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Review

Lifestyle Modifications and Nonpharmacologic Interventions to Improve Outcomes in Psoriatic Arthritis: A Systematic Review

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ABSTRACT

Purpose: Psoriatic arthritis (PsA) is a multisystem inflammatory disorder associated with significant mortality and morbidity, including functional impairment and psychological disability. Although evidence-based treatment recommendations are available for the use of drug treatments in PsA, there is little guidance for health professionals on nonpharmacologic and psychological interventions that may be useful in PsA. The objective of this systematic review (SR) was to identify how lifestyle modifications and the use of nonpharmacologic and psychological interventions may improve the outcomes of patients with PsA.

Methods: Studies were included if they evaluated adults diagnosed with PsA and included exposure to nonpharmacologic interventions, psychological interventions, and lifestyle modifications. The outcomes used needed to have been validated in PsA. A systematic literature search was run on May 28, 2021, in the Cochrane Central Register of Controlled Trials (CENTRAL), Cumulative Index to Nursing and Allied Health Literature (CINAHL), Allied and Complementary Medicine Database (AMED), EMBASE, Global Health, MEDLINE, and PsycINFO databases to identify articles related to lifestyle modifications and nonpharmacologic or psychological interventions for adults with PsA published between 2010 and 2021. Two review authors independently screened and selected full-text studies for inclusion in the SR. Risk of bias was assessed with either the Risk of Bias 2 (ie, *RoB 2*) tool or Critical Appraisal Skills Program checklist depending on the study type.

Findings: The search strategy identified 26,132 references. Eight studies examining lifestyle modifications and the effect on PsA were eligible to be included in the SR. Three of the 8 studies were randomized controlled trials, and 5 were nonrandomized studies. Three studies assessed physical activity, 3 assessed diet, 1 study assessed smoking, and another study assessed mud bath therapy. There was large heterogeneity between studies, and the measures of disease activity, and psychological and functional outcomes varied widely between studies.

Implications: Although this SR identified 8 relevant studies, these studies did not provide high-quality evidence to guide patients for non-drug treatments of PsA. The effectiveness of these interventions has therefore not been established. We found that physical activity seems to have a positive impact on disease activity and psychological well-being. Further well-designed research studies are needed to develop treatment recommendations. PROSPERO identifier: CRD42021257404.

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Introduction

Psoriatic arthritis (PsA) is an inflammatory condition that affects multiple organ systems, primarily the skin and musculoskeletal system.[1] Despite an increasing number of therapies available to treat PsA, a significant ongoing impact of the disease remains in terms of pain, functional ability, and psychological effects. It is also common for this condition to be associated with a number of other comorbid conditions such as obesity, sedentary lifestyles, excessive alcohol consumption, smoking, poor sleep, exhaustion, and anxiety. As a result, people with PsA are more likely to develop metabolic syndrome and cardiovascular disease (CVD), as well as have an increased risk of mortality and morbidity.[2–4] Hence, lifestyle modifications or healthy lifestyle changes, nonpharmacologic interventions, or psychological interventions are imperative.

Health-related quality of life (QoL) is significantly worse in patients with PsA than in the general population.[5] In addition to comorbid physical conditions, these patients are more likely to experience psychological stress, anxiety, depression, and suicidal thoughts.[6] They are also subjected to stigma in social environments as well as at work, which results in them experiencing self-esteem and body image issues, as well as lower levels of productivity at work.[5–7]

Health advice is clear that exercising regularly, improving diet, stopping smoking, and decreasing stress all play significant roles in reducing CVD and mortality risks,[8,9] as well as reducing health care expenditures.[10] However, evidence specific for patients with PsA is limited.

Although there are many published national and international treatment recommendations for PsA,[11–13] most do not comment on nonpharmacologic treatment given the limitations in the evidence. The 3 main treatment guidelines for PsA, including those by the European League Against Rheumatism (EULAR),[12] the Group for Research and Assessment of Psoriasis and Psoriatic Arthritis (GRAPPA),[11] and the American College of Rheumatology (ACR)/National Psoriasis Foundation (NPF),[13] all recommend similar pharmacologic therapy guidance. However, only the ACR/NPF guidelines mention nonpharmacologic therapies, recommending low-impact (over high-impact) exercise, physical therapy, occupational therapy, weight loss in patients who are overweight or obese, massage, acupuncture, and smoking cessation. They acknowledge the weak evidence base for all the recommendations except smoking cessation.[14]

A James Lind Alliance Priority Setting Partnership was completed to address the key unmet research needs in PsA in 2021.[15] The highest ranked question prioritized by patients and clinicians was "what is the best strategy with PsA including non-drug and drug treatments for patients?" In line with the Declaration of Helsinki, before planning more primary research, a systematic review (SR) should be undertaken to consolidate the current scientific literature and avoid repeating satisfactory research.[16]

The present SR investigates this question further, identifying the current evidence for nonpharmacologic interventions in PsA and addressing the knowledge gap that remains. It will therefore contribute to the development of evidence-based, effective interventions/protocols that would enhance the health-related QoL of this patient cohort in the future.

The primary objective of the present study was to identify whether making lifestyle modifications and using nonpharmacologic or psychological interventions to improve QoL are effective and should be recommended to patients with PsA to improve outcome.

Materials and Methods

We developed a protocol in which the inclusion criteria, outcomes, and methods of analysis were specified a *priori* and followed through all stages of the review. The review protocol was registered with PROSPERO and can be accessed at http://www.crd.york.ac.uk/prospero/ under the SR registration number CRD42021257404. This article was written according to the Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) 2020 guidelines[17] and the PRISMA for Abstracts checklist.[18] A copy of the PRISMA checklist is presented in **Supplemental Information File 1**.

Criteria for Considering Studies for This Review

Types of Studies

Because the focus of the present review was on QoL and lifestyle, we anticipated that a wide range of study types (eg, qualitative and quantitative methodologies) would be retrieved. We therefore included qualitative studies and quantitative studies that reported data on patient-reported outcomes relating to at least one of our primary outcomes. This included randomized controlled trials (RCTs) and nonrandomized studies (NRS), including before and after studies and observational studies (cohort studies, case-control studies, and case series). NRS were included because of the lack of randomized trials, and we wanted to identify the best available evidence in the SR. SRs, case studies, and publications such as conference abstracts, editorials, comments, and non-English language studies were excluded.

Types of Participants

Trials of adults (age >18 years) affected by PsA with a diagnosis made by a rheumatologist or using validated classification criteria (eg, CASPAR [Classification Criteria for Psoriatic Arthritis])[19] were sought. Studies with participants with psoriasis or axial spondylarthritis would only be included if they reported outcomes for PsA as a separate subgroup or if separate data were available from study authors upon request.

Studies were excluded if the participants were children (age <18 years) or where there was uncertainty over the diagnosis of PsA.

