Effects of physical exercise and body weight on disease-specific outcomes of people with rheumatic and musculoskeletal diseases (RMDs): systematic reviews and meta-analyses informing the 2021 EULAR recommendations for lifestyle improvements in people with RMDs

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ABSTRACT

Background A European League Against Rheumatism (EULAR) taskforce was convened to develop recommendations for lifestyle behaviours in rheumatic and musculoskeletal diseases (RMDs). This paper reviews the literature on the effects of physical exercise and body weight on disease-specific outcomes of people with RMDs.

Methods Three systematic reviews were conducted to summarise evidence related to exercise and weight in seven RMDs: osteoarthritis, rheumatoid arthritis, systemic lupus erythematosus, axial spondyloarthritis (axSpA), psoriatic arthritis, systemic sclerosis and gout. Systematic reviews and original studies were included if they assessed exercise or weight in one of the above RMDs, and reported results regarding disease-specific outcomes (eg, pain, function, joint damage). Systematic reviews were only included if published between 2013–2018. Search strategies were implemented in the Medline, Embase, Cochrane Library of systematic reviews and CENTRAL databases.

Results 236 articles on exercise and 181 articles on weight were included. Exercise interventions resulted in improvements in outcomes such as pain and function across all the RMDs, although the size of the effect varied by RMD and intervention. Disease activity was not influenced by exercise, other than in axSpA. Increased body weight was associated with worse outcomes for the majority of RMDs and outcomes assessed. In general, study quality was moderate for the literature on exercise and body weight in RMDs, although there was large heterogeneity between studies.

Conclusion The current literature supports recommending exercise and the maintenance of a healthy body weight.
INTRODUCTION

Rheumatic and musculoskeletal diseases (RMDs) comprise a wide range of conditions characterised by pain, disability and poorer quality of life (QoL). Globally, these conditions comprise a significant burden which is continuing to increase. For instance, the Global Burden of Disease study reported that the percentage increase of disability adjusted life years driven by RMDs (other than lower back pain) was 128.9% (95% CI 122.0% to 136.3%) between 1990 and 2019 across all age groups. While some RMDs have many effective pharmacological treatments (eg, rheumatoid arthritis (RA)), for some the treatment options are limited (eg, systemic lupus erythematosus (SLE)) and for others there are no effective disease modifying treatments (eg, osteoarthritis (OA)). However, there is room for additional improvements in outcomes in all RMDs, potentially through modification of lifestyle behaviour.

Physical activity (including exercise) is clearly beneficial for health, regardless of the presence of chronic diseases such as RMDs. The WHO and American institutions recommend that all adults aged 18–65 years should participate in at least 150 min per week of moderate-intensity aerobic physical activity, or do at least 75 min of vigorous-intensity aerobic physical activity, or an equivalent combination of moderate- and vigorous-intensity activity (moderate intensity=3.0 to <6.0 METs (metabolic equivalent of task), vigorous intensity =≥6 METs, where 1 MET is the rate of energy expenditure at rest). Additionally, all adults aged 18–65 years should perform muscle-strengthening activities (eg, resistance training and weight lifting) involving major muscle groups on two or more days a week. In 2018, the European League Against Rheumatism (EULAR) recommended physical activity for people with inflammatory arthritis and OA, after a systematic review illustrating the benefits of exercise on strength, flexibility and cardiovascular fitness. Furthermore, exercise is closely linked to body weight. The prevalence of global obesity is increasing and obesity, as well as physical inactivity, is associated with poor health, comorbidity (eg, cardiovascular disease, diabetes) and increased risk of mortality. Therefore, there is an urgent need for strategies to ameliorate the obesity epidemic for the benefit of global health.

However, it is unclear whether exercise is effective at improving RMD-specific outcomes (eg, pain, disability), or whether excess weight is associated with worse RMD outcomes. Therefore, a EULAR taskforce was convened in 2018 to develop recommendations for lifestyle improvements in RMDs, with the focus on lifestyles that affect disease progression. The taskforce decided to focus on six lifestyle factors: diet, exercise, body weight, alcohol, smoking and (paid) work-participation, in seven diseases: RA, OA, SLE, axial spondyloarthritis (axSpA), psoriatic arthritis (PsA), systemic sclerosis (SSc) and gout (henceforth referred to collectively as RMDs). For each of these lifestyle factors, systematic reviews were performed, aiming to collate all relevant literature on each factor in order to formulate evidence-based recommendations. This article presents the results of the systematic reviews assessing the impact of exercise and body weight on the disease-specific outcomes of people with RMDs.

METHODS

Design

These reviews were conducted following EULAR’s standard operating procedure for EULAR endorsed recommendations and are reported according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines.

Search strategy

A two-step process was used to identify studies to include in each review. Initially, a review of systematic reviews was conducted using the MEDLINE, EMBASE and Cochrane Library databases, aiming to identify existing systematic reviews on the included exposures and RMD progression (online supplemental tables 1 and 2, defined a priori by the study team) that were published from 1 January 2013 to 18 September 2018. Two reviewers screened the titles and abstracts (JMG and MW) and then a team of four reviewers screened the eligible full texts (JMG, MW, JR-C and GC; each full text screened by two reviewers). Only existing systematic reviews relating to exercise and weight are presented here.

Following this, separate systematic reviews of original studies of exercise and weight in RMDs were conducted (from inception to search date). It was decided that there were sufficient numbers of published systematic reviews regarding exercise and OA and therefore OA was not included in the systematic review of original studies of exercise. Search strategies for each review were developed based on a predefined PICO strategy (participants, intervention/exposure, comparison, outcome) (online supplemental tables 3 and 4 for search strategies) and implemented in the MEDLINE, EMBASE and CENTRAL databases (dates when strategies were implemented: exercise: 18 March 2019; weight: 14 March 2019). Titles and abstracts, followed by full texts, were screened by two reviewers (exercise: JMG and GC; weight: JMG and SMMV).

Inclusion and exclusion criteria

Systematic reviews were included if they:

- Included adults with an RMD (OA, RA, SLE, axSpA, PsA, SSc, gout).
- Studied the relationship between exercise or weight and disease-specific outcomes (online supplemental table 5 for list of included outcomes).
- Published in English, French, Spanish or Italian.
- No restrictions were implemented regarding the included study designs of studies in systematic reviews.

Original studies were included if they:

- Used a longitudinal study design (randomised controlled trials (RCTs), non-randomised trials,
single-arm intervention studies, longitudinal observational studies)

- Included adults with an RMD (RA, SLE, axSpA, PsA, SSc, gout (and OA for the weight review)).
- Studied the relationship between exercise or weight and outcomes (online supplemental table 5 for list of included outcomes).
- Published in English, French, Spanish or Italian. Conference abstracts were excluded.

