19–21} Age is another important demographic factor that should be considered. As age increases, the association between waist circumference and BMI with depression becomes stronger in the general population.²² It is yet to be determined whether there is a link between body weight and mental health in psoriasis and if it is gender- or age-dependent.

To recognize the complex relationship between obesity and mental health in psoriasis, we need to look beyond general weight loss models that focus on dietary habits and physical activity.⁷ Tailored illness-specific interventions that recognize the role of demographic, illness-related and mental health factors

What is already known about this topic?

- High body weight, common in psoriasis, is associated with depression and anxiety. Depression and anxiety affect disproportionately women with psoriasis compared to men. Multimorbidity and greater psoriasis severity may increase the psychological burden on patients' lives. Despite that, current research is mostly cross-sectional and underestimates the role of demographic and illness-related factors in the association between depression and anxiety with body weight in psoriasis.

What does this study add?

- We found no evidence of associations between depression and anxiety with body weight after adjusting for demographic and illness-related factors. Further research needs to investigate the relationship between depression and anxiety with body weight in a more robust study design and explore the underlying cognitive and behavioural components that may help to explain the high incidence of obesity in psoriasis.

have been linked to better weight outcomes in other patient populations.^{19,23} Depression and anxiety can be significant barriers to engagement with and adherence to weight-loss recommendations, and they can also prevent long-term maintenance of weight loss.^{24,25} Psoriasis management guidelines recommend a holistic approach in which patients' treatment goals include both weight management and improved mental health.¹⁴ As a result, it is critical to build a better understanding of the role of depression and anxiety in psoriasis' body weight, taking into consideration nuances related to demographic factors and illness severity. This would allow for a more tailored and effective approach to weight reduction that addresses the multifaceted needs of people living with psoriasis, ultimately resulting in better patient outcomes.⁷

This study used data collected as part of routine specialist care to gain a more robust understanding of the role of depression and anxiety in psoriasis patients' weight-related outcomes (including waist circumference and BMI), considering the limitations of earlier studies. First, the relationship between illness-related factors and body weight outcomes in psoriasis were assessed to determine if they may be potential confounds in the relationship between depression or anxiety and weight-related outcomes. Secondly, we assessed the relationship between mental health and weight outcomes when

adjusting for both demographic and illness related factors cross-sectionally. We also explored the longitudinal relationship between mental health at time one with body weight outcomes measured at 12 months follow-up. The following hypotheses were formulated.

1. Multimorbidity and more severe psoriasis at time one will be positively associated with waist circumference and BMI (i) at time one and (ii) at 12 months follow-up; after adjusting for demographic variables (age, gender and ethnicity).
2. Depression and anxiety at time one will be positively associated with waist circumference and BMI (i) at time one and (ii) at 12 months follow-up; after adjusting for demographic and illness-related variables (psoriasis severity, comorbidities, and psoriasis treatment).
3. Gender will moderate the relationship between depression and anxiety at time one with waist circumference and BMI (i) at time one and (ii) at 12 months follow-up; where the relationship between depression and anxiety with waist circumference and BMI at both time one and 12 months follow-up will be greater for women than men.

2 | METHODS

2.1 | Patients

Patients were recruited between 2014 and 2020 during routine dermatology outpatient visits at a large specialist psoriasis centre serving London and South East England. Routine psoriasis treatment data from 727 patients were combined with depression and anxiety screening data from the same patients collected through the Integrating Mental and Physical Healthcare: Research Training and Services (IMPARTS) screening programme. The IMPARTS programme provides a multifaceted platform of clinical and research services to assist in the integration of mental healthcare into routine care for patients with physical health conditions and is further described elsewhere.²⁶ At each appointment, participants filled out self-report measures of depression and anxiety using a tablet. As part of their usual care, they were then clinically assessed by their doctor. Patients could have multiple appointments during the follow-up period (between 1 and 23). To maximize the use of available data, three analytical samples were defined (Table 1) all of which had complete data on either BMI or waist circumference, on covariates (e.g., demographic, illness-related), and mental health variables (depression and anxiety). Patients with incomplete data on BMI or waist circumference, covariates (e.g., demographic, illness-related), or mental health variables (depression and anxiety) were excluded from the analytical samples.

TABLE 1 The analytical samples in the analysis

| Description | Identifier | |
|---|-------------|--------------|
| | At time one | At follow-up |
| Patients with complete waist circumference data | A | B |
| Patients with complete BMI data | C | D |
| Patients with missing waist circumference and/or BMI data | E | F |

Since IMPARTS data collection is part of routine clinical care, formal consent to participate is not required. Patients are told that their anonymized data may be used for research purposes (REC reference: 12/SC/0422) and that they can opt-out at any time. This study followed the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) reporting guideline²⁷ (See supplementary material C).

