Exploring the Impact of a 7-Week Heart Rate Variability Biofeedback Protocol on Skin Severity, Quality of Life, and Mental Health in a Proof-of-Concept Pre–Post Trial of Individuals with Psoriasis

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ABSTRACT

Background: Psoriasis often coexists with psychiatric disorders and decreased quality of life (QoL), with treatments commonly overlooking the psychological impact of the disease. Heart rate variability biofeedback (HRVB) may offer a mind–body solution by providing real-time feedback on autonomic functions, teaching individuals to manage stress via controlled breathing.

Objective: To examine the impact of a 7-week HRVB protocol on skin severity (SS), QoL, and mental health (MH) in individuals with psoriasis and determine the sustainability of any outcomes post-intervention.

Methods: A single-arm, proof-of-concept pre–post trial was conducted at Bastyr University Clinic in San Diego, CA. Five individuals were recruited, screened, and underwent a 7-week HRVB protocol. Assessments included SS through the Psoriasis Area and Severity Index (PASI-P and PASI-C), QoL via the Cardiff Dermatology Life Quality Index (DLQI), and MH using the Generalized Anxiety Disorder-7 (GAD-7) and Patient Health Questionnaire-9 (PHQ-9). Data collection points were baseline, post-protocol, and 1-month follow-up.

Results: Notable improvements were observed between baseline and post-protocol for PASI-P, DLQI, and GAD-7. A significant change remained for GAD-7 between baseline and follow-up. No major differences were identified for PASI-C and PHQ-9 across any timeframe, and other scales remained consistent between post-protocol and follow-up.

Conclusion: HRVB showed promise in enhancing perceived SS, QoL, and anxiety over 7 weeks. Further studies should expand participant numbers and diversify initial scores, comparing HRVB with a control group.

Trial registration: ClinicalTrials.gov NCT05506644, retrospectively registered on 16 August 2022.

Key Words Psoriasis, psychophysiological, psychocutaneous, heart rate variability, biofeedback, mind-body

INTRODUCTION

Psoriasis is a chronic, immune-mediated, psychophysiological disorder of the skin and joints that affects approximately 3% of the US adult population.[1] Psychophysiological disorders are defined as physical diseases in which psychological stress is the key element behind the precipitation or exacerbation of symptoms. The physiologic and clinical impacts of stress have been implicated in a wide variety of conditions, such as asthma, chronic pain, fibromyalgia, hypertension, irritable bowel syndrome (IBS), migraines and tension headaches, and several skin diseases. Psychophysiological skin disorders, or "psychocutaneous disorders," include psoriasis vulgaris, acne vulgaris, acne rosacea, alopecia areata, atopic dermatitis, seborrheic dermatitis, and chronic spontaneous urticaria.[2] The bidirectional interaction between the skin and the mind, however, makes it difficult to determine whether psychological stress is the etiology behind the dermatosis, or conversely, if the dermatosis precipitates the psychiatric manifestations.[2]

There are several clinical types of psoriasis, but the most common form is plaque psoriasis which typically presents as chronic, recurrent, erythematous, itchy or painful plaques with a characteristic silvery-white scale. Psoriasis is often associated with significant impairments to physical, emotional, and social well-being and quality of life (QoL) due to the stress resulting from disfigurement,

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stigmatization, avoidance coping behaviour, chronic pruritus, and other comorbidities.[3] Individuals with psoriasis are at increased risk for psychiatric disorders such as anxiety and depression, and there is growing evidence suggesting these individuals have the highest risk of suicidality of any skin disease.[4,5] Pharmacological interventions and phototherapy provide effective, albeit temporary, relief of the dermatosis; however, they frequently fail to address the psychological impacts of psoriasis.

The current standard-of-care treatments for psoriasis are largely aimed at alleviating symptoms and range from topical treatments to systemic therapies. Topical corticosteroids and vitamin D analogues are frequently employed as first-line treatments for mild to moderate psoriasis, although the exact efficacy in terms of PASI score achievement is not well documented in the literature and can vary depending on the severity and type of psoriasis being treated. According to a Cochrane systematic review, vitamin D analogues were found to be more effective than placebo in treating chronic plaque psoriasis, with about 57% of patients achieving at least a 50% improvement in their PASI score.[6] However, the same study found that vitamin D analogues were less effective than potent or very potent topical corticosteroids but more effective than weak topical corticosteroids. For moderate to severe psoriasis, narrowband UVB (NB-UVB) phototherapy is commonly used, with approximately 50% to 70% of patients reportedly achieving PASI 75 (75% reduction in their PASI symptoms) after approximately 20 to 30 sessions of NB-UVB phototherapy.[7] Systemic treatments such as methotrexate and cyclosporine are also utilized, reportedly resulting in PASI 75 scores for around 46% to 58% of patients after 12 to16 weeks of treatment.[8] Recently, biologic agents have shown even higher efficacy, with drugs like etanercept, infliximab, ustekinumab, and secukinumab helping 50% to 82% of patients achieve PASI 75 after 10 to 12 weeks of use.[9-12] Despite the efficacy of these options, the chronic and psychocutaneous nature of psoriasis necessitates ongoing management and treatment customization, with an emphasis on treating the psychological factors that contribute to the physical manifestation of psoriasis.