**Risk of bias assessment**

To assess the risk of bias of included systematic reviews and meta-analyses, the AMSTAR-2 tool was used. For included RCTs, an abbreviated version of the Cochrane Risk of Bias tool was used, assessing four criteria: randomisation procedure, allocation concealment procedure, blinding of participants and blinding of assessors. Each aspect was rated as either low or high/unclear risk of bias. A machine learning algorithm was used to assist the process, which identifies passages of text from included manuscripts and assigns grades for each criteria. A reviewer (JMG) checked each of the algorithm’s grades and if there was disagreement, changed the grade. The QUIPS tool was used to assess the quality of observational studies across six domains: study population, attrition, exposure measurement, outcome measurement, confounding and statistical analysis.

**Synthesis of data**

Data from articles were extracted into prespecified tables, including study design, demographics, and results of outcomes and follow-up. The data from the individual articles are presented in the form of a narrative summary. Where possible, the mean and SD were extracted. SDs were estimated from 95% CIs or SEs when not reported. Means and SDs were estimated from medians and range/IQR when only these summary statistics were presented. Furthermore, standardised mean differences (SMD) were calculated for individual studies as this allows results measured on different instruments to be compared and combined (SDMs provided in online supplemental materials). The SMD was estimated as the difference between the scores of the intervention and control group at follow-up divided by the pooled SD. Meta-analysis was used to combine the results of RCTs where possible. An SMD ≥0.2 was considered a small effect, ≥0.5 as a medium-sized effect and ≥0.8 as a large effect. Heterogeneity was quantified using the I² statistic. All statistical analyses were performed using Stata V.14 (StataCorp).

Grades of Recommendations, Assessment, Development and Evaluation (GRADE) defines high-quality evidence as evidence where further research is very unlikely to change our confidence in the estimate of effect. Therefore, evidence was rated as high quality if supported by meta-analyses of ≥5 RCTs at low/moderate risk of bias reporting consistent results without important limitations. GRADE defines moderate quality evidence as evidence where further research is likely to have an important impact on the confidence of the estimate of effect, or may change the estimate. Evidence was rated as moderate if supported by meta-analyses of ≥3 RCTs or supported by a single RCT with a sample size ≥100 and at low/moderate risk of bias or multiple large observational studies. GRADE defines low quality evidence as evidence where further research is very likely to have an important influence on our confidence in the estimates, or likely to change the estimate. Evidence was rated as low if supported by multiple RCTs of small sample size or high risk of bias or by single observational studies only. GRADE defines very low quality of evidence as evidence where the estimate of the effect is very uncertain. Evidence was rated as very low if supported by single small RCTs, or non-randomised trials or single arm intervention studies. Evidence could be downgraded in the event of other potential biases (such as study limitations, inconsistency of results, imprecision, publication bias or conflicts of interest).

**RESULTS**

**Search strategy and study characteristics**

The search strategy to identify published systematic reviews identified 1507 abstracts, of which 16 were duplicates and were removed by reference managing software. After title and abstract screening, 1366 abstracts were excluded and the full manuscripts of the remaining 125 were screened. Seventy-nine of these assessed exercise and 10 assessed weight (Figure 1).

The search strategy to identify original articles assessing exercise in RMDs identified 4031 abstracts. After removal of 597 duplicates, 3434 titles and abstracts were screened. Of these 223 full manuscripts were screened, of which 157 are included in this review (Figure 2). The search...
strategy to identify original articles assessing weight identified 3973 abstracts. Once duplicates were removed, 3625 abstracts were screened, followed by screening of 304 full manuscripts. In total, 171 studies on weight were included (figure 3). Results are summarised in tables 1 and 2, with additional information on demographics, specific interventions and control groups (typically usual care or wait-list control), and results of meta-analyses provided in online supplemental material.

Exercise

Osteoarthritis

Aerobic exercise

Four meta-analyses of RCTs, 25–28 four systematic reviews of RCTs, 29–32 and three systematic reviews of observational studies 33–35 assessed aerobic exercise for OA. Aerobic exercise improved pain 25–27 30–33 and function 25 29–32 34 with small-medium effect sizes (pain SMD ranges from −0.24 (95% CI −0.50 to 0.02) to −0.61 (95% CI −0.75 to −0.48); function −0.30 (95% CI −1.53 to 0.92) to −0.58 (95% CI −0.75 to −0.40)) as well as one study reporting an association with health-related QoL (HR-QoL). 36

Aquatic exercise

Five meta-analyses of RCTs 28 36–39 and three systematic reviews of RCTs 7 32 40 studied aquatic exercise for OA. Small effects on pain 7 28 32 36 37 39 (SMDs ranging from −0.26 (95% CI −0.41 to −0.11) to −1.16 (95% CI −3.03 to 0.71)) and function 7 32 37–39 (SMDs ranging from −0.22 (95% CI −0.38 to −0.07) to −0.55 (95% CI −0.94 to −0.16)) as well as HR-QoL 37–39 (SMDs ranging from −0.21 (95% CI −0.39 to 0.18) to −0.25 (95% CI −0.49 to −0.01)) were reported.

Guidelines / recommendations

Two systematic reviews 41 42 summarised recent guidelines and evidence for OA and exercise, both concluding that exercise is strongly recommended for OA. A third paper 43 contained a literature review supporting EULAR recommendations for the non-pharmacological management of OA, also recommending that patients with OA have regular, individualised exercise regimens (online supplemental tables 10 and 11).

High vs low intensity exercise

One Cochrane review 44 reported that high intensity exercise was more beneficial than low intensity exercise for pain (meta-MD in the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) pain scale −0.84 (95% CI −1.63 to −0.04)) and function (meta-MD WOMAC function −2.65 (95% CI −5.29 to −0.01)) in OA. A systematic review 45 identified one prospective study 46 that reported no exercise or low intensity exercise was associated with deterioration in physical function (online supplemental tables 12 and 13).

Home exercise

One meta-analysis 47 reported that home exercise interventions were superior to no exercise in terms of pain (SMD −0.46 (95% CI −0.68 to −0.24)) and function (SMD −0.35 (95% CI −0.56 to −0.15)) in OA, but home exercise programmes were inferior to supervised exercise (online supplemental tables 14 and 15).