3 | MEASURES

3.1 | Weight-related outcomes

Weight-related data (waist circumference [cm], height [m] and weight [kg]) are routinely collected during dermatology appointments. BMI was calculated as weight in kg divided by height in m². BMI categories were defined as healthy weight (BMI between 18.5 and 24.9 kg/m²), overweight (BMI between 25.0 and 29.9 kg/m²), obese (BMI between 30.0 and 40.0 kg/m²), and morbidly obese (BMI ≥ 40.0 kg/m²).¹² The threshold for healthy waist circumference was defined as < 94 cm and 80 cm for men and women, respectively.²⁸ Abdominal obesity was considered as 'present' if the threshold was reached or exceeded.

The term 'time one' refers to patients' first appointment in the database. Most participants will have had appointments before this time, preceding the data collection period. Based on data availability and completeness, a 12-month follow-up appointment was chosen to extract follow-up data (the appointment closest to 12 months was selected, within a window of 10 to 14 months).

3.2 | Mental health

The two-item and nine-item Patient Health Questionnaire (PHQ-2, PHQ-9) were used to screen for probable major depressive disorder (herein, depression).^{29,30} The two-item and seven-item Generalised Anxiety Disorder Scale-7 (GAD-2, GAD-7) were used to screen for probable generalized anxiety disorder (herein, anxiety).³¹ Details can be found in the eMethods (see supplementary material B).

3.3 | Covariates

Covariates were selected based on theory and prior evidence and measured at time one. Demographic covariates included age, gender and ethnicity. Because of the scarcity of routine care data from patients belonging to minority ethnic groups (19.9% of the overall patient sample), ethnicity was dichotomized into (i) White and (ii) Black, Asian, and minority ethnic (BAME). Illness-related factors included the total number of physical comorbidities,¹⁰ current treatment type³² and psoriasis severity.³³ The number of comorbidities was calculated using routine data on the presence or absence of seven psoriasis- and obesity-related physical comorbidities (hypertension, type 2 diabetes, liver disease, bone disease, asthma, psoriatic arthritis and cancer).^{34,35} A total count of present comorbid conditions was also computed (range between 0 to 7). While comorbid depression and anxiety were recorded, these were removed from the count of comorbidities to avoid overlap with the variables of interest, PHQ and GAD. Treatment was dichotomized as either (i) systemic therapy (treatment for psoriasis taken orally, subcutaneous, or intravenously) or (ii) no systemic treatment. This approach was taken in line with consensus that systemic therapies generally indicate more severe disease³⁶ requiring more intensive treatment compared to topicals.³⁷ Psoriasis severity was measured with the Psoriasis Area Severity Index (PASI), a clinician-rated scale for measuring the severity of psoriatic lesions based on area coverage and plaque appearance.³⁸

3.4 | Statistical analyses

There were four stages to the analysis.

First, to investigate the impact of missing data, patients with and without outcome data (waist circumference and BMI) at time one and follow-up were compared for demographic, illness-related and mental health variables (independent-measures *t*-test for

continuous variables and χ^2 test for categorical variables; see Tables S1 and S2). Patients with available weight-related data at time one versus those with available data at follow-up were also compared (Table 3).

Second, we used correlations, χ^2 tests and *t*-tests to explore bivariate associations between demographic, illness-related, and mental health variables, and outcomes. This was done to assess associations between (i) variables measured at time one; and (ii) variables measured at time one and outcomes measured at follow-up (see Table S3).

Third, predictors of waist circumference and BMI were evaluated using multiple linear regression models. We estimated models to test whether depression and anxiety at time one were associated with weight-related outcomes (i) at time one and (ii) at 12 months follow-up. All models were adjusted for demographic and illness-related covariates measured at time one. In the models using weight-related outcomes at 12 months follow-up, we did not adjust for waist circumference and BMI at time one as the preliminary analyses showed no clinically meaningful weight changes (i.e., at least a 5% reduction in weight from baseline level).³⁹ Between time one and 12 months follow-up, waist circumference showed a mean reduction of 1.8% (-0.82 cm, $p = 0.163$) and BMI a mean reduction of 2.3% (-0.21 kg/m², $p = 0.088$).