The recognition of the link between skin disorders and psychiatric comorbidities has grown; however, an increase in the provision of services to address these concerns has yet to follow.[2] An estimated 30% to 60% of all dermatological patients have an associated psychiatric disorder,[13] higher than the prevalence in neurologic, oncologic, and cardiac patients combined.[14] In a survey examining dermatologists' beliefs and practice styles toward psychocutaneous diseases, 98% of respondents believed there was a relationship between skin and mental health, and 100% of respondents reported seeing patients with a known psychiatric disorder in their practice, 61.7% of them more than once a week.[15] Despite this, only 23% of practices administered psychiatric questionnaires, and only 6.4% of them at every appointment, due to time constraints, lack of familiarity, and the perception that it was outside the scope of dermatological practice.[15] Thus, there is an urgent need for increased education about psychocutaneous disorders across healthcare professions and evidence-based, integrative approaches that offset both the physical and psychological burdens of skin conditions such as psoriasis.

Mind–body therapies (MBTs) are interventions that aim to use the mind in order to influence physical health and have become increasingly popular in the management of psychocutaneous disorders.[16] MBTs, such as mindfulness-based stress reduction (MBSR),[17,18] cognitive behavioural therapy (CBT),[19] biofeedback,[20] and emotional writing disclosure,[21] have been studied in psoriasis with promising results. In a meta-analysis of psychological interventions for adults with skin conditions, MBTs demonstrated overall improvements in the parameters of itch/scratch, psychosocial outcomes, and skin severity (SS) in individuals with psoriasis compared with healthy controls.[22] Concomitant use of MBTs with conventional treatments has demonstrated efficacy in reducing the amount of medication and phototherapy necessary to improve symptoms in psoriasis.[23] Further, higher clinical and psychological benefits have been observed in individuals with psoriasis from the use of MBTs with phototherapy than with phototherapy alone, even after conclusion of the trial,[20,21] suggesting that skills learned from adjuvant MBTs may potentially help provide lasting therapeutic benefit.

Heart rate variability biofeedback (HRVB) is a safe, non-invasive, and relatively low-cost MBT that provides real-time visual feedback on an individual's autonomic functioning in order to modify their physiological stress response through diaphragmatic, paced breathing.[24] HRVB may be beneficial in individuals with psoriasis as the feedback tools may help them to develop the necessary skill set to maintain regulatory control over their stress responses, even after the end of their therapies.[20] HRVB has been studied for anxiety,[25-27] depression,[27-29] insomnia,[28,30] post-traumatic stress disorder,[31] substance use disorders,[32-34] asthma,[35] athletic performance,[36,37] cardiovascular disease,[38] fibromyalgia,[39] and IBS;[40] however, there is currently a paucity of literature on HRVB for psoriasis. Thus, the objective of this proof-of-concept pre–post trial was to explore the impact of a 7-week HRVB protocol on SS, QoL, and mental health (MH) in individuals with psoriasis (n=5).

MATERIALS AND METHODS

Study Design

This was a single-center, single-arm, proof-of-concept pre–post trial conducted at Bastyr University Clinic in San Diego, CA, between June 2022 and December 2022 (ClinicalTrials.gov ID: NCT05506644). The trial was conducted according to the guidelines of the Declaration of Helsinki and approved by the Institutional Review Board of Bastyr University (IRB #22-1714, approved 7 June 2022). Written informed consent was obtained from all study participants.

Eligibility Criteria

Table 1 lists the inclusion and exclusion criteria that all participants were screened for in order to participate in the trial.

Intervention

The intervention was a 7-week HRVB protocol offered at Bastyr University Clinic as a part of clinical care. The protocol consisted of weekly visits of up to an hour and participants were assigned

TABLE 1 Eligibility Criteria for Participants to Enroll in the Study

Inclusion Criteria	Exclusion Criteria
1. Age ≥ 18 years old. 2. Previous diagnosis of psoriasis and/or currently experiencing symptoms of psoriasis. 3. Located in or within driving distance of San Diego. 4. Able to read and understand English. 5. Willing to commit to eight in-person visits at Bastyr University Clinic. 6. Willing to commit to ≥ 30 minutes of at-home breathing exercises for 7 weeks. 7. Daily access to a smart phone, computer, or tablet.	1. Pacemaker 2. History of chronic kidney disease or epilepsy. 3. Currently pregnant. 4. Currently under treatment for any significant medical condition (e.g., cancer, HIV). 5. High risk of suicidality.

at-home breathing practices for 20 minutes twice daily. Each visit is designed to build upon the previous week and to allow time for participants to integrate the breathing practices into their daily lives. Participants were also asked to avoid smoking, aerobic exercise, caffeine, and heavy meals for at least 1 hour prior to each visit. In the first visit, a breath inquiry was performed and participants were taught to practice paced breathing at a rate of six breaths per minute. In the second visit, the blood-volume pulse (BVP) and respiration sensor (i.e., breathing belt) devices were introduced and heart rate variability (HRV) was measured using the PhysioData program. In the third visit, the participant's resonant frequency (RF) breathing rate was identified and participants were instructed to continue their at-home breathing exercises at their specific RF breathing rate going forward. In the fourth visit, participants were switched to an infrared pulse plethysmograph PPG sensor and the emWave program to measure HRV and taught the concept of emotional coherence. In the fifth through seventh visits, participants were asked to come up with stressor storylines, with each week increasing in intensity, in order to activate their physiological stress response. This was followed by RF breathing as a method to regulate their stress response, practice emotional regulation, and desensitize themselves to the stressor. Over the course of the 7-week HRVB protocol, participants also practiced the use of vision statements and guided meditations.