Land-based exercise

Several articles assessed the efficacy of any type of land-based exercise (as opposed to aquatic) for OA: five meta-analyses of RCTs, 36 48–51 one systematic review of meta-analyses, reviews and RCTs 7 and one systematic review of RCTs 40. The meta-analyses all reported small effects in favour of land-based exercise in terms of pain (SMDs ranging from −0.24 (95% CI −0.42 to −0.06) to −0.49 (95% CI −0.59 to −0.39)) and function (SMDs ranging from −0.34 (95% CI −0.50 to −0.18) to −0.52 (95% CI −0.64 to −0.39)), with the systematic reviews in agreement. One meta-analysis also reported an improvement.
in HR-QoL following exercise (SMD 0.28 (95% CI 0.15 to 0.40))\(^{51}\) (online supplemental tables 16 and 17).

**Multidisciplinary interventions**

One meta-analysis\(^52\) and one systematic review\(^53\) reported multimodal interventions were superior to exercise only for pain, function and HR-QoL (online supplemental tables 18 and 19).

**Muscle strengthening exercise**

Nine meta-analyses of RCTs,\(^25-28\) 54-58 four systematic reviews of RCTs,\(^29\) 59 60 and one review of meta-analyses,\(^7\) assessed muscle strengthening exercise for OA. Small\(^26\) 55 56 58 to medium\(^25\) 27 28 sized effects on pain,\(^7\) 59 60 (SMDs ranging from −0.23 (95% CI −0.42 to −0.04)\(^{51}\) to −1.19 (95% CI −1.67 to −0.70)\(^{17}\), as well as small\(^28\) 56 to medium\(^25\) 57 58 effects on function were reported\(^7\) 59 60 (SMDs ranging from −0.10 (95% CI −0.33 to 0.13)\(^{35}\) to −0.60 (95% CI −0.83 to −0.37)\(^{25}\)). One meta-analysis reported no effect of muscle strengthening exercise on HR-QoL for hand OA,\(^8\) whereas a systematic review reported improvements in HR-QoL in knee OA\(^9\) (online supplemental tables 20 and 21).

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**Table 1** Summary table of results regarding exercise

| Level of evidence | Disease | Effect size | None | Small | Medium | Large |
|-------------------|---------|-------------|------|-------|--------|-------|
| Very low          | OA      | SLE         | None | Small | Medium | Large |
|                   | axSpA   | Muscle strengthening (disease activity) |       |       |        |       |
| Other             | SLE     | Muscle strengthening (function, disease activity) |       |       |        |       |
|                   | SSc     | Muscle strengthening (function) |       |       |        |       |
| Low               | OA      | Yoga        | None | Small | Medium | Large |
|                   | axSpA   | Yoga (function) |       |       |        |       |
| Other             | SLE     | Aerobic (function) |       |       |        |       |
|                   | SSc     | Aerobic + muscle strengthening (pain) |       |       |        |       |
|                   | Other   | Muscle strengthening (pain, function, disease activity) |       |       |        |       |
|                   | SLE     | Aerobic (fatigue) |       |       |        |       |
| Moderate          | OA      | Aquatic (pain, function, HR-QoL); Exercise therapy (pain, function); Tai chi (stiffness, HR-QoL) |       |       |        |       |
|                   | axSpA   | Muscle strengthening (pain, function) |       |       |        |       |
| Other             | SLE     | Aerobic (pain, function) |       |       |        |       |
|                   | Other   | Land-based (pain, function) |       |       |        |       |
|                   | Other   | Tai chi (pain, function) |       |       |        |       |
| High              | OA      | Aquatic (pain, function, HR-QoL); Exercise therapy (pain, function); Tai chi (stiffness, HR-QoL) |       |       |        |       |
|                   | axSpA   | Muscle strengthening (pain, function) |       |       |        |       |
| Other             | SLE     | Muscle strengthening (pain, function, disease activity) |       |       |        |       |
|                   | Other   | Muscle strengthening (pain, function) |       |       |        |       |

axSpA, axial spondyloarthritis; HR-QoL, health-related quality of life; OA, osteoarthritis; PsA, psoriatic arthritis; RA, rheumatoid arthritis; SLE, systemic lupus erythematosus; SSc, systemic sclerosis.
### Table 2 Summary table of results from observational studies within the weight systematic review

| Outcome                  | OA | RA | SLE | axSpA | PsA | SSc | Gout |
|--------------------------|----|----|-----|-------|-----|-----|------|
| Pain                     | ✔  | ✔  | ✔   | ✔     | ✔   | ✔   | ✔    |
| Function                 | ✗  | ✔  | ✔   | ✔     | ✔   | ✔   | ✔    |
| Radiographic progression | ✗  | ✔  | ✔   | ✔     | ✔   | ✔   | ✔    |
| Disease activity         | ✗  | ✔  | ✔   | ✔     | ✔   | ✔   | ✔    |
| Fatigue                  | ✗  | ✔  | ✔   | ✔     | ✔   | ✔   | ✔    |
| Comorbidities            | ✗  | ✔  | ✔   | ✔     | ✔   | ✔   | ✔    |
| Other                    | ✗  | ✔  | ✔   | ✔     | ✔   | ✔   | ✔    |
| Mortality                | ✗  | ✔  | ✔   | ✔     | ✔   | ✔   | ✔    |

Level of evidence of an association between weight and outcome: ✔=very low quality, ✔✔=low quality, ✔✔✔=moderate quality, ✔✔✔✔=high quality, ✗=no evidence of association between weight and outcome from included observational studies, —=No information from included observational studies

This table refers to results where increasing weight is associated with worse scores on outcome measures or higher risk of poor outcomes, other than where noted as follows

*Higher weight associated with lower risk of mortality.
†Higher weight associated with lower radiographic progression in RA.
axSpA, axial spondyloarthritis; OA, osteoarthritis; PsA, psoriatic arthritis; RA, rheumatoid arthritis; RMD, rheumatic and musculoskeletal diseases; SLE, systemic lupus erythematosus; SSc, systemic sclerosis.

### Physical exercise therapy

In total, five meta-analyses of RCTs, 61–63 two systematic reviews of RCTs, 62–64 and one systematic review of reviews and RCTs 65 assessed exercise therapy for OA. Small effects for pain 60–62–64, 66 (SMDs ranging from −0.20 (95% CI −0.28 to −0.11) 62 to −0.71 (95% CI −0.28 to 0.16) 63 (online supplemental tables 22 and 23).

One systematic review reported inconsistent findings in terms of the effect of yoga on HR-QoL 74 (online supplemental tables 26 and 27).