Fourth, using interaction terms and stratified regression models, we tested whether gender moderated the associations between depression and anxiety measured at time one with weight-related outcomes measured at (i) time one and (ii) 12 months follow-up. We included interaction terms (e.g., female gender \times anxiety) and main effects into the above regression models. The statistical significance of the interaction was tested with likelihood-ratio tests.

Model fit was evaluated using a ΔF -statistic. Improvement in explained variance with each regression step was calculated using adjusted ΔR^2 . Statistical significance level was assumed at $p \leq 0.05$. All analyses were conducted in Stata 16.⁴⁰

TABLE 2 Participant data (*n*) and exclusions for each analytic sample

| Excluded – waist circumference/BMI | Excluded comorbidities | Excluded treatment type | Excluded PASI |
|--------------------------------------|------------------------|-------------------------|--------------------|
| Time one sample A (<i>n</i> = 326) | | | |
| <i>n</i> = 328, 45.1% | <i>n</i> = 54, 13.2% | <i>n</i> = 14, 3.4% | <i>n</i> = 5, 1.2% |
| Follow-up sample B (<i>n</i> = 191) | | | |
| <i>n</i> = 502, 69.0% | <i>n</i> = 25, 11.2% | <i>n</i> = 7, 3.1% | <i>n</i> = 2, 0.9% |
| Time one sample C (<i>n</i> = 399) | | | |
| <i>n</i> = 247, 34.0% | <i>n</i> = 57, 11.9% | <i>n</i> = 16, 3.3% | <i>n</i> = 8, 1.7% |
| Follow-up sample D (<i>n</i> = 233) | | | |
| <i>n</i> = 450, 62.0% | <i>n</i> = 34, 12.4% | <i>n</i> = 8, 2.9% | <i>n</i> = 2, 0.7% |

Note: Total *N* on IMPARTS database = 727.

TABLE 3 Demographic, illness-related and mental health characteristics of the analytical samples at time one and at 12 months follow-up

| Variable | Time one (the first available data entry) | | Follow-up (12 months later) | | Time one versus follow-up | |
|--|--|--|--|--|--------------------------------------|--------------------------------------|
| | Sample A with information on waist circumference (N = 326) | Sample C with information on BMI (N = 399) | Sample B with information on waist circumference (N = 191) | Sample D with information on BMI (N = 233) | Sample A versus Sample B | Sample C versus Sample D |
| Gender, n (%) | | | | | | |
| Female | 128 (31.2%) | 168 (35.2%) | 69 (30.9%) | 89 (32.5%) | $\chi^2 = 0.001$, $p = 0.943$ | $\chi^2 = 0.55$, $p = 0.458$ |
| Male | 282 (68.8%) | 310 (64.8%) | 154 (69.1%) | 165 (67.5%) | | |
| Age (year), mean (SD) | 46.04 (13.6) | 45.7 (13.3) | 45.6 (12.7) | 45.3 (12.9) | $t(631) = -0.44$, $p = 0.662$ | $t(750) = -0.33$, $p = 0.742$ |
| Ethnicity n (%) | | | | | | |
| White | 333 (81.2%) | 385 (80.5%) | 178 (79.8%) | 216 (78.8%) | $\chi^2 = 0.18$, $p = 0.670$ | $\chi^2 = 0.32$, $p = 0.573$ |
| Black and ethnic minorities | 77 (18.8%) | 93 (19.5%) | 45 (20.2%) | 58 (21.2%) | | |
| Treatment n (%) | | | | | | |
| Systemic treatment, yes | 232 (60.1%) | 270 (58.7%) | 144 (66.7%) | 158 (59.4%) | $\chi^2 = 2.54$, $p = 0.111$ | $\chi^2 = 0.03$, $p = 0.853$ |
| No systemic treatment, yes | 154 (39.9%) | 190 (41.3%) | 72 (33.3%) | 108 (40.6%) | | |
| PASI, mean (SD) | 4.7 (5.1) | 4.8 (4.8) | 3.4 (4.4) | 3.7 (4.0) | $t(614) = -3.02$, $p = 0.0027^*$ | $t(738) = -3.16$, $p = 0.0016^*$ |
| Comorbidities n (%) | | | | | | |
| Diabetes | 26 (6.3%) | 32 (6.7%) | 13 (5.8%) | 19 (6.9%) | $\chi^2 = 0.07$, $p = 0.798$ | $\chi^2 = 0.02$, $p = 0.900$ |
| Hypertension | 82 (20.0%) | 110 (23.0%) | 67 (24.5%) | 44 (19.7%) | $\chi^2 = 0.01$, $p = 0.935$ | $\chi^2 = 0.20$, $p = 0.654$ |
| Presence of liver disease, n (%) | 42 (10.2%) | 45 (9.4%) | 24 (10.8%) | 31 (11.3%) | $\chi^2 = 0.04$, $p = 0.838$ | $\chi^2 = 0.692$, $p = 0.406$ |
| Total number of comorbid medical conditions, mean (SD) | 1.02 (1.29) | 1.02 (1.32) | 0.93 (1.34) | 1.10 (1.35) | $t(552) = -0.75$, $p = 0.451$ | $t(659) = 0.74$, $p = 0.461$ |
| Depression (PHQ), n (%) | | | | | | |
| Depressed | 86 (20.9%) | 81 (16.9%) | 34 (15.2%) | 42 (15.3%) | $\chi^2 = 3.09$, $p = 0.079$ | $\chi^2 = 0.33$, $p = 0.564$ |
| Not depressed | 324 (79.1%) | 397 (83.1%) | 189 (84.8%) | 232 (84.7%) | | |
| Anxiety (GAD), n (%) | | | | | | |
| Anxious | 71 (17.3%) | 72 (15.1%) | 30 (13.5%) | 32 (11.7%) | $\chi^2 = 1.61$, $p = 0.205$ | $\chi^2 = 1.67$, $p = 0.196$ |
| Not anxious | 339 (82.7%) | 406 (84.9%) | 193 (86.5%) | 242 (88.3%) | | |
| Abdominal obesity, n (%) | | | | | | |
| Obese | 225 (54.8%) | 347 (72.6%) | 136 (61.0%) | 208 (75.9%) | $\chi^2 = 2.20$, $p = 0.138$ | $\chi^2 = 0.99$, $p = 0.319$ |
| Non-obese | 185 (45.2%) | 131 (27.4%) | 87 (39.0%) | 66 (24.1%) | | |