Outcomes

All outcomes measuring SS, QoL, and MH were collected at baseline (T1), post-protocol (T2), and follow-up 1 month after the last biofeedback session (T3) (Table 2). Skin severity was assessed with the Psoriasis Area and Severity Index (PASI),[41] QoL was assessed using the Cardiff Dermatology Life Quality Index (DLQI),[42] and MH was assessed using the Generalized Anxiety Disorder-7 (GAD-7),[43] and Patient Health Questionnaire-9 (PHQ-9).[44]

Skin Severity

The PASI is considered the gold standard for assessing clinical severity and extent of, and response to treatment for, psoriasis.[41] PASI was graded by both the participant (PASI-P) and clinician (PASI-C). Self-assessment of the PASI has been validated in a previous study.[45] The PASI measures erythema, induration, scaling, and the percentage of body surface coverage from psoriatic plaques, and scores can range from 0 to 72; the higher the score, the more severe the disease. To measure psoriasis severity, the body is divided into four sections: head, upper extremities, trunk, lower extremities. The severity of erythema, induration, and scaling is measured for each body section on a scale from 0 to 4, where 0 means none and 4 means very severe. To assess extent of psoriasis, a score from 0 to 6 is assigned to each body section based on the percentage of skin affected, with 0 indicating no involvement and 6 indicating involvement of over 90% of the skin. The sum of these scores is used to calculate the total PASI score, ranging from 0 to 72, where a higher score indicates more severe psoriasis. 0 to 5 indicates none to mild psoriasis, 6 to 10 indicates moderate psoriasis, and 11 or above indicates severe psoriasis.

Quality of Life

The DLQI is a 10-item, dermatology-specific validated questionnaire that assesses six different aspects pertaining to QoL in relation to the distress caused by the dermatosis.[42] The DLQI is the most common QoL questionnaire used for skin disease. Each question asks how much the skin disease has affected the individual's life over the previous week, and scores range from 0 to 30; a higher score indicates a greater impairment to QoL. A score of 0 to 1 indicates no impact on patient's life, 2 to 5 a small impact, 6 to 10 a moderate impact, 11 to 20 a very large impact, and 21 to 30 an extremely large impact on the patient's QoL.

Mental Health

The GAD-7 and PHQ-9 are common, validated diagnostic tools for mental health disorders, specifically anxiety and depression, respectively.[43,44] Both questionnaires ask the individual to rate their symptoms over the previous 2 weeks on a scale of not at all (0), several days (1), more than half the days (2), nearly every day (3), and the sum of these questions is the total score. GAD-7 scores can range from 0 to 21; a score of 0 to 4 indicates none to minimal anxiety, 5 to 9 indicates mild anxiety, 10 to14 indicates moderate anxiety, and 15 to 21 indicates severe anxiety. PHQ-9 scores can range from 0 to 27; a score of 0 to 4 indicates none to minimal depression, 5 to 9 indicates mild depression, 10 to14 indicates moderate depression, 15 to 19 indicates moderately severe depression, and 20 to 27 indicates severe depression.

Table 3 indicates the timing of the evaluations.

Recruitment

Five participants were recruited through flyers and referrals within Bastyr University Clinic. This sample size was determined based on similar studies of proof-of-concept design. All eight study visits were provided free of charge, in addition to any additional visits required to establish care at Bastyr University Clinic. Participants were also incentivized with a $100 Amazon gift card ($75 at T2, $25 at T3).

Data Collection and Management

The PASI-P and PASI-C were completed in-person at Bastyr University Clinic, and paper copies were scanned into the participant's chart and placed in a locked medical record filing cabinet. The scores were recorded in a de-identified Excel spreadsheet. All other questionnaires were administered via Research Electronic Data Capture (REDCap) tools hosted at Bastyr University. REDCap is a secure, web-based application designed to support data capture for research studies.[46] Photos taken of the participants' skin were free of any identifiers (e.g., tattoos, birthmarks) and stored in a password-protected device. All study personnel having contact with participants were appropriately trained in medical research ethics in accordance with the Collaborate Institutional Training Initiative (CITI) program.

Statistical Methods

Descriptive statistics are reported as mean ± standard deviation (SD). To test the effects of the HRVB protocol, a 1-tailed paired *t*-test was used to determine the significant difference of scores from T1 to T2, T2 to T3, and T1 to T3 for outcome measures of PASI-P, PASI-C, DLQI, GAD-7, and PHQ-9. No corrections for multiple comparisons were conducted to avoid inflation of type II errors.