### OA summary

The majority of systematic reviews and meta-analyses reported medium-sized effects of physical activity on pain and function in OA, including both aerobic and muscle strengthening physical activity. The quality of the evidence was generally moderate to high (table 1). While the majority of studies on OA included people with knee or hip OA, several studies included people with hand OA.

### Rheumatoid arthritis

#### Aerobic exercise

One meta-analysis, 75 three systematic reviews 76–78 (which highlighted a 2010 meta-analysis, 79) eight RCTs, 80–87 four non-randomised studies, 88–91 one case–control study, 92 and two prospective cohort studies 93 94 assessing aerobic exercise in RA were included. Aerobic exercise improved pain 76, 77, 79, 80, 82, 84, 87 (meta-analysis 79: SMD 0.31 (95% CI 0.06 to 0.55)); and function 76, 79, 80, 84 (meta-analysis 79: SMD 0.24 (95% CI 0.10 to 0.38)) in RA with small effect sizes, although some studies reported statistically non-significant results. One meta-analysis and four included RCTs reported no effect of aerobic exercise on disease activity 79, 80, 82, 83 (meta-analysis 79, SMD 0.08 (95% CI −0.08 to 0.25)), while another reported a weak correlation. 78 Furthermore, studies reported a small effect on HR-QoL. 79 81, 82, 84 Small effects were also reported on fatigue (meta-analysis 75: SMD −0.31 (95% CI −0.55 to −0.06)), anxiety, depression and self-efficacy. 75, 81, 82, 85 (online supplemental tables 28–31).
Aerobic + muscle strengthening exercise
Twenty-one reports of RCTs,\textsuperscript{95–115} one non-randomised trial,\textsuperscript{116} and seven single arm studies\textsuperscript{117–123} reported on interventions containing both aerobic and muscle strengthening elements in RA. Small effects were reported for pain,\textsuperscript{96} \textsuperscript{99} \textsuperscript{101} \textsuperscript{106} \textsuperscript{110} to \textsuperscript{112} and function,\textsuperscript{95} \textsuperscript{100} \textsuperscript{102} \textsuperscript{106} \textsuperscript{108} \textsuperscript{111} \textsuperscript{115} with wide heterogeneity between studies potentially due to differences in the interventions and follow-up lengths. No effect was observed for disease activity,\textsuperscript{102} \textsuperscript{106} \textsuperscript{108} \textsuperscript{110} and depression.\textsuperscript{97} \textsuperscript{101} Two RCTs reported a small effect on HR-QoL, which was not statistically significant.\textsuperscript{98} \textsuperscript{102} One recent RCT reported a medium-sized effect on fatigue,\textsuperscript{96} with two older RCTs reporting no effect.\textsuperscript{101} \textsuperscript{115} (online supplemental tables 32 and 33).

Aerobic exercise
Two systematic reviews,\textsuperscript{77} \textsuperscript{124} four RCTs\textsuperscript{87} \textsuperscript{125}–\textsuperscript{127} and one non-randomised trial\textsuperscript{89} studied aerobic exercises for RA. Small-medium effects on pain\textsuperscript{87} \textsuperscript{124} \textsuperscript{126} and function\textsuperscript{77} \textsuperscript{124}–\textsuperscript{127} were reported (online supplemental tables 34–36).

High vs low intensity
Three RCTs\textsuperscript{128–130} and one long-term extension\textsuperscript{131} were included, with none reporting significant differences between high and low intensity exercise on pain or function (online supplemental tables 37 and 38).

Home exercise
Two systematic reviews,\textsuperscript{77} \textsuperscript{132} and five RCTs\textsuperscript{101} \textsuperscript{133}–\textsuperscript{136} studied home exercise programmes. The reviews concluded that home exercise was beneficial for reducing pain and function.\textsuperscript{77} \textsuperscript{132} In studies comparing home-based unsupervised physical activity to supervised physical activity, inconsistent results were reported in terms of pain,\textsuperscript{101} \textsuperscript{134} \textsuperscript{135} and function\textsuperscript{134}–\textsuperscript{136} potentially due to differences in the interventions between studies (online supplemental tables 39–41).

Muscle strengthening exercise
One meta-analysis of hand muscle strengthening exercises,\textsuperscript{137} three systematic reviews (including a 2012 meta-analysis),\textsuperscript{138} 77 \textsuperscript{139} \textsuperscript{140} 17 reports of RCTs and long-term extensions,\textsuperscript{128} \textsuperscript{131} \textsuperscript{141}–\textsuperscript{145} 1 non-randomised trial\textsuperscript{156} and 1 single-arm study\textsuperscript{157} assessed muscle strengthening exercise in RA. Small effects from muscle strengthening exercise were reported on pain\textsuperscript{77} \textsuperscript{137} \textsuperscript{138} \textsuperscript{140} \textsuperscript{141} \textsuperscript{145} \textsuperscript{144} \textsuperscript{153} (meta-analysis\textsuperscript{138}: MD pain Visual Analogue Scale –4.13 (95% CI –10.97 to 2.71)). Inconsistent results were reported in terms of function, with several studies reporting improvements in function\textsuperscript{77} \textsuperscript{137} \textsuperscript{138} \textsuperscript{143} \textsuperscript{148} \textsuperscript{149} \textsuperscript{151} (meta-analysis\textsuperscript{138}: MD Health Assessment Questionnaire –0.22 (95% CI –0.35 to –0.10)), whereas other RCTs reported no benefit,\textsuperscript{128} \textsuperscript{144} \textsuperscript{147} \textsuperscript{152} \textsuperscript{153} potentially due to differences in the comparison group where some were given low-intensity exercise or exercise advice. No effect was reported on disease activity\textsuperscript{128} \textsuperscript{140} \textsuperscript{143} \textsuperscript{145} \textsuperscript{147} and HR-QoL\textsuperscript{142} \textsuperscript{144} \textsuperscript{145} \textsuperscript{147} (online supplemental tables 42–44).

Tai chi
One systematic review (which identified a 2004 review\textsuperscript{158})\textsuperscript{77} one RCT,\textsuperscript{159} one non-randomised trial\textsuperscript{160} and two single-arm studies\textsuperscript{161} \textsuperscript{162} assessed tai chi for RA. The reviews and RCT reported no benefit in terms of pain,\textsuperscript{159} function,\textsuperscript{77} \textsuperscript{158} \textsuperscript{159} disease activity,\textsuperscript{77} \textsuperscript{158} or depression\textsuperscript{159} (online supplemental tables 45–47).