Types of Intervention

Studies that evaluated the outcome of nonpharmacologic interventions, psychological interventions, and lifestyle modifications for PsA were included. These included alcohol, diet, pain management, physical activity, recreational drug use, sleep, smoking, stress management, and weight management.

Interventions were defined as specific attempts applied to populations, groups, areas, or institutions to change the social, physical, or economic environments. Such approaches could also form part of broader, multifaceted interventions in workplaces or communities. Studies that reported on the effect of pharmacologic interventions were excluded. Where relevant, for example, from RCTs and cohort studies, the comparator could be either a nonexposed control group, "treatment as usual," or "standard care." Standard care was the care expected for patients with PsA during the period when this review was conducted (2021–2023).

Types of Outcome Measures

Patient-centered outcomes are important in PsA research.[20] The outcomes selected were based on the recommendations of the OMERACT (Outcome Measures in Rheumatology) Groups PsA Core Domain Set.[21] The Grading of Recommendations, Assessment, Development and Evaluation (GRADE) Working Group[22] suggest only including studies that assess at least one primary outcome.

The primary outcome measures were disease activity scores as measured by the following composite indexes: Arithmetic Mean of the Desirability Function – Group for Research and Assessment of Psoriasis and Psoriatic Arthritis Composite ScorE (AMDF-GRACE),[23] the Composite Psoriatic Arthritis Disease Activity Index (CPDAI),[24] and minimal disease activity (MDA).[25] All these outcomes accrue information on at least 3 domains, as they encompass skin status (through the Psoriasis Area and Severity Index [PASI][26]), musculoskeletal system status (although to different extents), and the physical function component (through the Health Assessment Questionnaire [HAQ][27]) and adverse events, including serious adverse events.

The secondary outcome measures considered included pain (eg, visual analog scale [VAS] or 10-point ordinal scale), radiographs or appropriate imaging changes, use of analgesics at longest follow-up, use of antirheumatic medication at longest follow-up, withdrawals due to adverse events, global disability score, health-related QoL, depression (eg, Beck Depression Inventory,[28] Fibromyalgia Impact Questionnaire subscale for depression),[29] fatigue, incidence of CVD at longest follow-up, and mortality (all causes and CVD mortality).

The review team originally wanted studies that had one of the primary outcomes, which were composite outcome measures of PsA disease activity or adverse events. Because so few studies were identified, the review team relaxed the main outcomes to also include our secondary outcome measures; that is, to be included, a study had to have a least one of the main outcomes or secondary outcomes. The PROSPERO protocol was updated to reflect the change.

Measures of Effect

The data collection points of outcome measures were evaluated as reported in the original studies retrieved by our search.

Literature Search

A systematic search was performed on May 28, 2021, in the Cochrane Central Register of Controlled Trials (CENTRAL) (via Cochrane Library, Wiley), Cumulative Index to Nursing and Allied Health Literature (CINAHL) (via EBSCOhost), Allied and Complementary Medicine Database (AMED) (via OVID), EMBASE (via OVID), Global Health (via OVID), MEDLINE (via OVID), and PsycINFO (via OVID) databases to identify articles related to lifestyle modifications and nonpharmacologic or psychological interventions for adults with PsA.

As a result of treatment advances for PsA during the last 10 years, the search was limited to retrieve papers published between 2010 and 2021. The search terms included both free text searched in the title, abstract, or key word fields and relevant controlled vocabulary headings for each database. Search terms for "psoriatic arthritis" (PsA) were combined with "and" with lifestyle or nonpharmacologic or psychological search terms using Boolean operators. The search strategy was designed to be broad and included the use of "wildcards" to ensure retrieval of all relevant studies related to lifestyle modifications, nonpharmacologic or psychological interventions, or QoL or lifestyle issues in patients with PsA. This approach involved a PsA-specific facet of a search strategy developed by the Group for Research and Assessment of Psoriasis and Psoriatic Arthritis 2021 Treatment Recommendations.[30] The search included smoking, alcohol consumption, recreational drug use, diet, physical exercise, mental health, nonpharmacologic pain management, sleep, healthy lifestyle, treatment adherence, psychological interventions, physical therapy, intimacy, relationships, psychological and social factors, and complementary therapies, including acupuncture, traditional or herbal Chinese medicine, alternative therapies, and mind–body therapies.

Apart from the date limit mentioned here, no other limits were applied to the search. A copy of the search strategies for all the databases searched is provided in **Supplemental Information File 2**. In a change to what is stated in the protocol, an update search was not conducted.

The review team are conducting 2 similar reviews (PROSPERO protocol 257395). Each review has a different focus, but the same search approach and strategies have been used to identify studies for both reviews.

Study Selection

After completing the initial searches, the review author uploaded the results first into the electronic software (EndNote) and then into the Covidence-specific software (Melbourne, Australia) used for primary screening and data extraction when conducting SRs.

Two reviewers (L.H.H. and D.M.) conducted an initial screening of the titles and abstracts identified from the search against the inclusion criteria to identify potentially relevant studies. They also screened the full-text papers identified as possibly relevant and independently assessed each one to determine whether it met the predefined inclusion criteria. In the case of uncertainty and if consensus could not be reached, a third reviewer (R.A.) resolved any differences of opinion. If it was obvious that the reference did not refer to a study on PsA and lifestyle modifications and nonpharmacologic or psychological interventions to improve outcome, it was excluded from the review. Excluded studies were recorded and added to the flowchart along with the reasons why they were excluded.

Data Extraction

A standardized data extraction sheet was developed within Covidence and piloted (L.H.H. and A.V.). Two members of the review team (L.H.H. and A.V.) independently extracted data according to study characteristics, inclusion/exclusion criteria, characteristics of participants, interventions, outcomes, and results and entered it into Covidence. In the case of uncertainty and if consensus could not be reached, the third reviewer was used (L.C.C.). The review author (L.H.H.) attempted to contact the authors of the primary studies to uncover any missing or additional data.

Study Quality

Two authors independently graded risk of bias or completed a quality assessment within the individual studies (L.H.H. and L.J.), evaluating the overall quality of evidence across the studies. Uncertainties were resolved by consensus among the 3 reviewers (L.H.H., L.J., and L.C.C.).

The review team planned to assess risk of bias for RCTs based upon the criteria using the Risk of Bias 2 (ie, RoB 2) tool.[31] The Cochrane-recommended RoB 2 tool provides a framework for considering the risk of bias within RCTs. The assessment is structured into a fixed set of domains through which bias might be introduced into trials. NRS were assessed by using ROBINS-I (*Risk of Bias In Non-randomized Studies—of Interventions)*[32] if studies examined the results of NRS that compared health effects of two or more interventions or the Critical Appraisal Skills Program (CASP) for qualitative studies checklist.[33] The ROBINS-I tool was developed to estimate the comparative effectiveness (harm or benefit) of interventions in NRS. Because none of the 5 NRS identified compared the health effects of 2 or more interventions, the review authors did not use the ROBINS-I to assess risk of bias in the NRS; instead, the CASP cohort studies checklist was used.[34] The PROSPERO protocol was updated to reflect the change.