RESULTS

Summary of Outcome Measures

Assessment scores measuring SS, QoL, and MH, along with their means and standard deviations, are listed in Table 4 for all participants at T1, T2, and T3 timepoints.

TABLE 2 Outcomes Collected for Analysis

Outcomes	Baseline (T1)	Post-Protocol (T2)	Follow-Up (T3)
Skin Severity			
PASI-P	X	X	X
PASI-C	X	X	X
Quality of Life			
DLQI	X	X	X
Mental Health			
GAD-7	X	X	X
PHQ-9	X	X	X

For detailed descriptions of the 5 cases, followed by an analysis and assessment of their clinical presentations and outcome measures at each visit, see Appendix A.

Statistical Analysis

The total scores, means, standard deviations (SD) for all scales and time points can be found in Table 4. *T*-tests were conducted between T1 and T2, T2 and T3, and T1 and T3 and assessed for significant difference in scores.

The mean (SD) scores for PASI-P at T1, T2, T3 were 3.9 (±3.0), 2.9 (±3.0) and 2.2 (±1.3), respectively. A one-tailed *t*-test showed

TABLE 4 A Summary of Total Scores, Mean, and Standard Deviations for all Participants at T1, T2, and T3.

Assessment	Baseline (T1)	Post-Protocol (T2)	Follow-Up (T3)
PASI-P			
Case 1	1.7	0.8	1.4
Case 2	5	2.9	3
Case 3	1.3	1.8	2.4
Case 4	8.7	8	3.7
Case 5	2.8	0.9	0.4
Mean (SD)	3.9 (3.0)	2.9 (3.0)	2.2 (1.3)
PASI-C			
Case 1	1.4	0.8	1.1
Case 2	6	2.1	3.1
Case 3	1	2	1.3
Case 4	4.5	3.4	2.1
Case 5	1	0.2	0.1
Mean (SD)	2.8 (2.3)	1.7 (1.2)	1.5 (1.1)
DLQI			
Case 1	6	2	1
Case 2	2	0	0
Case 3	2	2	1
Case 4	3	3	5
Case 5	19	14	3
Mean (SD)	6.4 (7.2)	4.2 (5.6)	2.0 (2.0)
GAD-7			
Case 1	5	3	2
Case 2	9	7	2
Case 3	5	3	2
Case 4	5	0	1
Case 5	7	5	1
Mean (SD)	6.2 (1.8)	3.6 (2.6)	1.6 (0.6)
PHQ-9			
Case 1	4	1	6
Case 2	6	11	7
Case 3	4	6	5
Case 4	3	1	1
Case 5	11	4	1
Mean (SD)	5.6 (3.2)	4.6 (4.2)	4.0 (2.8)

TABLE 3 Schedule of Evaluations

Activity/Assessment	Pre-Study (T0)	Baseline (T1)	Post-Protocol (T2)	Follow-Up (T3)
Eligibility Criteria	X			
Verbal Consent	X			
Written Consent		X		
Psoriasis History		X		
Skin Assessment and Photos		X	X	X
REDCap Questionnaires		X	X	X
Biofeedback Protocol		X	X	

a significant difference between T1 and T2 (t-statistic = 2.18, p = 0.005), with a non-significant difference between T2 and T3 (p = 0.2) and T1 and T3 (p = 0.09). Linear regressions showed a negative slope for all cases except Case 3 (Figure 1).

The mean (SD) scores for PASI-C at T1, T2, and T3 were 2.8 (±2.3), 1.7 (±1.2) and 1.5 (±1.1), respectively. A one-tailed t-test resulted in non-significant differences for all time points (T1 to T2, p = 0.1; T2 to T3, p = 0.4; T1 to T3, p = 0.06). Individual linear regressions showed a negative slope for all participants except for Case 3 (Figure 2).

The mean (SD) scores for DLQI at T1, T2, and T3 were 6.4 (±7.2), 4.2 (±5.6) and 2.0 (±2.0), respectively. A one-tailed t-test showed significant difference between T1 and T2 (t-statistic = 2.16, p = 0.05); however, differences between T2 and T3 (p = 0.2) and T1 and T3 (p = 0.1) were not significant. Linear regressions saw a decrease in scores over time for all except case 4 (Figure 3).

The mean (SD) scores for GAD-7 at T1, T2, and T3 were 6.2 (±1.8), 3.6 (±2.6), and 1.6 (±0.6), respectively. A one-tailed t-test showed a significant difference between T1 and T2 (t-statistic = 4.3, p = 0.006), and T1 and T3 (t-statistic = 5.7, p = 0.002). There was a non-significant difference between T2 and T3 (p = 0.07). Linear regressions by case showed decreasing scores for all cases (Figure 4).

The mean (SD) scores for PHQ-9 at T1, T2, and T3 were 5.6 (±3.2), 4.6 (±4.2), and 4.0 (±2.8), respectively. A one-tailed t-test resulted in non-significant differences for all time points (T1 to T2, p = 0.3; T2 to T3, p = 0.4; T1 to T3, p = 0.3). Linear regressions showed mixed results over time with Cases 1, 2, and 3 positively correlated and Case 4 and 5 negatively correlated (Figure 5).