**p ≤ 0.001; *p < 0.05.

4 | RESULTS

4.1 | Sample characteristics

There were 326 and 191 patients with available weight circumference data at time one and follow-up, respectively; and 399 and 233 patients with available BMI data at time one and follow-up, respectively. Of these, just over half (54%) had abdominal obesity based on waist circumference at time one. Most patients (75%) at time one were overweight, with 19% and 18% living with obesity or morbid obesity based on BMI, respectively. At time one, depressed and anxious patients reported higher PASI and fewer comorbidities (likely due to the little variability in the number of comorbidities) compared to those not depressed and not anxious (see Table S8).

4.2 | Missing data

We compared samples with available waist circumference and BMI data to those with missing waist circumference and BMI data on a variety of demographic, illness severity, and mental health measures at time one and at 12 months follow-up. This consideration allowed us to ascertain if missing data influenced the conclusions on the associations between mental health and body weight (i) at time one and (ii) at 12 months follow-up.

When looking at availability of weight-related outcome data at time one, males were significantly more likely to have available waist circumference data compared to females (males = 60%; females = 40%, $p = 0.008$). At time one, patients who were not depressed were significantly more likely to have available BMI data than patients who presented as depressed (68% vs. 32%, $p = 0.004$). There were no other differences between those with and without BMI and waist circumference data at time one (see Tables S1 and S2).

When looking at availability of weight-related outcome data at 12 months follow-up, patients with missing waist circumference and BMI data at follow-up, were significantly less likely to be on systemic treatment for psoriasis compared to those not missing weight-related outcome data (27% vs. 73%, $p = 0.030$; see Tables S1 and S2).

Furthermore, patients with available waist circumference and BMI data at time one had significantly higher PASI scores than patients with available waist circumference and BMI at 12 months follow-up. Table 2 summarises the patterns of missing and analytical data. Table 3 shows the demographic, illness-related and mental health characteristics of the sample at time one and at 12 months follow-up.

4.3 | Bivariate associations between demographic, illness-related and mental health (explanatory variables), and waist circumference and BMI (outcome variables)

Age and the total number of comorbidities were significantly positively correlated with waist circumference and BMI at time one. Significantly larger waist circumference was observed among males compared to females, but no difference was observed in BMI by gender. PASI scores at time one were significantly positively correlated with higher BMI, but not waist circumference, at 12 months follow-up (see Table S3).