The studies' overall methodologic quality were assessed for each outcome using the GRADE approach.[22] Domains assessed were risk of bias, consistency, directness, and precision. The overall strength of evidence was graded as high, moderate, low, very low, or no evidence.

Data Synthesis

We anticipated there would likely be significant heterogeneity regarding participants, interventions, and outcomes from the included studies. If this was the case, there would be limited scope for meta-analysis of quantitative data.

For qualitative studies, a meta-synthesis approach for qualitative data was used to identify common themes. A qualitative analysis was performed to summarize and describe each included study. The methodologic quality of the qualitative and NRS studies was assessed by using the CASP qualitative or cohort studies checklist.[33,34]

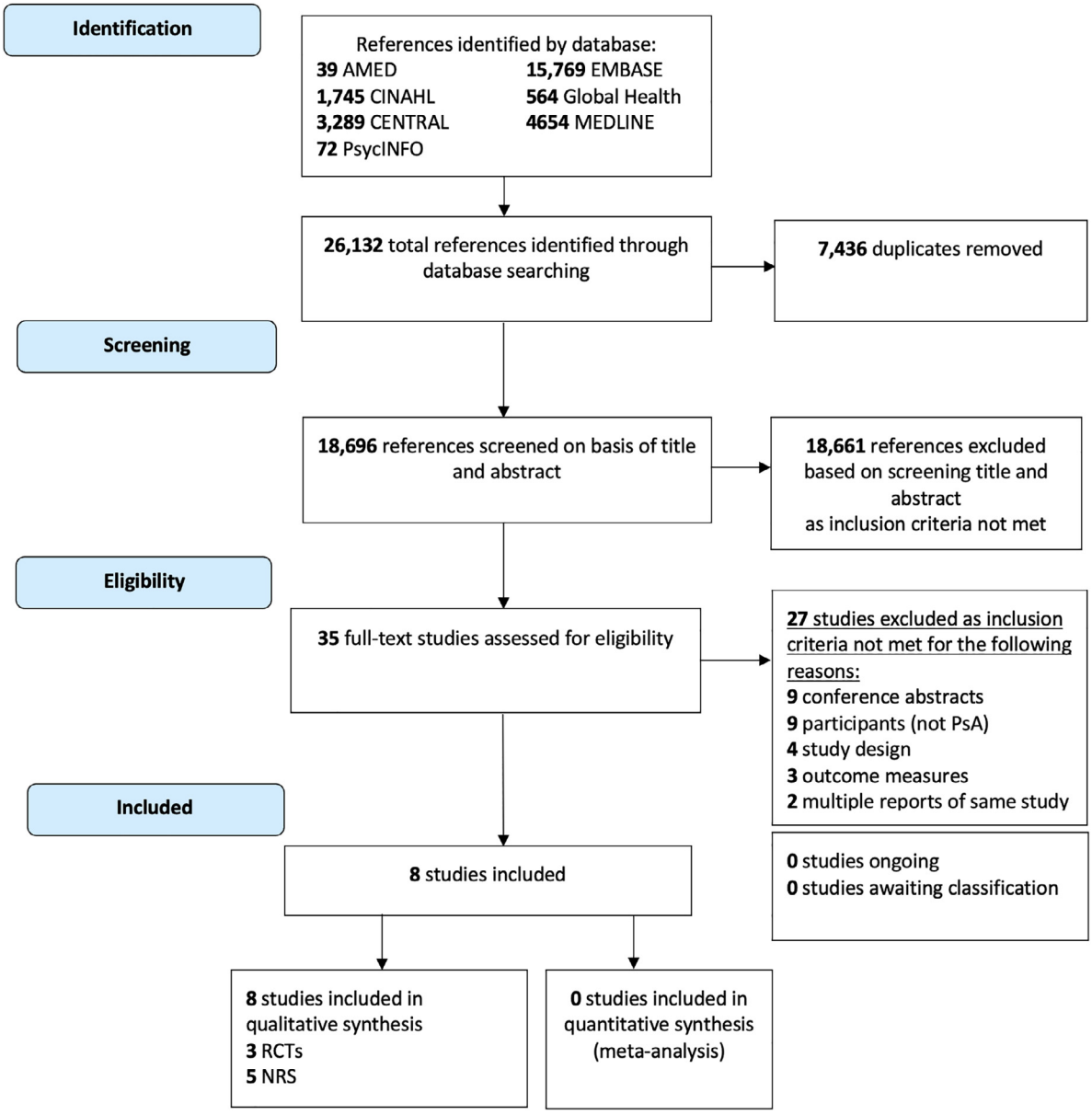


Fig. 1. Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) flow diagram for study selection. AMED = Allied and Complementary Medicine Database; CENTRAL = Cochrane Central Register of Controlled Trials; CINAHL = Cumulative Index to Nursing and Allied Health Literature; NRS = nonrandomized studies; PsA = psoriatic arthritis; RCTs = randomized controlled trials.

Results

Search Strategy and Study Characteristics

The literature search retrieved a combined total of 26,132 references. Initially, the references were imported into EndNote, and one reviewer (L.H.H.) used the automatic software to de-duplicate the references and then performed a manual screen to remove additional duplicates that were not picked up by the software. The references were then imported into the Covidence software. Following de-duplication using the Covidence software, 18,696 references remained and were screened and examined for eligibility. Thirty-five full-text studies were reviewed for eligibility; 25 of these full-text articles were excluded because they failed to meet the inclusion criteria (9 were conference abstracts, 9 had the wrong type of participants [not PsA], 3 had no appropriate outcome measure, and 4 were the wrong study design [SRs or case studies] or were not intervention studies [eg, editorials or letters]). An additional 2 studies were excluded because it became clear that 4 of the references by Thomsen et al[35,36] and Klingberg et al[37,38] were multiple reports of the same studies. The references were merged and combined into 2 studies for the purpose of the review.[36,37] Overall, 8 studies were included in the review.[36,37,39–44] The Fig. 1 shows the flow of studies through the review process.

Statistical analysis of the data was not possible because the studies were not presented with means or SDs for continuous data. For each included study, a qualitative analysis was conducted to summarize and describe the participants, interventions, and outcomes. Meta-analysis was not performed due to significant heterogeneity.

The 8 studies included 795 participants in total with a mean sample size of 99.4, ranging from 36 to 267. Of the 8 studies, 3 studies were RCTs (144 participants),[36,41,43] and 5 were NRS (651 participants).[37,39,40,42,44] Table 1 is an overview of studies included in the SR listed by intervention. It summarizes the purpose of the study, intervention and comparator (where applicable), inclusion/exclusion criteria,

Table 1
Overview of studies included in systematic review listed by intervention.