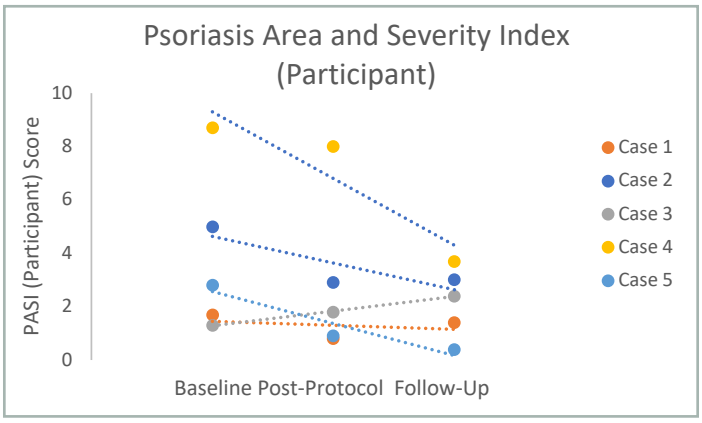

FIGURE 1 Data points and trendlines for all PASI scores self-graded by the participants.

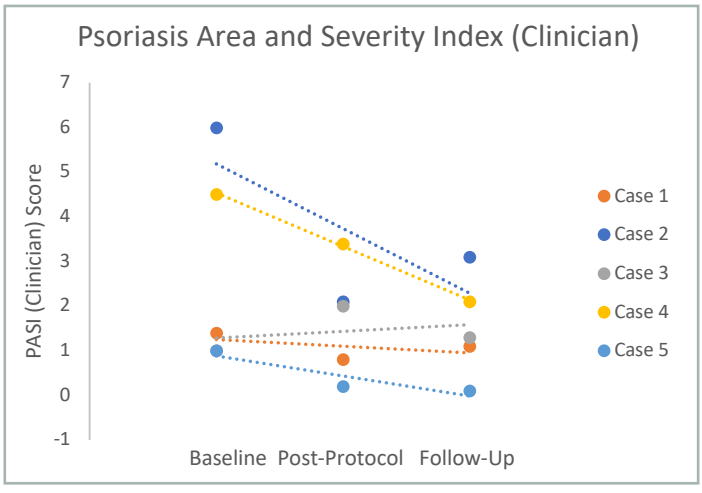

FIGURE 2 Data points and trendlines for all PASI scores graded by the study clinician.

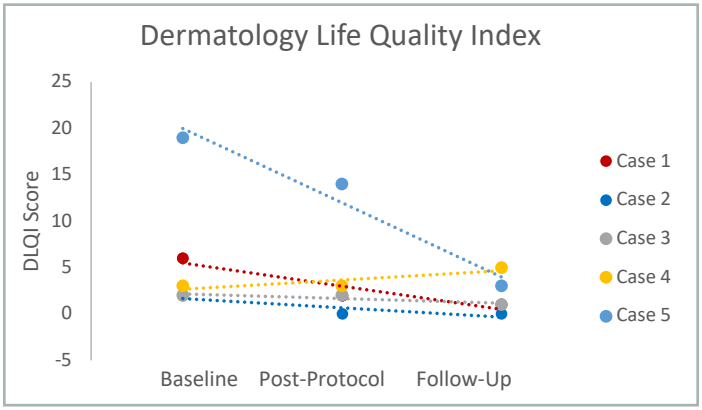

FIGURE 3 Data points and trendlines for all DLQI scores.

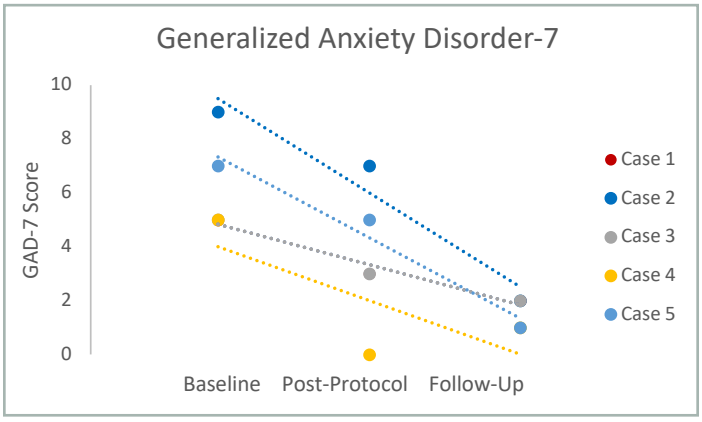

FIGURE 4 Data points and trendlines for all GAD-7 scores. Note: Case 1 and Case 3 had identical scores and overlapping data points, therefore, the trendline for Case 1 is not visible in this graph.