Yoga
One meta-analysis\textsuperscript{72} one systematic review,\textsuperscript{73} three RCTs\textsuperscript{163–165} and two non-randomised trials\textsuperscript{166} \textsuperscript{167} studied yoga for RA. The meta-analysis reported a large effect of yoga on pain (but included some patients with OA),\textsuperscript{72} as did one RCT,\textsuperscript{165} whereas two other RCTs reported no effect, and the systematic review graded the evidence as very low.\textsuperscript{73} \textsuperscript{163} \textsuperscript{164} The meta-analysis (only including studies of RA)\textsuperscript{72} and one RCT reported medium-sized effects on function,\textsuperscript{163} whereas another RCT reported no effect.\textsuperscript{164} No effect on disease activity was reported by two RCTs,\textsuperscript{163} \textsuperscript{164} Studies were generally small therefore potentially some findings are due to chance (online supplemental tables 48–50).

RA summary
There was moderate-high quality evidence of a small effect of physical activity on pain and function in RA. Physical activity did not affect disease activity (table 1).

Systemic lupus erythematosus

Aerobic exercise
Two meta-analyses,\textsuperscript{168} \textsuperscript{169} three systematic reviews,\textsuperscript{170–172} four RCTs\textsuperscript{173–176} and three non-randomised trials\textsuperscript{177–179} assessed aerobic exercise in SLE. One RCT reported lower pain,\textsuperscript{173} whereas another did not\textsuperscript{174} although both studies had low sample sizes. No effect of disease activity was reported.\textsuperscript{168} \textsuperscript{173} \textsuperscript{175} \textsuperscript{176} A medium-sized effect on fatigue was also reported (MD –0.61 (95% CI –1.19 to –0.02))\textsuperscript{168}; MD –0.52 (95% CI –0.92 to –0.13).\textsuperscript{169} \textsuperscript{168} \textsuperscript{169} \textsuperscript{170} \textsuperscript{171} \textsuperscript{172} \textsuperscript{173} \textsuperscript{174} \textsuperscript{175} \textsuperscript{176} (online supplemental tables 51–53).

Aerobic & muscle strengthening exercise
One meta-analysis,\textsuperscript{168} one systematic review\textsuperscript{171} and three RCTs\textsuperscript{173} \textsuperscript{180} \textsuperscript{181} compared aerobic and muscle strengthening exercise, whereas one RCT\textsuperscript{182} and one non-randomised trial\textsuperscript{183} assessed interventions combining both aerobic and muscle strengthening exercises. Aerobic exercise was reported to lead to less fatigue compared with muscle strengthening in two studies,\textsuperscript{168} \textsuperscript{171} but two other RCTs reported no difference,\textsuperscript{180} \textsuperscript{181} although again sample sizes were small. No difference was reported in terms of disease activity\textsuperscript{168} \textsuperscript{173} \textsuperscript{181} or depression\textsuperscript{168} \textsuperscript{173} \textsuperscript{180} (online supplemental tables 54–56).

Muscle strengthening exercise
One RCT compared muscle strengthening exercise to control in SLE,\textsuperscript{173} reporting no effect on disease activity, pain and fatigue, but a medium-sized effect
on depression in favour of muscle strengthening exercise (online supplemental tables 57 and 58).

**SLE summary**

There is moderate quality evidence of a medium-sized effect of aerobic exercise on fatigue in SLE. There is low-quality evidence that physical activity does not affect disease activity in SLE (table 1).

**Axial spondyloarthritis**

**Aerobic exercise**

Two systematic reviews,184 185 four RCTs,186–189 one single arm study190 and three prospective cohort studies191–193 assessed aerobic exercise in axSpA. One RCT investigating exercising with the aid of a video game console reported a medium-sized effect on pain, function and disease activity, whereas other studies of traditional exercise interventions reported no effect184 187–189 (online supplemental tables 59–62).

**Aerobic + muscle strengthening exercise**

Six meta-analyses,194–196 three systematic reviews,184 185 200 10 RCTs,201–210 three non-randomised trials211–213 five single arm studies214–218 and one prospective cohort study219 assessed aerobic + muscle strengthening exercise in axSpA. Small effects were reported for pain, function and disease activity,186 whereas other studies of traditional interventions reported no effect184 187–189 (online supplemental tables 59–62).

**Aquatic exercise**

Three systematic reviews184 200 202 and two RCTs221 222 assessing aquatic exercise for axSpA were included. Small, inconsistent effects were reported in terms of pain, function184 220–222 and disease activity184 220–222 and no effect on spinal mobility184 221 222 (online supplemental tables 67–69).

**Home-based exercise**

One meta-analysis,197 one systematic review,185 eight RCTs,186 189 203 207 210 223–225 five non-randomised trials212 226–229 and one single arm study217 assessed home-based exercise. Compared with control, home exercise had a medium-sized effect on pain, function,186 189 210 223–225 disease activity,186 197 223 224 and HR-QoL.186 224 However, several studies found that group-based exercise was more effective than home-based exercise in terms of function203 207 and disease activity203 (online supplemental tables 70–72).

**Muscle strengthening exercise**

Eight RCTs (and two long-term follow-ups),223 225 230–237 three non-randomised trials226–228 and three single arm studies228–230 assessed muscle strengthening exercise. Medium-sized effects of muscle strengthening exercise were reported in terms of pain,225 231–233 disease activity,223 225 230–233 and function223 230 232–235 (online supplemental tables 73 and 74).

**Psoriatic arthritis**

**Muscle strengthening exercise**

One RCT241 and one single arm study242 assessed muscle strengthening exercise in PsA. The RCT reported better function and disease activity at 12 weeks compared with the control arm241 (online supplemental tables 75 and 76).

**Systemic sclerosis**

**Aerobic exercise**

One single arm study243 reported improvements in function between baseline and 4 months after the intervention (online supplemental tables 77 and 78).

**Aerobic + muscle strengthening exercise**

One systematic review,244 two RCTs245 246 and one single arm study247 assessed aerobic plus muscle strengthening interventions for SSc, reporting a small effect on function245 246 but no effect on pain246 (online supplemental tables 79–81).

**Aquatic exercise**

One RCT,248 which only reported data on the intervention group, showed improvements in function from baseline to 18 weeks follow-up (online supplemental tables 82 and 83).

**Muscle strengthening exercise**

One RCT,249 one non-randomised trial250 and three single arm studies251–253 assessed muscle strengthening exercise in SSc. The RCT reported a medium-sized effect on function249 and the non-randomised study reported better outcomes in terms of pain and function in the exercise arm250 (online supplemental tables 84 and 85).