Study	Design	Study Size	Age	Duration Of Study	Intervention Setting	Outcomes Measured
Pain management						
Cozzi et al, 2015[41] (Italy)	RCT: open-label, controlled clinical study	36	NK	2 weeks	1. Pain management: mud bath therapy	CRP, PASI, DAS-28, swollen and tender joint count, VAS pain, HAQ, and SF-36
	Summary of findings					
	Purpose of study: Primary outcome—to evaluate the effects of mud bath therapy on patients with PsA treated with TNF inhibitors. Secondary outcome–to assess synovial inflammation in hand joints detected by using contrast-enhanced ultrasound. Other aims to consider were the risk of arthritis flare and to evaluate the effects of spa treatment on function and QoL. Intervention: Mud bath therapy (12 mudpacks and 12 thermal baths), maintaining treatment with TNF inhibitors (Group A). Comparator: Continued pharmacologic therapy (Group B). Inclusion criteria: Clinical involvement of hand joints: articular pain and swelling were evident in 1 or more joints of at least 1 hand. Low to moderate disease activity (DAS-28 <5.1) during the last 3 months of treatment with TNF inhibitors. Exclusion criteria: Concomitant diseases contraindicating spa therapy and/or the use of ultrasound contrast agent. Patients undergoing spa therapy in the year before the study were also excluded. Results: Improvement in PASI ($P < 0.005$), DAS-28 ($P < 0.05$), swollen joint count and tender joint count ($P < 0.001$), and HAQ ($P < 0.001$) between baseline assessment (T0) and follow-up at 45 days (T1) was observed in group A. No patient experienced a flare-up of arthritis. Ultrasound videos showed a significant delay in appearance ($P < 0.05$) and faster washout ($P < 0.02$) of contrast dye in group A patients with respect to the control group. Authors' conclusions: A reduction of residual synovial inflammation and a favorable clinical effect of spa therapy for patients treated with TNF inhibitors.					
Physical activity						
Roger-Silva et al, 2018[43] (Brazil)	RCT	41	NK	12 weeks	1. Physical activity (resistance exercises)	HAQ-S, BASDAI, BAFSI, DAS-28
	Summary of findings					
	Purpose of study: To assess the effectiveness of resistance training in patients with PsA. Intervention: Resistance exercises for the following muscle groups: upper limbs, lower limbs, and trunk. The exercises were divided into 3 sets of 12 repetitions for each muscle group and performed twice a week for 12 weeks. Comparator: Patients remained on waiting list while continuing with the standard pharmacologic treatment during the entire study. Inclusion criteria: PsA diagnosis as defined by using the CASPAR criteria, ages between 18 and 65 years and of both sexes, use of DMARDS and anti-TNF therapy with stable doses for at least 3 months, and stable doses of NSAIDs and corticosteroids for at least 4 weeks. Exclusion criteria: Noncontrolled cardiovascular diseases, uncontrolled diabetes mellitus, severe psychiatric diseases, fibromyalgia, history of regular exercise (at least 30 minutes twice a week) in the last 6 months, arthroplasty of hip and/or knee over the last 12 months, and any other medical condition that would prohibit the patient from performing resistance exercises. Results: The intervention group significantly improved functionally for HAQ-S and disease activity (BASDAI), compared with the control group, at week 12. QoL improved in the intervention group (domains "pain" and "general health status) vs the control group ($P < 0.05$). Strength exercises improved for the intervention group, except in the exercise for biceps. Authors' conclusions: Resistance exercises are effective in improving functional capacity, disease activity, and the overall QoL of patients with PsA. There were no improvements related to increase in muscle strength.					
Thomsen et al, 2018[36] (Norway)	RCT: 2 parallel groups	67	NK	11 weeks	1. Physical activity/exercise program (HIIT training)	PGA, fatigue VAS, pain VAS, DAS-44
	Summary of findings					
	Purpose of study: Primary outcome—to evaluate the effect of HIIT on CVD risk factors, disease activity, and disease perception in patients with PsA. Secondary outcome—to study if the effects could be sustained over time. Intervention: Performing HIIT three times per week for 11 weeks. Comparator: Control group with no change in prestudy physical exercise habits. Inclusion criteria: Patients with PsA needed to be between ages 18 and 65 years and fulfill the CASPAR criteria. Exclusion criteria: Patients with inability to exercise; patients with unstable ischemic CVD or severe pulmonary disease; pregnancy; breastfeeding; drug or alcohol addictions; and an anticipated need for a change in synthetic or biologic DMARDs during the intervention period. A change of DMARDs was possible during the follow-up period from 3 to 9 months. A change in corticosteroid doses and intra-articular corticosteroid injections was allowed until 4 weeks before any follow-up. Results: Three months—no changes in the PGA score (–0.49 [95% CI, –10.91 to 9.94]), DAS-44 (–0.08 [95% CI, –0.36 to 0.20]), or pain intensity (5.45 [95% CI, –4.36 to 15.26]) between the groups. Patients in the intervention group had less fatigue (–12.83 [95% CI, –25.88 to 0.23]) than the control group. No evidence of long-term effects of HIIT on outcomes measured at 9 months. Authors' conclusions: HIIT exercises had no effect on disease activity markers in patients with PsA. The intervention (exercise) group reported less fatigue.					
Chimenti et al, 2014[40] (Italy)	NRS: cohort study	30	NK	12 weeks	2. Physical activity: home exercise program	Global Health, SpA-HAQ, SF-36, Pain VAS
	Summary of findings					
	Purpose of study: To evaluate the benefits of home-based exercise program on disease activity and QoL in patients with PsA treated with anti-TNF and DMARD therapy. Intervention: Physical activity, an aerobic exercise program delivered by a single physiotherapist. Leaflets with written instructions and images of the exercises. Comparator: None. Inclusion criteria: Patients with PsA classified by using CASPAR criteria. MDA-PsA on stable drug therapy over the last 3 months. Exclusion criteria: Not stated.					