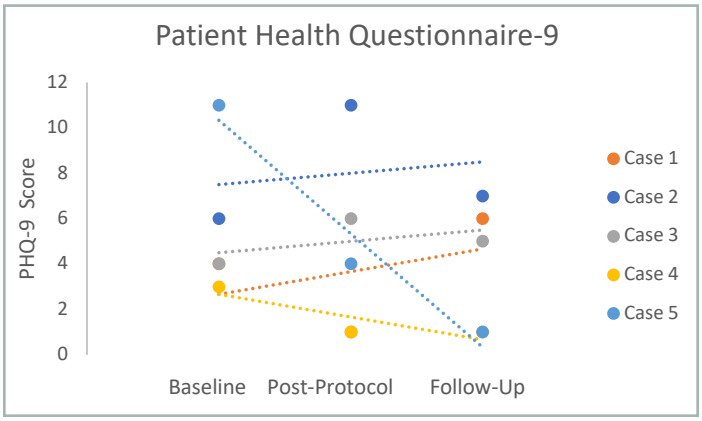

FIGURE 5 Data points and trendlines for all PHQ-9 scores.

DISCUSSION

Main Results

To the best of our knowledge, this is the first study to describe the impact of HRVB on SS, QoL, and MH in individuals with psoriasis. Our findings indicate significant differences in scores between T1 and T2 for PASI-P, DLQI, and GAD-7, suggesting that HRVB was associated in improvements in participant perception of SS, QoL, and anxiety. Interestingly, there was not a significant improvement in PASI-C at any time points. In a Multinational Assessment of Psoriasis and Psoriatic Arthritis (MAPP) survey,[47] participants and clinicians assessed disease severity differently, and in the present study, participant perception of SS was generally higher than the perception of the clinician. Further, although the self-assessment of the PASI was validated in a previous study, the authors reported that the self-assessment tended to overestimate the disease severity compared with the clinician's assessment.[45] This finding reflects the complex interplay that exists between physical symptoms and patient perceptions in psoriasis. Additionally, these findings may be reflective of the subjective burden of psoriasis which includes distress, social isolation, and stigma, all which may not be fully captured by existing clinical assessments. The improvements in PASI-P scores coinciding with improvements in DLQI and GAD-7 between T1 and T2 may imply that patients' experience and perception of psoriasis is not only physical, but also psychological.

Despite being the most widely used tool for assessing psoriasis severity, the PASI scale has been criticized for lacking sensitivity due to equal weight being placed on erythema, desquamation, induration, and their scores within each of the four body regions.[48] For example, if a participant were to report a reduction in induration but an increase in erythema, this would be recorded as the same PASI score. Further, the PASI scale also does not correlate with QoL and psychological stress associated with the disease, which is often worse than the clinician's rating of SS.[49] Thus, the DLQI was used in this study, which revealed significant improvement in QoL from T1 to T2. This could suggest that as participant perception of SS improved, QoL also improved. Alternatively, this could also suggest that improvements in QoL and psychological stress led to improvements in participant perception of SS. For future studies, coupling clinical measures such as the PASI with the DLQI or other patient-reported outcomes may enable a more nuanced understanding of treatment effects and help capture a wide spectrum of patient experiences with psoriasis.

With respect to GAD-7 scores, there was a significant difference between T1 and T2, and between T1 and T3. This suggests that anxiety was significantly improved over the 7-week HRVB protocol and that this improvement was sustained for at least 1 month following the end of the protocol. The impact of HRVB on anxiety has been well-established, and these results are consistent with these previous studies.[25-27] Anxiety was the only outcome that was significantly improved between T1 and T3. Although there were improvements in PASI-P, PASI-C, DLQI, and PHQ-9 between T1 and T3, they were not significant. Despite this, the significant reduction in anxiety alone emphasizes the potential of HRVB as a valuable adjunctive therapy for reducing anxiety in psoriasis patients. The strong link between anxiety and psoriasis, and the vicious cycle they often create, has been well-documented.[50] By breaking this cycle through reducing anxiety, HRVB may not just alleviate the psychological burden of psoriasis but has the potential to improve disease severity in the long term.

There was no significant difference in PHQ-9 between any time points, which contradicts previous studies suggesting the effectiveness of HRVB in reducing depression.[27-29] However, it is important to note that this cohort did not initially exhibit significant levels of depression at baseline, making the non-significant difference in PHQ-9 a predictable outcome. This finding also suggests that the benefits of HRVB may be more prominent for individuals experiencing higher PHQ-9 scores at baseline. It is worth noting that while there were no significant changes in the scales for T2 and T3, there were sustained improvements made between T1 and T2. This suggests that HRVB may have a lasting impact on participant well-being and may emphasize the importance of long-term follow-up to assess the effectiveness and durability of HRVB as an adjunctive treatment approach for psoriasis.

Limitations

In this proof-of-concept study, recruitment was a significant limitation. Although we were able to recruit 5 individuals as participants with psoriasis as intended, we did not require that all participants have associated psychiatric comorbidities due to the limited patient population as recruitment was conducted internally through flyers and referrals from clinicians and students within the clinic. Additionally, most participants had mild psoriasis at T1, and future studies should include a wider diversity of SS scores, as well as a larger study population.