4.4 | Associations between demographic, illness-related and mental health (explanatory variables), and waist circumference and BMI (outcome variables) at time one

Table 4 presents associations of mental health at time one with waist circumference and BMI at time one, adjusting for demographic and illness-related variables at time one. In the final models, there was no evidence for a significant association between depression and anxiety with waist circumference or BMI. Age ($B = 0.20$, 95% CI 0.05, 0.34; $B = 0.06$, 95% CI 0.02, 0.11, respectively) and the total number of comorbid medical conditions ($B = 2.06$, 95% CI 0.63, 3.48; $B = 0.87$, 95% CI 0.42, 1.32, respectively) remained significantly associated with both waist circumference and BMI. Male gender was associated with larger waist circumference ($B = 6.48$, 95% CI 2.77, 10.18), but not BMI.

The models for time one waist circumference ($F(9, 316) = 5.28$, $p \leq 0.001$) and BMI ($F(9, 389) = 5.01$, $p \leq 0.001$) were statistically significant and explained a total of 13% and 10% of variance in waist circumference and BMI, respectively. Demographic and illness-related variables explained the larger proportion of the variance in both weight-related outcomes.

4.5 | Associations between time one explanatory variables and waist circumference and BMI measured at 12 months follow-up

Table 5 presents associations of mental health at time one with waist circumference and BMI at 12 months follow-up, adjusting for demographic and illness-related variables at time one. We found no evidence of associations between mental health at time one and weight-related outcomes at 12 months follow-up. The total number of comorbid medical conditions was associated

TABLE 4 Regression models of waist circumference and BMI as outcomes at time one

| | Waist circumference at time one (N = 326) | | BMI at time one (N = 399) | |
|-----------------------------|---|-------------------|---------------------------------|------------------|
| | B | 95% CI | B | 95% CI |
| | Step 1, R ² = 7.16% | | Step 1, R ² = 4.32% | |
| Age | 0.23** | 0.12–0.35 | 0.09** | 0.05–0.12 |
| Gender, male | 6.27** | 2.94–9.60 | 0.16 | –0.89–1.21 |
| Ethnicity, White | 0.74 | –3.24–4.71 | 0.65 | –0.60–1.94 |
| | Step 2, R ² = 11.97% | | Step 2, R ² = 9.92% | |
| Age | 0.20* | 0.06–0.35 | 0.06* | 0.02–0.11 |
| Gender, male | 6.33** | 2.64–10.02 | –0.22 | –1.38–0.95 |
| Ethnicity, White | 1.55 | –2.66–5.76 | 0.88 | –0.46–2.23 |
| Comorbidities, total | 1.93* | 0.51–3.34 | 0.85** | 0.40–1.30 |
| Systemic treatment, present | 1.49 | –1.98–4.95 | 0.81 | –0.30–1.93 |
| PASI | 0.32 | –0.02–0.65 | 0.11 | –0.004–0.23 |
| | Step 3, R ² = 12.57% | | Step 3, R ² = 10.17% | |
| Age | 0.20* | 0.05–0.34 | 0.06* | 0.02–0.11 |
| Gender, male | 6.50** | 2.80–10.19 | –0.16 | –1.33–1.02 |
| Ethnicity, White | 1.75 | –2.46–5.97 | 0.92 | –0.42–2.27 |
| Comorbidities, total | 2.06* | 0.64–3.48 | 0.88** | 0.42–1.33 |
| Systemic treatment, present | 1.79 | –1.69–5.28 | 0.89 | –0.24–2.01 |
| PASI | 0.26 | –0.08–0.61 | 0.10 | –0.02–0.22 |
| Depression, present | 3.40 | –1.14–7.95 | 0.84 | –0.75–2.44 |
| | Step 4, R ² = 12.58% | | Step 4, R ² = 10.37% | |
| Age | 0.20* | 0.05–0.34 | 0.06* | 0.02–0.11 |
| Gender, male | 6.48** | 2.77–10.18 | –0.19 | –1.36–0.99 |
| Ethnicity, White | 1.75 | –2.47–5.97 | 0.86 | –0.49–2.22 |
| Comorbidities, total | 2.06* | 0.63–3.48 | 0.87* | 0.42–1.32 |
| Systemic treatment, present | 1.78 | –1.71–5.27 | 0.87 | –0.26–1.99 |
| PASI | 0.26 | –0.08–0.60 | 0.10 | –0.02–0.21 |
| Depression, present | 3.90 | –2.87–10.66 | 1.66 | –0.66–3.98 |
| Anxiety, present | –0.69 | –7.69–6.31 | –1.15 | –3.54–1.23 |

** $p \leq 0.001$; * $p < 0.05$.

with both waist circumference ($B = 2.28$, 95% CI 0.60, 3.95) and BMI ($B = 0.66$, 95% CI 0.02, 1.30) at follow-up. Age ($B = 0.28$, 95% CI 0.10, 0.45), male gender ($B = 6.85$, 95% CI 2.50, 11.20), and PASI ($B = 0.94$, 95% CI 0.49, 1.38), remained significantly associated with waist circumference at 12 months follow-up (Table 5).