(*continued on next page*)

Table 1 (*continued*)

Study	Design	Study Size	Age	Duration Of Study	Intervention Setting	Outcomes Measured
	Results: Self-reported rate of adherence to home-based exercise was 76.6%. Overall, 23.4% were lost to follow-up at 12 weeks. A negative correlation was found between total physical activity and SF-36 bodily pain (Pearson's $r = -0.3$). Positive correlations were observed between total physical activity and SpA HAQ (Pearson's $r = 0.24$), SF-36 role-physical (Pearson's $r = 0.23$), SF-36 physical function (Pearson's $r = 0.28$), and SF-36 vitality (Pearson's $r = 0.23$) after 4 weeks and 12 weeks. Mean pain VAS initially reduced from 43.7 (23.1) at baseline to 34 (27.4) at 4 weeks and increased to 48.6 (24.8) at 12 weeks. Authors' conclusions: Good self-reported rates of adherence to a home-based program of exercises (76.6%). The exercise program improved self-reported health and mental assessments in patients affected by MDA-PsA, treated with anti-TNF and DMARD therapy, and with a low SpA HAQ score.					
Diet						
Caso et al, 2020[39] (Italy)	NRS: cross-sectional study	211	48–62 y	NA	1. Diet	CPDAI, HAQ
	Summary of findings Purpose of study: To evaluate the adherence to the Mediterranean diet in patients (PsA) and its impact on disease activity. Diet was measured by using a validated 14-item questionnaire for the assessment of adherence to the Mediterranean diet (PREDIMED). Intervention: None. Comparator: None. Inclusion criteria: Both sexes, age >18 years, and the fulfilment of CASPAR criteria. Exclusion criteria: Current use of corticosteroids, recent use of at least 6 months of corticosteroids, and endocrinopathies and use of progestins. Results: Median of the Mediterranean diet score was 7 (6–9). Moderate adherence to Mediterranean diet was found in 66.35%; 15.64% and 18.01% showed low and high adherence to the dietary pattern, respectively. Negative association between DAPSA and adherence to Mediterranean diet (B = − 3.291; 95% CI, − 5.884 to − 0.698). DAPSA was positively associated with BMI (B = 0.332; 95% CI, 0.047 to 0.618) and HAQ (B = 2.176; 95% CI, 0.984 to 3.368). Authors' conclusions: Not adhering to a Mediterranean diet was linked to higher PsA activity.					
Klingberg et al, 2019[37] (Sweden)	NRS: cohort study	46	NK	12–16 weeks	1. Diet was VLED	MDA, pain VAS, fatigue VAS
	Summary of findings Purpose of study: To prospectively study the effects of weight loss treatment with VLED on disease activity in patients with PsA and obesity (BMI ≥33 kg/m^2). Intervention: VLED (640 kcal/d) was used for 12–16 weeks, depending on pretreatment BMI. Afterward, an energy-restricted diet was gradually reintroduced. Weight loss treatment was given within a structured framework for support and medical follow-up. Comparator: None. Inclusion criteria: Patients with PsA fulfilling CASPAR criteria, with a BMI ≥33 kg/m^2 and age 25–75 years, were eligible for inclusion. If using conventional synthetic and/or biologic DMARDs, treatment had to be constant and unchanged from 3 months before baseline until 6 months after baseline. Exclusion criteria: Pregnancy; porphyria; epilepsy; type 1 diabetes; severe heart, kidney, or catabolic disease; binge-eating disorders; treatment with warfarin, lithionin, or phenantoin; mental imbalance affecting participation; being subject to a heart infarction, stroke, major surgery, or trauma during the last the 3 months; and being treated for cancer during the last 5 years. Results: Raised BMI at baseline associated with higher disease activity and worse function. Median weight loss of 18.7 kg (IQR, 14.6–26.5 kg) or 18.6% (IQR, 14.7–26.3 kg) of the baseline weight. Many of the disease activity parameters improved significantly after weight loss, including 68/66 tender/swollen joint count, CRP, BSA, Leeds Enthesitis Index, HAQ, and patient VAS for global health, pain, and fatigue. Greater weight loss resulted in additional improvement in a dose–response manner. MDA increased from 29% to 54% (P =0.002). PsARC was reached by 46.3%. The ACR20, ACR50, and ACR70 responses were 51.2%, 34.1%, and 7.3%, respectively. Authors' conclusions: Using a VLED to achieve short-term weight loss was linked to positive effects on disease activity (joints, entheses, and skin for patients with PsA and obesity).					
Leite et al, 2020[42] (Brazil)	NRS: cross-sectional study	97	NK	NA	1. Diet	MDA, PASI, BSA, DAS-28
	Summary of findings Purpose of study: To evaluate the relationships among body composition measurements, food intake (using a 3-day food record), and disease activity in patients with PsA. Intervention: None. Comparator: None. Inclusion criteria: Patients with PsA according to the CASPAR and a signed informed consent form. Specific medications for PsA and physical activity levels were required to be stable for the last 3 months. Exclusion criteria: Patients with gastrointestinal, endocrine, pulmonary, kidney, hepatic, and neuromuscular diseases; HIV-positive; pregnant or breast-feeding; history of cancer. Patients taking sex steroid hormones, protein supplements, vitamins, multivitamins, nutraceuticals, or antioxidants. Results: Prevalence of obesity was higher, according to the fat mass index (92.7%), as was metabolic syndrome (54%). No significant changes for lean or bone mass were found. Joint disease activity was positively correlated with total body fat ($r = 0.4$; $P < 0.001$), fat mass index ($r = 0.33$; $P < 0.001$), BMI ($r = 0.20$; $P < 0.049$), and waist circumference ($r = 0.27$; $P = 0.009$). In addition, joint disease activity was negatively associated with muscle mass ($r = -0.38$; $P < 0.001$). Skin disease activity was positively correlated with total cholesterol ($r = 0.3$; $P = 0.003$) and LDL-C ($r = 0.28$; $P = 0.006$) levels. After multiple adjustments, patients with severe joint disease activity had higher body adiposity than patients in remission or with low disease activity. Skin disease activity was associated with higher trans fat intake and lower omega-6 consumption. Authors' conclusions: Patients with active PsA have higher prevalence of obesity and adiposity					
Smoking						
Tillett et al, 2013[44] (United Kingdom)	NRS: cohort study	267	NK	NA	1. Smoking 2. Physical activity	HAQ
	Summary of findings Purpose of study: To identify predictors of poorer physical function in established PsA. Patients with disease duration of >10 years (identified from the Bath longitudinal cohort). Intervention: None. Comparator: None.					

(*continued on next page*)

Table 1 (*continued*)

Study	Design	Study Size	Age	Duration Of Study	Intervention Setting	Outcomes Measured
	Inclusion criteria: Patients who fulfilled the CASPAR criteria (98.2% of the cohort fulfilled the criteria). HAQ completed at 10 years' disease duration or more. Exclusion criteria: Not stated. Results: The model predicted significant increases on the HAQ related to smoking (0.23 [95% CI, 0.04 to 0.42]), age >50 years at diagnosis (0.27 [95% CI, 0.03 to 0.51]), symptom duration of ≥1 year before diagnosis (0.22 [95% CI, 0.02 to 0.42]), female sex (0.39 [95% CI, 0.20 to 0.57]), and history of treatment with an anti-TNF agent (0.63 [95% CI, 0.32 to 0.93]) at follow-up. Authors' conclusions: Poorer physical function was linked to patients with PsA who smoke, have a delayed diagnosis and older age at diagnosis, are female, and have a record of anti-TNF treatment.					