**SSc summary**

There is very-low-quality evidence of a medium effect of physical activity on function in SSc (table 1).
**Gout**

**Aerobic exercise**

One case–control study reported that performing regular exercise ≥150 min per week was associated with reduced odds of tophus in gout (online supplemental tables 86 and 87).

**Yoga**

One RCT compared yoga to blood-letting in gout, reporting benefits of yoga in terms of pain and serum uric acid (online supplemental tables 88 and 89).

**Gout summary**

There is little research on the effect of physical activity in gout.

**Body weight and weight reduction**

**Osteoarthritis**

Two meta-analyses, systematic reviews, 21 reports describing RCTs and long-term follow-up studies, 2 non-randomised trials and 6 single-arm intervention studies assessing weight-loss interventions, as well as 44 observational studies assessing the association between body weight and outcomes in OA were identified. From studies assessing weight-loss interventions, small effects on pain, function, stiffness and walking tests, but no effect on HR-QoL or patient global assessment were reported. In observational studies, higher body weight was associated with higher pain but not with worse function. One systematic review, one single-arm study and five observational studies were identified assessing the relationship between weight and outcomes in OA.

**Rheumatoid arthritis**

Three meta-analyses and 61 observational studies assessed the relationship between body weight and outcomes in RA. Higher weight was associated with worse pain, function, disease activity, enthesis occurrence and psoriasis score, as well as more comorbidities. Higher baseline weight was associated with lower risk of death. However, high rates of weight loss were associated with increased mortality risk. Higher weight was associated with lower radiographic progression (online supplemental tables 116–132).

**Systemic lupus erythematosus**

Eight prospective studies were identified assessing the relationship between body weight and outcomes in SLE. Higher weight was associated with worse function, comorbidity, employment status and mental health, but no associations between weight and disease activity or fatigue were reported (online supplemental tables 133–139).

**Axial spondyloarthritis**

Thirteen observational studies were identified assessing the relationship between body weight and outcomes in axSpA. Higher weight was associated with worse pain, disease activity, fatigue and radiographic progression, or comorbidity, and lower odds of meeting response criteria. One unadjusted analysis reported people with higher weight were more likely to discontinue anti-tumour necrosis factor treatment, but another study adjusting for confounders reported no association (online supplemental tables 140–149).

**Psoriatic arthritis**

One meta-analysis, one RCT, and seven observational studies were identified assessing the relationship between weight and outcomes in PsA. Higher weight was associated with worse pain, function, disease activity, joint counts, enthesis occurrence and psoriasis score. Interventional studies reported improvements in pain, function, patient global assessment, and reductions in disease activity and C-reactive protein following weight loss (online supplemental tables 150–170).

**Systemic sclerosis**

Two observational studies reported that higher weight was associated with a lower risk of mortality in SSc. Two observational studies assessed the relationship between weight and outcomes in PsA. Higher weight was associated with worse pain, disease activity, fatigue, stiffness, function, and enthesitis occurrence and psoriasis score. Interventional studies reported improvements in serum uric acid level and more frequent gout attacks. Higher weight was associated with renal failure in one study but not another.

**DISCUSSION**

These three systematic reviews summarise the current evidence regarding the effects of physical activity and body weight on disease outcomes of people with seven RMDs. The data from over 400 published reviews and original articles suggests there are benefits of exercising for a range of outcomes important to people with RMDs, and also indicate an association between heavier body weight and worse outcomes, although differences were noted across RMDs. There was moderate-to-high-quality evidence that exercise interventions resulted in less pain and better function in RMDs, and exercise was also associated with reductions in disease activity in axSpA. The size of the effect of exercise varied between RMDs. For instance, there were medium-sized effects demonstrated in people with axSpA and only small effects in those with...
RA. There was moderate-quality evidence that heavier body weight was associated with poorer outcomes, including pain, function and disease activity, with relatively consistent results across the seven RMDs. However, the amount of available evidence varied considerably between RMDs, with the majority of studies focusing on OA, RA, axSpA and to a lesser extent SLE, with only a few studies available focusing on PsA, SSc and gout.

The majority of studies of exercise across the RMDs focused on aerobic and muscle strengthening exercise. Both appeared to improve outcomes in the seven RMDs included in this review, and when combined they seemed to produce stronger effects, although relatively few studies compared aerobic plus muscle strengthening exercise to either form of exercise individually. A few studies indicated that supervised exercise was marginally more effective than unsupervised home-based exercise, although this should not deter individuals who do not wish to attend exercise classes from performing home-based exercise. Overall, the current evidence base indicates that exercising results in better outcomes in people with RMDs, when compared with groups assigned to control groups with no exercise intervention. People with RMDs should be encouraged by their health professionals to start exercising if they currently perform no exercise, or maintain their exercise if they already perform a sufficient amount of exercise. Health professionals should also recognise that there are potentially large barriers to initiating and continuing to exercise for people with RMDs, including time, resources and lack of motivation, as well as disease specific barriers.

Heavier body weight was consistently associated with poorer outcomes, including pain, function, disease activity, fatigue and comorbidities. The included studies evaluating weight-loss interventions typically reported improved outcomes in the weight-loss groups compared with controls. Additionally, multiple observational studies have reported an association between heavier baseline weight and worse disease outcomes. While these observational studies typically have longer follow-up periods than the few interventional studies included, there is the possibility of differential attrition leading to biased results. For instance, those with higher weight may be more likely to have worse outcomes, which could lead them to leave the study before these outcomes are assessed. Lastly, as the evidence within this review was used to formulate the taskforce’s recommendations, an update was not deemed appropriate. However, this means that some relevant papers have been published in the interim between implementing the search strategy and publishing this paper which are not included.

In conclusion, these reviews inform the 2021 EULAR recommendations which advise people with RMDs to perform sufficient amounts of exercise, given the beneficial effects of exercise on numerous outcomes. Furthermore, the 2021 EULAR recommendations also advise people with RMDs to maintain a healthy weight, given the association between heavier weight and poor outcomes, as detailed in this review.

This review has several limitations. While the large scope and high number of studies included means that a large proportion of the literature has been surveyed, due to the breadth of the research questions, some studies may have been missed. However, the extensive search strategies which were implemented in several databases should mean that these missing studies comprise a low proportion of the total evidence base. Due to the large number of studies, data extraction and risk of bias assessment were not performed in duplicate. Furthermore, due to the nature of the method of identifying studies, some selection bias could be influencing the results, particularly in the body weight systematic review. Many studies will assess multiple factors influencing progression of outcomes, and will often only report the significant associations in their abstracts. As our search strategy identified studies reporting that they studied the association between weight and outcomes in their abstracts, this potentially means we missed studies that assessed the association, found no relationship, and therefore did not report they had assessed weight in their abstract. The majority of studies on exercise were RCTs, with strict inclusion criteria, meaning the samples in these studies were often highly selected, thus reducing generalisability. The majority of studies on weight were longitudinal observational studies. While these studies typically had longer follow-up periods than the few interventional studies included, there is the possibility of differential attrition leading to biased results.