The overall models for waist circumference ($F(9, 181) = 7.87$, $p \leq 0.001$) and BMI ($F(9, 223) = 2.33$, $p = 0.02$) at 12 months follow-up were significant, explaining a total of 30% and 8% of variance in waist circumference and BMI, respectively. Demographic and illness-related variables explained the larger proportion of the variance in both weight-related outcomes.

4.6 | Gender as moderator

There was no evidence of an interaction effect between gender and mental health on waist circumference and BMI at time one and follow-up in any of the models (see Tables S4–S7).

5 | DISCUSSION

This study drew on routine care data to gain a better understanding of the role of depression and anxiety in people with psoriasis' weight-related outcomes. It adds

TABLE 5 Regression models of waist circumference and BMI as outcomes at 12 months follow-up

| | Waist circumference at follow-up (N = 191) | | BMI at follow-up (N = 233) | |
|-----------------------------|--|-------------|--------------------------------|-------------|
| | B | 95% CI | B | 95% CI |
| | Step 1, R ² = 17.44% | | Step 1, R ² = 4.87% | |
| Age | 0.39** | 0.25–0.54 | 0.09* | 0.03–0.14 |
| Gender, male | 7.39** | 3.44–11.34 | 0.48 | –0.98–1.93 |
| Ethnicity, White | 2.47 | –2.14–7.08 | 1.07 | –0.59–2.73 |
| | Step 2, R ² = 26.36% | | Step 2, R ² = 7.50% | |
| Age | 0.28* | 0.10–0.45 | 0.06 | –0.01–0.12 |
| Gender, male | 6.67* | 2.34–11.01 | 0.31 | –1.34–1.97 |
| Ethnicity, White | 4.21 | –0.64–9.07 | 1.23 | –0.57–3.02 |
| Comorbidities, total | 2.21* | 0.57–3.85 | 0.62* | –0.01–1.26 |
| Systemic treatment, present | 0.26 | –4.01–4.53 | 0.54 | –1.01–2.10 |
| PASI | 0.96** | 0.52–1.41 | 0.07 | –0.12–0.25 |
| | Step 3, R ² = 26.97% | | Step 3, R ² = 7.59% | |
| Age | 0.28* | 0.10–0.45 | 0.06 | –0.01–0.12 |
| Gender, male | 6.86* | 2.52–11.20 | 0.33 | –1.33–2.00 |
| Ethnicity, White | 4.75 | –0.18–9.67 | 1.27 | –0.54–3.08 |
| Comorbidities, total | 2.29* | 0.65–3.93 | 0.63* | –0.003–1.27 |
| Systemic treatment, present | 0.22 | –4.05–4.48 | 0.54 | –1.02–2.09 |
| PASI | 0.94** | 0.49–1.38 | 0.06 | –0.13–0.25 |
| Depression, present | 3.55 | –2.11–9.21 | 0.54 | –1.64–2.72 |
| | Step 4, R ² = 29.97% | | Step 4, R ² = 7.98% | |
| Age | 0.28* | 0.10–0.45 | 0.06 | –0.004–0.12 |
| Gender, male | 6.85* | 2.50–11.20 | 0.35 | –1.31–2.02 |
| Ethnicity, White | 4.74 | –0.21–9.68 | 1.26 | –0.55–3.06 |
| Comorbidities, total | 2.28* | 0.60–3.95 | 0.66* | 0.02–1.30 |
| Systemic treatment, present | 0.21 | –4.07–4.49 | 0.59 | –0.97–2.16 |
| PASI | 0.94** | 0.49–1.38 | 0.06 | –0.13–0.25 |
| Depression, present | 3.82 | –4.77–12.41 | –0.47 | –3.46–2.53 |
| Anxiety, present | –0.37 | –9.15–8.41 | 1.64 | –1.70–4.98 |

**p ≤ 0.001; *p < 0.05.

to the small number of studies in this area by examining the association between mental health and body weight using waist circumference as a valid marker of abdominal and visceral fat,⁴¹ in addition to more commonly used BMI. The study improves on prior cross-sectional research by adjusting the analysis for several important demographic and illness-related factors, which could confound links between mental health and weight-related outcomes. In addition, this is the first study to examine these relationships over time.