Given that this was a proof-of-concept study, we did not include a control cohort or limit concomitant treatments. This makes it difficult to delineate whether the improvements were due to HRVB or were the result of any confounding variables. No participants reported using phototherapy or pharmaceutical interventions during the time of the protocol, but some were attempting dietary modifications to help manage their symptoms. Additionally, over the course of the 11 weeks, we could not control new life events that occurred, which caused significant added psychological stress in the participants' lives. In this real-life setting, HRVB was associated with significant improvements in participant perception of SS, QoL, and anxiety over a 7-week period.

In conclusion, this study provides an exploration into the impact of HRVB on SS, QoL, and MH in individuals with psoriasis. The findings present a compelling case for considering HRVB as a non-invasive adjunctive treatment, potentially improving patient perceptions of SS, QoL, and anxiety. This work underscores the need for further investigations to validate our findings and explore the potential of HRVB for other psychocutaneous conditions. Further studies should include a larger cohort with more variation in SS, QoL, and MH scores at T1 and compare the HRVB protocol against a control group.

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CONFLICTS OF INTEREST DISCLOSURE

We have read and understood the *CAND Journal*'s policy on conflicts of interest and declare that we have none.

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APPENDIX A

Case 1, 46-Year-Old Male

T1: A 46-year-old male presented with psoriatic plaques on his nails, behind his ears, and scalp. He reported that the psoriasis started on his nails 7 to 8 years ago and behind his ears 1 year ago. He reported pruritus that was alleviated by over-the-counter 1% hydrocortisone cream but denied pain. He denies noticing any seasonal variation in the severity of symptoms. He reported that his top three stressors were his children, job dissatisfaction, and existential/mid-life crisis and that his stress management techniques were exercise, music, and alcohol consumption. At T1, PASI-P was 1.7 (mild psoriasis), PASI-C was 1.4 (mild psoriasis), DLQI was 6 (moderate effect), GAD-7 was 5 (mild anxiety), and PHQ-9 was 4 (none–minimal depression).

T2: The participant reported that stress had been constant throughout the HRVB protocol but that he was able to utilize the techniques learned during the protocol, leading to an overall decrease in skin itching. The participant did note that there was one recent flare with symptoms of pruritus. At this visit, he reported that he had been practicing resonant frequency breathing for an average of 15 to 20 minutes daily. Additionally, the participant has seen significant improvements in sleep quality. At T2, PASI-P was 0.8 (mild psoriasis), PASI-C was 0.8 (mild psoriasis), DLQI was 2, GAD-7 was 3 (minimal anxiety), and PHQ-9 was 1 (none–minimal depression).

T3: The participant reported that he had an increase in stress over the previous month but was able to maintain 5 to 10 minutes of home practice a week. At T3, PASI-P was 1.4 (mild psoriasis), PASI-C was 1.1 (mild psoriasis), DLQI was 1 (no effect on participant's life), GAD-7 was 2 (none–minimal anxiety), PHQ-9 was 6 (mild depression).

Case 2, 26-Year-Old Male

T1: A 26-year-old male presented with psoriatic plaques on his eyelids, behind his ears, elbows, knees, legs, ankles, and feet. He reported that the psoriasis was present since birth and that the plaques were present all over his body as an infant. The plaques were described as red, scaly, flakey, and raw, but he denied pruritus or pain. He reported the psoriasis is aggravated by stress, cold weather, and possibly the consumption of gluten or dairy, and it is alleviated by restrictive diets and being in the sun. Treatments tried included steroids, biologics, topical creams, and phototherapy but he did not notice improvement when using them. He reported his top three stressors were his work, social life, and not achieving his goals; he denied currently using any techniques to manage his stress. At T1, PASI-P was 5 (mild psoriasis), PASI-C was 6 (moderate psoriasis), DLQI was 2 (small effect on participant's life), GAD-7 was 9 (mild anxiety), and PHQ-9 was 6 (mild depression).

T2: Throughout the HRVB protocol, the participant had reported extreme stress from an ongoing work conflict, which resolved by T2. At this visit, he reported he had been practicing resonant frequency breathing for an average of 45 minutes daily. At T2, PASI-P was 2.9 (mild psoriasis); PASI-C was 2.1 (mild psoriasis), DLQI was 0 (no effect on participant's life), GAD-7 was 7 (mild anxiety), and PHQ-9 was 11 (moderate depression).

T3: The participant reported he was only practicing the resonant frequency breathing sporadically, as needed in times of stress. At T3, PASI-P was 3 (mild psoriasis), PASI-C was 3.1 (mild psoriasis), DLQI was 0 (no effect on participant's life), GAD-7 was 2 (none–minimal anxiety), and PHQ-9 was 7 (mild depression).