In conclusion, these reviews inform the 2021 EULAR recommendations which advise people with RMDs to perform sufficient amounts of exercise, given the beneficial effects of exercise on numerous outcomes. Furthermore, the 2021 EULAR recommendations also advise people with RMDs to maintain a healthy weight, given the association between heavier weight and poor outcomes, as detailed in this review.

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REFERENCES

1 Smolen JS, Aletaha D, Barton A, et al. Rheumatoid arthritis. Nat Rev Dis Primers 2018;4:18001.
2 Martel-Pelletier J, Barr AJ, Cicuttini FM, et al. Osteoarthritis. Nat Rev Dis Primers 2016;2:16072.
3 Kaul A, Gordon C, Crow MK, et al. Systemic lupus erythematosus. Nat Rev Dis Primers 2016;2:16039.
4 GBD 2019 Diseases and Injuries Collaborators. Global burden of 369 diseases and injuries in 204 countries and territories, 1990-2019: a systematic analysis for the global burden of disease study 2019. Lancet 2020;396:1204–22.
5 Singh JA, Christensen R, Wells GA, et al. Biologics for rheumatoid arthritis: an overview of Cochrane reviews. Cochrane Database Syst Rev 2009;4:CD007848.
6 Fanourakis A, Kostopoulos M, Alumo A, et al. 2019 update of the EULAR recommendations for the management of systemic lupus erythematosus. Ann Rheum Dis 2019;78:736–45.
7 McAlindon TE, Bannuru RR, Sullivan MC, et al. OARSI guidelines for the non-surgical management of knee osteoarthritis. Osteoarthr Cartil 2014;22:363.
8 Caspersen CJ, Powell KE, Christenson GM. Physical activity, exercise, and physical fitness: definitions and distinctions for health-related research. Public Health Rep 1985;100:128–31.
9 U.S. Department of Health and Human Services. Physical activity guidelines for Americans. 2nd edn. Washington, DC, 2018.
10 World Health Organisation. Global recommendations on physical activity for health, 2010.
11 Rausch Osthoff A-K, Niedermann K, Braun J, et al. 2018 EULAR recommendations for physical activity in people with inflammatory arthritis and osteoarthritis. Ann Rheum Dis 2018;77:1251–60.
12 Rausch Osthoff A-K, Juhl CB, Knitlle K, et al. Effects of exercise and physical activity promotion: meta-analysis informing the 2018 EULAR recommendations for physical activity in people with rheumatoid arthritis, spondyloarthritis and hip/knee osteoarthritis. RMD Open 2018;4:e000713.
13 . Alshifi A, Forouzanfar MH, GBD Obesity Collaborators, et al. Health effects of overweight and obesity in 195 countries over 25 years. N Engl J Med 2017;377:13–27.
14 Abdullah A, Peeters A, de Courten M, et al. The magnitude of association between overweight and obesity and the risk of diabetes: a meta-analysis of prospective cohort studies. Diabetes Res Clin Pract 2010;89:309–19.
15 van der Heijde D, Aletaha D, Carmona L, et al. 2014 update of the EULAR standardised operating procedures for EULAR-endorsed recommendations. Ann Rheum Dis 2015;74:8–13.
16 Moher D, Liberati A, Tetzlaff J, et al. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. PLoS Med 2009;6:e1000097.
17 Shea BJ, Reeves BC, Wells G, et al. AMSTAR 2: a critical appraisal tool for systematic reviews that include randomised and non-randomised studies of healthcare interventions, or both. BMJ 2017;358:j34006.
18 Higgins JPT, Altman DG, Gøtzsche PC, et al. The Cochrane collaboration’s tool for assessing risk of bias in randomised trials. BMJ 2011;343:d5926.
19 Soboczenski R, Trikalinos TA, Kuiper J, et al. Machine learning to help researchers evaluate biases in clinical trials: a prospective, randomized user study. BMC Med Inform Decis Mak 2019;19:96.
20 Hayden JA, van der Windt DA, Cartwright JL, et al. Assessing bias in studies of prognostic factors. Ann Intern Med 2013;158:280–6.
21 Wan X, Wang W, Liu J, et al. Estimating the sample mean and standard deviation from the sample size, median, range and/or interquartile range. BMC Med Res Methodol 2014;14:135.
22 Cohen J. Statistical power analysis for the behavioral sciences. 2nd ed. Hillsdale, NJ: Erlbaum, 1988.
23 Guyatt GH, Oxman AD, Vist GE, et al. GRADE: an emerging consensus on rating quality of evidence and strength of recommendations. BMJ 2008;336:924–6.
24 Guyatt GH, Oxman AD, Kunz R, et al. What is “quality of evidence” and why is it important to clinicians? BMJ 2008;336:985–8.
25 Juhl C, Christensen R, Roos EM, et al. Impact of exercise type and dose on pain and disability in knee osteoarthritis: a systematic
review and meta-regression analysis of randomized controlled trials. *Arthritis Rheumatol* 2014;66:622–36.

26 Corbett MS, Rice SJ, Madurasinghe V, et al. Acupuncture and other physical treatments for the relief of pain due to osteoarthritis of the knee: a network meta-analysis. *Osteoarthr Cartilage* 2013;21:1290–8.

27 Tanaka R, Ozawa J, Kito N, et al. Efficacy of strengthening or aerobic exercise on pain relief in people with knee osteoarthritis: a systematic review and meta-analysis of randomized controlled trials. *Clin Rehabil* 2013;27:1059–71.

28 Utthman OA, van der Windt DA, Jordan JL, et al. Exercise for lower limb osteoarthritis: systematic review incorporating trial sequential analysis and network meta-analysis. *BMJ* 2013;347:f5555.

29 Wijnen A, Bouma SE, Seeber GH, et al. Acupuncture and effectiveness of physiotherapeutic exercise following total hip arthroplasty for osteoarthritis: a systematic review. *PLoS One* 2018;13:e0194517.

30 Alrushud AS, Rushton AB, Kanavaki AM, et al. Effect of physical activity and dietary restriction interventions on weight loss and the musculoskeletal function of overweight and obese older adults with knee osteoarthritis: a systematic review and mixed method data synthesis. *BMJ Open* 2017;7:e014537.