Contrary to hypotheses and previous studies,^{4,5,7} we found no evidence of associations between depression and anxiety at time one with weight-related

outcomes cross-sectionally or 12 months later, when adjusting for a wide range of demographic and illness-related factors. In line with hypotheses, we found positive associations between the number of comorbidities and weight-related outcomes cross-sectionally and 12 months later. Greater psoriasis severity at time one, measured by PASI, was also positively associated with waist circumference 12 months later. In terms of demographics, older age was positively associated with waist circumference cross-sectionally and 12 months later, and with BMI cross-sectionally only. Male gender was associated with waist circumference cross-sectionally and 12 months later, but not with BMI.

Contrary to expectations, there was no moderation effect of gender on the relationship between mental health and weight outcomes.

5.1 | In comparison to previous literature

Our cross-sectional findings were inconsistent with previous cross-sectional studies that reported positive associations between depression and anxiety with weight-related outcomes in psoriasis.⁷ These inconsistencies may be explained by previous studies not adjusting for the role of psoriasis severity and medical comorbidities.^{4,7,42} They may also relate to the fact that in this study we also used a cut-off to define probable caseness of depression and anxiety.^{30,31} Continuous measures were adopted in other research that indicated a link between depression and weight outcomes.⁴³ It may be that distress, rather than clinically defined categories of anxiety and depression, is associated with weight outcomes.^{67,68}

It is also possible that both non-response and attrition biases may have played a role in the lack of association observed between depression and anxiety with weight-related outcomes.^{64,65} Nearly half of participants at time one were missing information on weight-related outcomes at follow-up. Our findings indicated that people without depression were significantly more likely to have data on BMI at time one in comparison to people with depression. There was also a large amount of missing data at follow-up, which may have obscured the association between depression and anxiety with weight-related outcomes.

The evidence of a positive association between older age and waist circumference at both time points, and with BMI cross-sectionally only, agrees with previous studies.^{44,45} Elderly people living with psoriasis and obesity are certainly at risk of added disability and morbidity⁴⁴ which should be of a particular focus in future studies. We found that male gender was associated with waist circumference cross-sectionally and at 12 months follow-up which is consistent with previous observations that men have a relatively more central fat distribution than females.⁴⁷ This finding confirms that using solely BMI to monitor impact of increasing weight status may lead to underestimation of the associated health burden.⁴⁶

The findings that both psoriasis severity and comorbidities are related to waist circumference and BMI are consistent with previous studies.^{2,48} These relationships are likely to be complex and bidirectional. Multimorbidity and greater severity of psoriasis can exacerbate the physical and psychological burden of psoriasis and act as a barrier to healthy behaviours,¹⁰ as well as contribute to depression.⁴⁹ Patients dealing with multimorbidity may be more prone to unhelpful

coping behaviours such as social withdrawal and emotional eating, both of which have been linked to obesity and depression.^{50–52} It is also important to consider potential mobility impairments due to multimorbidity. Disability may act as an additional barrier to healthy behaviours,⁵³ leading to reduced activity levels.⁵⁴

Equally, excess weight may contribute to multimorbidity and more severe disease as it interferes with treatment response.² People with a high BMI and multiple medical conditions are more likely to report worsened psoriasis symptoms such as pain and pruritus.⁵⁵ This is important because a greater severity of psoriatic symptoms leads to an increase in the levels of depressive⁸ and anxiety⁹ symptoms.

However, regardless of the physical factors, each person with psoriasis is likely to react differently to their illness-related symptoms. According to the Common-Sense Model of Self-Regulation,⁵⁶ beliefs patients hold about their illness (illness perceptions) play an important role in mental and physical health outcomes.⁶⁹ To illustrate this, a patient with normal body weight who *perceives* their psoriasis as being more severe than a patient who is overweight is more likely to suffer from low self-esteem, body image issues, and social isolation.⁵⁷ Patients who *self-assess* their psoriasis as severe are especially vulnerable to mental health issues.^{58,59} Together these perceptions can stifle physical activity and motivation to engage in healthy behaviours,⁶⁰ contributing to obesity. In a study, beliefs about psoriasis causing weight gain were linked to a higher BMI.⁵ Exploration of illness perceptions may reveal important information about how patients conceptualise their psoriasis and the consequences of this on their mental health and psoriasis-related behaviours, as well as weight-related behaviours.^{61,62} Future studies should investigate these underlying cognitive and behavioural factors that may better explain the high rates of obesity in psoriasis, beyond the role of depression and anxiety.⁷

5.2 | Strengths and limitations

To the best of our knowledge, this is the first study to look at the association between mental health and body weight, measured cross-sectionally and 12 months later. Compared to previous studies,⁷ the main strengths of the study are its large sample size, the adjustment for several important demographic and illness-related covariates, and the use of waist circumference as an outcome as a more accurate indication of body fat.