ACR 20, 50 and 70 = American College of Rheumatology (representing at least a 20%, 50%, and 70% improvement, respectively, in tender and swollen joint counts and in three of the five additional criteria); BAFSI = Bath Ankylosing Spondylitis Functional Index; BASDAI = Bath Ankylosing Spondylitis Disease Activity Index; BMI = body mass index; BSA = body surface area; CASPAR = Classification Criteria for Psoriatic Arthritis; CPDAI = Composite Psoriatic Arthritis Disease Activity Index; CRP = C-reactive protein; CVD = cardiovascular disease; DAPSA = Disease Activity Index for Psoriatic Arthritis; DAS-28 = Disease Activity Score 28; DAS-44 = Disease Activity Score 44; DMARDs = disease-modifying antirheumatic drugs; HAQ = Health Assessment Questionnaire; HAQ-S = Health Assessment Questionnaire for the Spondyloarthropathies; HIIT = high-intensity interval training; IQR = interquartile range; MDA = minimal disease activity; NA = not applicable; NK = not known; NRS = nonrandomized studies; PASI = Psoriasis Area and Severity Index; PGA = Patient's Global Assessment; PREDIMED = Prevención con Dieta Mediterránea; PsA = psoriatic arthritis; PsARC = Psoriatic Arthritis Response Criteria; QoL = quality of life; RCT = randomized controlled trial; SF-36 = 36-Item Short Form Health Survey; TNF = tumour necrosis factor; VAS = visual analoge scale; VLED = very low energy diet.

and results, and it provides information regarding the overall conclusions reached by the authors.

Physical Activity

Among the 8 studies included in this review, 3 examined physical activity at short-term follow-up (ranging between 4 and 12 weeks). Two were RCTs,[36,43] and one was a nonrandomized study.[40] Exercise programs ranged from home-based exercises to high-intensity interval training (HIIT). The effect of exercise was assessed by using a variety of different measures across the studies. Exercise types and assessment criteria varied widely.

The nonrandomized study conducted by Chimenti et al[40] assessed the effectiveness of a 12-week home-based exercise program in patients with PsA treated with anti–tumor necrosis factor (anti-TNF) and disease-modifying antirheumatic drug therapy. The exercise program was completed by 23 (76.6%) of the 30 participants. Exercises were performed twice a week at home in 3 circuits of 4 minutes each (total 40 minutes), 10 times daily. The metabolic equivalents (MET) value related to the exercises completed was calculated to allow statistical analyses. MET scores encompass the exercise intensity MET value × minutes × times per week. In this study, the exercise program was 4 × 40 × 2. The authors stated that all 23 participants self-reported they had performed 100% of the prescribed exercises using the International Physical Activity Questionnaire.[45]

A negative correlation was found between total physical activity and 36-Item Short Form Health Survey (SF-36) bodily pain (Pearson's $r = -0.3$). Positive correlations were observed between total physical activity and the Health Assessment Questionnaire for the Spondyloarthropathies (HAQ-S) (Pearson's $r = 0.24$), SF-36 role-physical (Pearson's $r = 0.23$), SF-36 physical function (Pearson's $r = 0.28$), and SF-36 vitality (Pearson's $r = 0.23$) at 12 weeks. In addition, physical activity and SF-36 social functioning were inversely related at 12 weeks (Pearson's $r = -0.44$). It was observed that self-reported rates of adherence to a home-based exercise program were very high (76.6%). Moreover, the positive impact of the exercise program was reflected in self-reported health and mental assessments, which resulted in a low HAQ-S score.

The RCT conducted by Roger-Silva et al[43] looked at the effectiveness of resistance training twice a week for 12 weeks. A total of 41 patients were randomized to a group: 20 to the intervention group and 21 to the control group (waiting list). There were no dropouts in either group. The outcome measurements used to assess general QoL and function were similar in both studies using the HAQ-S and SF-36 questionnaires. In addition, they assessed the following outcomes: the Bath Ankylosing Spondylitis Functional Index (BAFSI) for functional capacity, the one-repetition maximum test[46] for muscle strength (at baseline, 6 weeks, and 12 weeks), and the Bath Ankylosing Spondylitis Disease Activity Index *(BASDAI)* and Disease Activity Score 28 (DAS-28) for disease activity. Statistical analysis followed an intention-to-treat model. The Bath Ankylosing Spondylitis Functional Index and DAS-28 improved in the exercise group over time. The only differences in SF-36 were found in pain ($P = 0.02$) and general health ($P = 0.002$) in favor of the exercise group. The one-repetition maximum test improved in most of the strength exercises done by the intervention group but also for some in the control group. The study concluded that resistance training is effective at improving functional capacity, disease activity, and QoL for patients with PsA.

The RCT conducted by Thomsen et al[36] examined the impact of HIIT exercise in 61 patients compared with 20 patients in the RCT by Roger-Silva et al.[43] They used the Patient's Global Assessment, fatigue VAS, pain VAS, and Disease Activity Score 44 (DAS-44) and found that HIIT did not affect disease activity markers in patients with PsA, although the intervention (exercise) group reported less fatigue after the intervention.[36] In patients with PsA, HIIT improves fatigue levels without leading to a deterioration in disease activity. The second part of the study looked at cardiovascular risk factors and body composition. The HIIT group had a 3.72 mL/ kg per minute (95% CI, 2.38 to 5.06) higher maximal oxygen uptake and a 1.28 (95% CI, −2.51 to −0.05) lower truncal fat percentage than control subjects. It was also evident that the HIIT group had a lower percent body fat (−0.80; 95% CI, −1.71 to 0.10) and slightly lower body mass index (BMI) (−0.31; 95% CI, −0.78 to 0.17) than the control group. HITT for 3 months resulted in a substantial increase in maximal oxygen uptake and a reduction in total body fat.

Diet

Diet and PsA were examined in 3 NRS.[37,39,42] Klingberg et al[37] conducted a cohort study evaluating the impact of a very low energy diet for 12 to 16 weeks on factors such as disease activity (MDA, 68/66 tender/swollen joints count, C-reactive protein, body surface area, the Leeds Enthesitis Index, HAQ, pain VAS and fatigue VAS, and obesity [BMI ≥33 kg/m^2]). The median weight loss was 18.7 kg (interquartile range, 14.6–26.5 kg). There was a dose–response relationship between weight loss and improvement in these parameters. The percentage of patients with MDA increased from 29% to 54% ($P = 0.002$). The Psoriatic Arthritis Response Criteria (PsARC) were reached by 46.3% of the study patients. The American College of Rheumatology (ACR) 20, 50, and 70 responses were 51.2%, 34.1%, and 7.3%, respectively.