Case 3, 37-Year-Old Male

T1: A 37-year-old male presented with psoriatic plaques on his eyelids, nose bridge, back of neck, knees, and left arm. He reported that the onset of psoriasis began in 2003. Symptoms included itchiness, dryness, flakiness, induration, and bumps that turn into scaly thick patches. His symptoms are aggravated by stress, dietary changes, and heat. Specifically, he reports that his psoriasis is worse in the summer due to the heat. Symptoms are alleviated by steroid cream application and dietary changes. His top three stressors are anxiety from work/career, left bicep injury, and his pet. He manages stress with deep breathing, meditating, going to the gym for resistance training, going on walks, and being outside. At T1, PASI-P was 1.3 (mild psoriasis), PASI-C was 1 (mild psoriasis), DLQI was 2 (small effect), GAD-7 was 5 (mild anxiety), and PHQ-9 was 4 (none–minimal depression).

T2: The participant reported higher stress levels in the week leading up this visit due to preparing for vacation. He reports that although he was unable to do resonant frequency breathing at home as frequently this week, in the previous weeks he was able to complete 5 to 6 minutes daily. At the T2 visit, PASI-P was 1.8 (mild psoriasis), PASI-C was 2 (mild psoriasis), DLQI was 2 (small effect), GAD-7 was 3 (minimal anxiety), and PHQ-9 was 6 (mild depression).

T3: The participant reported fluctuating stress levels in the month following the last visit. However, he reports that he felt he had the tools to be able to manage them. At T3, PASI-P was 2.4 (mild psoriasis), PASI-C was 1.3 (mild psoriasis), DLQI was 1 (no effect), GAD-7 was 2 (minimal anxiety), and PHQ-9 was 5 (mild-depression).

Case 4, 27-Year-Old Female

T1: A 27-year-old female presented at T1 with psoriasis on her elbows, knees, ankles, shins, scalp, and behind the ears. The psoriasis

was characterized as a rash with occasional flaking, and presence of white spots mainly around joints. The participant reported no pain or itchiness. Aggravating factors included alcohol, sugar, gluten, dairy, stress and an infection-induced flare-up 2 years prior. She also reported experiencing associated symptoms such as digestive issues, cramping, abdominal pain, and vitiligo. Stress management techniques included meditation, yoga, and Ketamine, and her top three stressors were reported to be finances, HSV outbreaks, and family issues. At T1, PASI-P was 8.7 (moderate psoriasis), PASI-C was 4.5 (mild psoriasis), DLQI was 3 (small effect), GAD-7 was 5 (mild anxiety), and PHQ-9 was 3 (none–minimal depression).

T2: The participant reported having integrated breath work into her daily routine for at least 15 minutes a day. She noticed significant improvements in stress and overall happiness and felt better equipped to handle stress and anxiety. Although the participant reported a flare-up in psoriatic symptoms with new ingestion of probiotic cookies, she noted that the psoriasis was getting better overall throughout the process. At T2, PASI-P was 8 (moderate psoriasis), PASI-C was 3.4 (mild psoriasis), DLQI was 3 (small effect), GAD-7 was 0 (none–minimal anxiety), and PHQ-9 was 1 (none–minimal depression).

T3: The participant reported feeling great and noted overall symptom improvement after discontinuing aggravating foods. She reported no more flaking or itching in the symptomatic areas. At T3, PASI-P was 3.7 (mild psoriasis), PASI-C was 2.1 (mild psoriasis), DLQI was 5 (small effect), GAD-7 was 1 (none–minimal anxiety), and PHQ-9 was 1 (none–minimal depression). Although DLQI was worse at this visit, the participant attributed it to the recent flare-up and was optimistic that she could fully resolve it now that she could identify the trigger.

Case 5, 19-Year-Old Female

T1: A 19-year-old female presented with psoriasis on her eyebrows, neck, and scalp. She reported that the onset of psoriasis began in the fourth grade. At age 16, the psoriatic plaques appeared on her neck, and around July 2021 over her body. She sought out naturopathic care at the time and reported that the symptoms resolved within 3 months. She experienced associated symptoms such as anxiety, itchiness, flaking, and dryness. Aggravating factors included gluten, dairy, beef, poor hygiene, not moisturizing, and picking the area. Alleviating factors included topical steroids but upon discontinuing, the symptoms returned. She has made dietary changes by cutting out gluten, dairy, beef, and peaches. Her current top stressors include general anxiety, family issues with her older sister, and figuring out her relationship with herself. She manages stress with breathing exercises, podcasts, and monthly therapy sessions. At T1, PASI-P was 2.8 (mild psoriasis), PASI-C was 1 (mild psoriasis), DLQI was 19 (very large effect), GAD-7 was 7 (mild anxiety), and PHQ-9 was 11 (moderate depression).

T2: The participant reported significant improvement in her general anxiety and reported that she was no longer worrying as much. The stress related to her older sister was also significantly improved as well as her relationship with herself. At T2, PASI-P was 0.9 (mild psoriasis), PASI-C was 0.2 (mild psoriasis), DLQI was 14 (moderate effect), GAD-7 was 5 (mild anxiety), and PHQ-9 was 4 (none–minimal depression).

T3: Participant reported further improvements in her general anxiety, family issues with her older sister, and relationship with herself. At T3, PASI-P was 0.4 (mild psoriasis), PASI-C was 0.1 (mild psoriasis), DLQI was 3 (small effect), GAD-7 was 1 (none–minimal anxiety), and PHQ-9 was 1 (none–minimal depression).