Despite the study's strengths, important limitations related to the use of real-world data need to be considered.⁶³ The analyses were restricted to the use of dichotomised variables of depression and anxiety,

indicative of probable diagnostic levels of depression and/or anxiety. This approach is likely to have obscured the association between mental health with weight-related outcomes due to reduced power.⁶⁶ There was substantial amount of missing weight-related outcome data (a typical characteristic of routine data) which reduced the analytical samples of patients.

Particularly, given the focus on mental health and weight here, as discussed earlier, non-response and attrition biases are likely present. Although treatment type was included as a control variable within the analysis, we were unable to consider the evidence that some biologic treatments such as tumour necrosis factor alpha inhibitors, but not interleukin (IL)-12/23, may be associated with increased body weight or BMI.⁷⁰ Therefore, any possibly conflicting effects of different types of biologics on waist circumference or BMI remain future research's priority. In addition, the highly selective population sample drawn from a tertiary clinic with integrated psychological support may limit the findings' generalisability.

6 | CONCLUSION

The lack of evidence linking mental health and body weight in this study suggests that obesity in psoriasis may be more directly related to comorbid conditions and severity of psoriasis. However, mental health in this study was limited to measures of probably anxiety and depression caseness. It is likely that more complex cognitive, behavioural, and emotional factors, including beliefs and perceptions about body weight, are relevant to understanding obesity in psoriasis. People living with obesity who deal with multimorbidity and greater disease severity may be more prone to psoriasis-related unhelpful coping behaviours such as social withdrawal and emotional eating or be restricted in their physical activity due to disability. The coping and adjustment demands imposed by multimorbidity and greater disease severity, if unmet, may drive mental health issues and contribute to an increase in body weight. Future studies are needed to (i) confirm the findings using rigorously designed longitudinal studies, (ii) further investigate the impact of depression and anxiety on body weight with a focus to reduce attrition among people who live with mental health problems, and (iii) explore the role of beliefs and behaviours in the association between obesity and mental health in psoriasis.

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CONFLICT OF INTEREST

Catherine Smith has received departmental research funding from industries that manufacture treatments for psoriasis including AbbVie, Boehringer Ingelheim, Glaxo SmithKline, Leo, Pfizer, Novartis, Regeneron, and is an investigator within consortia that have industry partners (see biomap.eu and psort.org.uk).

ETHICS STATEMENT

The research data used in this study has been granted ethical approval by the National Health Service (NHS) Research Ethics Committee in the United Kingdom (REC reference: 12/SC/0422) until 2023. Since IM-PARTS data collection is part of routine clinical care, formal consent to participate is not required.

AUTHOR CONTRIBUTIONS

Neli T. Pavlova: Conceptualization (lead); Data curation (lead); Formal analysis (lead); Investigation (lead); Methodology (lead); Project administration (equal); Resources (lead); Validation (lead); Writing - original draft (lead); Writing - review & editing (lead). **Rona Moss-Morris:** Conceptualization (equal); Data curation (equal); Formal analysis (equal); Investigation (equal); Methodology (equal); Resources (equal); Supervision (equal); Validation (equal); Writing - original draft (equal); Writing - review & editing (equal). **Catherine Smith:** Conceptualization (equal); Formal analysis (equal); Methodology (equal); Supervision (equal); Validation (equal); Writing - original draft (equal); Writing - review & editing (equal). **Ewan Carr:** Methodology (equal); Supervision (equal); Validation (equal); Writing - original draft (equal); Writing - review & editing (equal). **Lauren Rayner:** Conceptualization (equal); Data curation (equal); Formal analysis (equal); Methodology (equal); Supervision (equal); Writing - original draft (equal); Writing - review & editing (equal). **Federica Picariello:** Conceptualization (lead); Data curation (lead); Formal analysis (lead); Investigation (equal); Methodology (lead); Project administration (equal); Resources (equal); Supervision (lead); Validation (lead); Writing - original draft (lead); Writing - review & editing (lead).

DATA AVAILABILITY STATEMENT

The data that support the findings are not publicly available due to containing information that could compromise the privacy of research participants.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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