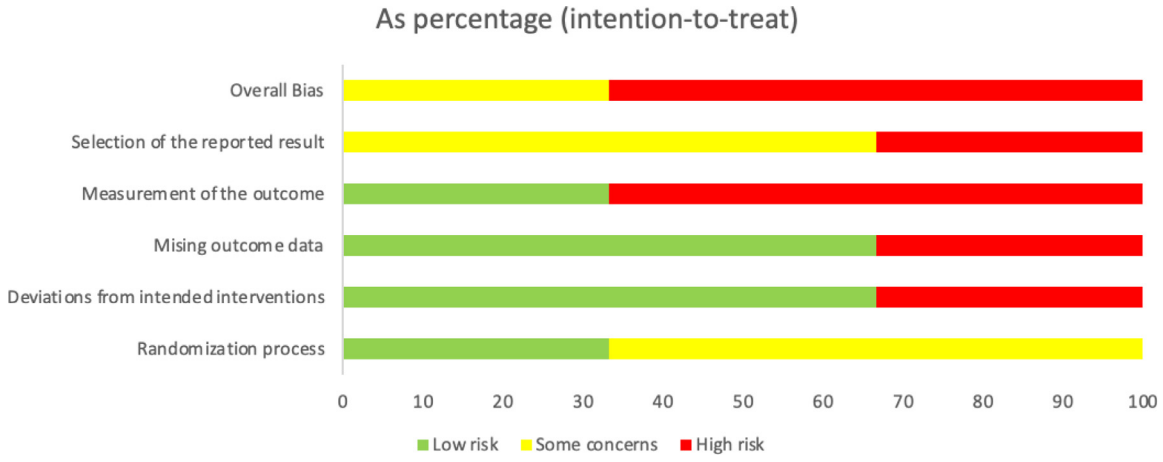
One NRS[39] examined the dietary habits of 211 white patients with PsA. The relationship between the patients with PsA who adhered to a Mediterranean diet and the severity of PsA was evaluated. A 14-point validated Prevención con Dieta Mediterránea (PREDIMED)[47] question-

Table 2
Summary of quality assessment across nonrandomized studies.

Study	1. Did the study address a clearly focused issue?	2. Was the cohort recruited in an acceptable way?	3. Was the exposure accurately measured to minimize bias?	4. Was the outcome accurately measured to minimize bias?	5a. Have the authors identified all important confounding factors?	5b. Have they taken account of the confounding factors in the design and/or analysis?	6a. Was the follow-up of subjects complete enough?	6b. Was the follow-up of subjects long enough?	9. Do you believe the results?	10. Can the results be applied to the local population?	11. Do the results of this study fit with other available evidence?	12. What are the implications of this study for practice?
Caso et al, 2020[39]	Y	Y	Y	Y	CT	N	Y	NA	Y	Y	Y	Y
Chimenti et al, 2014[40]	Y	CT	CT	CT	N	N	N	N	N	N	CT	CT
Klingberg et al, 2019[37]	Y	CT	Y	N	N	N	N	N	CT	N	Y	CT
Leite et al, 2020[42]	Y	CT	Y	Y	Y	CT	Y	N	Y	CT	Y	N
Tillett et al, 2013[44]	Y	Y	Y	Y	N	N	Y	Y	Y	Y	Y	CT

CT = cannot tell; N = no; NA = not applicable; Y = yes.
Questions 7 (What are the results?) and 8 (How precise are the results?) are not included in this table. These are presented as results in Table 1.

Table 3
Summary of risk of bias across randomized controlled trials.



naire was used to assess adherence to observing the participants' current dietary habits. Overall, 65.35% of the cohort remained moderately adherent to the Mediterranean diet, and 15.64% and 18.01% had low and high adherence, respectively. They reported a negative association between the Disease Activity Index for Psoriatic Arthritis (DAPSA) and adherence to the Mediterranean diet (B = −3.3; 95% CI, −5.9 to −0.70). DAPSA scores were positively associated with BMI (B = 0.33; 95% CI, 0.05 to 0.62) and HAQ (B = 2.18; 95% CI, 0.98 to 3.37). BMI scores were similar across all patients with PsA regardless of their reported adherence to a Mediterranean diet (low = 26.57; moderate = 26.57; high = 26.45), suggesting that adhering to a Mediterranean diet did not influence body weight. They found that high PsA activity, as measured by the DAPSA, is associated with low adherence to the Mediterranean diet. The study reported that the Mediterranean diet was found to be beneficial in reducing disease activity in patients with PsA due to its anti-inflammatory properties.

The NRS conducted by Leite et al[42] studied the association between body composition, self-reported dietary intake (using a 3-day food record), and disease activity in 97 patients with PsA. Obese patients and those with increased total body fat were most likely to have active PsA (total body fat, $r = 0.4$ [$P < 0.001$]), fat mass index ($r = 0.33$; $P < 0.001$), BMI ($r = 0.20$; $P < 0.049$), and waist circumference ($r = 0.27$; $P = 0.009$). Increased skin disease activity was evident in patients with PsA with raised cholesterol levels (total cholesterol, $r = 0.38$ [$P = 0.003$]; LDL-C, $r = 0.28$ [$P = 0.006$]).

Smoking

One NRS[44] concluded that smoking was associated with poor physical function as measured by using the Stanford Health Assessment Questionnaire. A total of 175 (65.5%) patients had mild disability, 63 (23.6%) had moderate disability, and 29 (10.9%) had severe disability. In summary, smoking is associated with worse physical function in established PsA.

Mud Bath Therapy

One RCT[41] evaluated the effects of 45 days of mud bath therapy in 18 patients treated with TNF inhibitors. C-reactive protein, PASI, DAS-28, swollen and tender joint count, VAS pain, HAQ, and SF-36 were evaluated. In addition, synovial inflammation in hand joints was assessed by using contrast-enhanced ultrasound. The experimental group exhibited significant improvement in PASI ($P < 0.005$), DAS-28 ($P < 0.05$), swollen joint count ($P < 0.001$), tender joint count ($P < 0.001$), and HAQ ($P < 0.001$) after 45 days. Regarding ultrasound assessment, significant delay in appearance ($P < 0.05$) and faster washout ($P < 0.02$) of contrast dye were observed in the treatment group. This study suggests that mud bath therapy has positive clinical outcomes and further reduces residual synovial inflammation as defined by using contrast-enhanced ultrasound.

Table 4
Risk of bias of individual randomized controlled trials (RCTs).

RCTs	D1	D2	D3	D4	D5	Overall		
Roger-Silva, 2018 (44)	+	+	+	-	-	-	+	Low risk bias
Thomsen, 2018 (37)	!	+	+	+	!	!	!	Some concerns
Cozzi, 2015 (42)	!	-	-	-	!	-	-	High risk bias

D1 = randomization process; D2 = deviations from intended interventions; D3 = missing outcome data; D4 = measurement of the outcome; D5 = selection of the reported outcome.

Harms

Six studies failed to report adverse events.[37,39–42,44] In the 2 studies that did, Roger-Silva et al[43] confirmed there were no adverse events within their trial. Thomsen et al[36] reported that one patient left the trial after having a stroke and finding the exercise program too hard, with no other adverse events reported. Exercise did not seem to worsen disease activity.

Certainty of Evidence

Across the included studies, there was substantial heterogeneity relating to type of intervention, comparators, and outcome measures. This precluded meta-analysis. The main limitations of the included studies were the lack of blinding of participants and assessors, potential selection bias, and unclear reporting. Quality assessment completed by using the CASP cohort studies checklist for the 5 NRS[37,39,40,42,44] is detailed in Table 2. One of the 3 RCTs[36] was considered to have some concerns of risk of bias, and two[41,43] were considered high risk. Table 3 presents a summary of the risk of bias across all 6 domains for the three RCTs.[36,41,43] Table 4 shows the overall risk of bias judgments for the individual RCTs based on intention to treat.

The GRADE methodology was used to assess the body of evidence across the included studies for disease activity. The quality of evidence for the three RCTs[36,41,43] was graded "very low" and for the 5 NRS[37,39,40,42,44] as "no evidence." The gradings reflect the limitations of the studies in terms of study design, high risk of bias, and heterogeneity.

Discussion

The management of patients with PsA is complex. Using a systematic approach, this review summarizes the current evidence in support of healthy lifestyle changes (or lifestyle modifications) and nonpharmaceutical and psychological interventions for PsA. Despite a comprehensive synthesis of the currently available literature, there is still insufficient evidence to recommend any lifestyle interventions other than physical activity. Further high-quality literature is needed to establish whether such interventions can affect PsA outcomes either at an individual or societal level.

Evidence from this review suggests that HIIT or resistance exercise improves functional capacity, disease activity, and QoL in patients, although it is difficult to make a general statement about exercise types and evaluation criteria across studies. Furthermore, in all 3 studies, exercise was evaluated for only 12 weeks, which is a relatively short period of time to evaluate its effectiveness.

There is growing evidence that diet can significantly influence chronic inflammatory conditions, making it a very critical area of research. Participants who adhere to a specific healthy diet are more likely to exercise regularly, maintain a healthy weight, and refrain from smoking. Thus, it is difficult to adjust for confounding factors in such studies, which has long been recognized as one of the limitations, particularly in the case of observational studies. Furthermore, participants' education and socioeconomic status heavily influence their understanding and perception of mental and physical health. It is possible that this will affect their perception of the severity and functional outcome of their disease activity.

Although we identified studies examining smoking cessation, physical activity, diet and mud baths, there is little evidence that these can influence PsA. We hoped to identify studies of nonpharmacologic interventions examining the impact of healthy lifestyle on the management of PsA (eg, topics such as pain, fatigue, mood, alcohol, intimacy, travel, work, social support). Unfortunately, this was not the case. Also, evidence was not identified showing that socioeconomic factors or educational status influenced nonpharmacologic management of PsA. However, research by Zhang et al[48] showed that adopting a healthy lifestyle lowers the risk of all-cause mortality in general populations.

The current body of evidence for healthy lifestyle modifications and nonpharmacologic interventions for patients with PsA is limited. The present SR identified a small number of studies that met the criteria for inclusion and that those which were included showed limited evidence of effect. However, this does not always mean that there is no effect in real life. A Cochrane UK blog highlights this by emphasizing that an "Absence of evidence is not evidence of absence."[49]

The present SR had certain strengths and limitations. With the available literature, which is relatively limited and of low quality, we have applied a formal structure to the SR to extract all useful information and reach conclusions that could guide future research.

One strength of this review was the comprehensive literature search and robust methodology used to conduct the SR according to the PRISMA guidelines. However, despite the search strategy having been designed to identify as many studies as possible evaluating effects of healthy lifestyle and nonpharmacologic interventions on PsA, studies evaluating complementary and alternative medicine such as acupuncture, mind–body therapeutic approaches, and supplements (with the exception of mud bath therapy) were lacking and therefore not able to be assessed.

This SR has several limitations. One limitation was the paucity of high-quality evidence in the literature. Too many different study designs (mixed study types), in particular NRS, increased the chance of heterogeneity (outcomes, interventions, and participants), making meta-analyses impossible. For example, in studies in which the outcomes mea-

sured were the same, the lifestyle intervention varied (eg, for physical activity, HITT vs a home exercise program). It is also harder to confidently assess potential bias and synthesize the results because of the heterogeneity. Despite applying the OMERACT principles, there is still a significant degree of heterogeneity with outcomes used within individual studies.

The reporting of the papers for the included studies was often incomplete. The review team could have attempted to contact more authors for the missing information, but, as Cochrane acknowledge, even when this contact is made, it can often lead to overly positive and potentially misleading answers.[50]

The NRS we included lacked adequate control for confounding factors, and it would be incorrect to assume that the effects they reported were causal. We accept that the extent to which a single casual factor influences outcome is difficult to establish. Risk factors are known to occur in clusters; an example is if people are physically active, they may also eat a healthier diet and be less likely to smoke. Or, conversely, if they smoke, they may be more at risk of being depressed and having an unhealthy diet. These inherent limitations and biases within the included studies (both RCTs and NRS) limit the robustness of the results.

Conclusions

Although we know that there are health benefits associated with healthy lifestyles in the general population,[48] there is no high-quality evidence published on lifestyle modifications and nonpharmacologic or psychological interventions for PsA specifically. In the absence of this evidence, it is not possible to reach any definite conclusion as to whether healthy lifestyle changes and/or nonpharmacologic interventions should be recommended in clinical practice, and it is impossible to estimate their likely impact.

The findings from our SR suggest there was limited evidence signifying that exercise, diet, and smoking cessation may improve outcomes, and this should be considered a research priority. Future studies require a more systematic process of research is required to evaluate and answer whether healthy lifestyle programs are beneficial in PsA and if so, assess which changes should be recommended as therapeutic intervention(s). We hope this SR contributes to increasing evidence-based research in PsA and highlights some of the research that needs to be done to inform future care.

Declaration of Competing Interest

No conflicts of interest were envisaged in which Pfizer could potentially benefit from the results of the project. The views expressed are those of the authors and not necessarily those of the National Health Service, the National Institute for Health Research, or the Department of Health.

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Author individual contributions were as follows: Ms Hailey: study design, literature search, figures, data collection, data interpretation, graphical abstract, and writing–original and editing. Drs Amarnani and Vivekanantham: study design, data collection, data interpretation, and writing–review and editing. Professor Bundy, Mr O'Sullivan, and Ms Steinkoenig: study design, literature search, and writing–review and editing. Dr McGagh: study design, literature search, data collection, data interpretation, and writing–review and editing. Dr James: data interpretation, figures, writing, and graphical abstract–original draft and editing. Mrs Kirtley: study design, literature search, figures, and writing–original draft and editing. Ms Suribhatla: writing–review and editing. Dr Coates: funding acquisition, study design, literature search, figures, data collection, data interpretation, and writing–original draft and editing.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.clinthera.2023.05.009.

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