31 Brossseau L, Taki J, Desjardins B, et al. The Ottawa panel clinical practice guidelines for the management of knee osteoarthritis. Part three: aerobic exercise programs. *Clin Rehabil* 2017;31:612–24.

32 Quintrec J-LL, Verhac B, Cadet C, et al. Physical exercise and weight loss for hip and knee osteoarthritis in very old patients: a systematic review of the literature. *Open Rheumatol J* 2014;8:89–95.

33 Pozzobon D, Ferreira PH, Blyth FM, et al. Can obesity and physical activity predict outcomes of elective knee or hip surgery due to osteoarthritis? A meta-analysis of cohort studies. *BMJ Open* 2018;8:e017689.

34 de Rooij M, van der Leeden M, Heymans MW, et al. Prognosis of pain and physical functioning in patients with knee osteoarthritis: a systematic review and meta-analysis. *Arthritis Care Res* 2016;68:481–92.

35 Bastick AN, Belo JN, Runhaar J, et al. What are the prognostic factors for radiographic progression of knee osteoarthritis? A meta-analysis. *Clin Orthop Relat Res* 2015;473:2969–89.

36 Beumer L, Wong J, Warden SJ, et al. Effects of exercise and manual therapy on pain associated with hip osteoarthritis: a systematic review and meta-analysis. *Br J Sports Med* 2016;50:458–63.

37 Bartels EM, Juul CB, Christensen R, et al. Aquatic exercise for the treatment of knee and hip osteoarthritis. *Cochrane Database Syst Rev* 2016;3:CD005523.

38 Lu M, Su Y, Zhang Y, et al. Effectiveness of aquatic exercise for treatment of knee osteoarthritis: systematic review and meta-analysis. *Z Rheumatol* 2015;74:543–52.

39 Waller B, Ogownowska-Slodownik A, Vitor M, et al. Effect of therapeutic aquatic exercise on symptoms and function associated with lower limb osteoarthritis: systematic review with meta-analysis. *Phys Ther* 2014;94:1383–95.

40 Romeo A, Paraza S, Boschi M, et al. Manual therapy and therapeutic exercise in the treatment of osteoarthritis of the hip: a systematic review. *Reumatismo* 2013;65:63–74.

41 Gay C, Cheluaud A, Quille E, et al. Educating patients about the benefits of physical activity and exercise for their hip and knee osteoarthritis. Systematic literature review. *Ann Phys Rehabil Med* 2016;59:174–83.

42 Nelson AE, Allen KD, Golightly YM, et al. A systematic review of recommendations and guidelines for the management of osteoarthritis: the chronic osteoarthritis management initiative of the U.S. bone and joint initiative. *Semin Arthritis Rheum* 2014;43:701–12.

43 Fernandes L, Hagen KB, Blijasma JWJ, et al. EULAR recommendations for the non-pharmacological core management of hip and knee osteoarthritis. *Ann Rheum Dis* 2013;72:1125–35.

44 Regnaux J-P, Lefevre-Colau M-M, Trinquart L, et al. High-intensity versus low-intensity physical activity or exercise in people with hip or knee osteoarthritis. *Cochrane Database Syst Rev* 2015;CD010203.

45 de Rooij M, van der Leeden M, Heymans MW, et al. Course and predictors of pain and physical functioning in patients with hip osteoarthritis: systematic review and meta-analysis. *J Rehabil Med* 2016;48:245–52.

46 Juhakoski R, Pavlivicara A, Lakka TA, et al. Determinants of pain and functioning in hip osteoarthritis - a two-year prospective study. *Clin Rehabil* 2013;27:281–7.

47 Anwer S, Alghadri A, Brième J-M. Effect of home exercise program in patients with knee osteoarthritis: a systematic review and meta-analysis. *J Geriatr Phys Ther* 2016;39:38–48.

48 Moseng T, Dafgnrud H, Smedslund G, et al. The importance of dose in land-based supervised exercise for people with hip osteoarthritis. A systematic review and meta-analysis. *Osteoarthr Cartilage* 2017;25:1563–76.

49 Fernandopulle S, Perry M, Manlapaz D, et al. Effect of Land-Based generic physical activity interventions on pain, physical function, and physical performance in hip and knee osteoarthritis: a systematic review and meta-analysis. *Am J Phys Med Rehabil* 2019;98:773–92.

50 Henriksen M, Hansen JB, Klokker L, et al. Comparable effects of exercise and analgesics for pain secondary to knee osteoarthritis: a meta-analysis of trials included in Cochrane systematic reviews. *J Comp Eff Res* 2016;5:411.

51 Fransen M, McConnell S, Hamer AR, et al. Exercise for osteoarthritis of the knee. *Cochrane Database Syst Rev* 2015;1:CD004376.

52 Aebischer B, Elsig S, Taeymat J. Effectiveness of physical and occupational therapy on pain, function and quality of life in patients with trapeziometacarpal osteoarthritis. A systematic review and meta-analysis. *Hand Ther* 2016;21:5–15.

53 Finney A, Healey E, Jordan JL, et al. Multidisciplinary approaches to managing osteoarthritis in multiple joint sites: a systematic review. *BMC Musculoskelet Disord* 2016;17:266.

54 Bartholdy C, Juhl C, Christensen R, et al. The role of muscle strengthening in exercise therapy for knee osteoarthritis: a systematic review and meta-regression analysis of randomized trials. *Semin Arthritis Rheum* 2017;47:9–21.

55 Magri N, McNair PJ, Rice DA. The effects of resistance training on muscle strength, joint pain, and hand function in individuals with hand osteoarthritis: a systematic review and meta-analysis. *Arthritis Res Ther* 2017;19:131.

56 Østerås N, Kjeken I, Smedslund G, et al. Exercise for hand osteoarthritis. *Cochrane Database Syst Rev* 2017;1:CD010388.

57 Coudyere E, Jegu AG, Giustannini M, et al. Isokinetic muscle strengthening for knee osteoarthritis: a systematic review of randomized controlled trials with meta-analysis. *Ann Phys Rehabil Med* 2016;59:207–15.

58 Li Y, Su Y, Chen S, et al. The effects of resistance exercise in patients with knee osteoarthritis: a systematic review and meta-analysis. *Clin Rehabil* 2016;30:947–59.

59 Brossseau L, Taki J, Desjardins B, et al. The Ottawa panel clinical practice guidelines for the management of knee osteoarthritis. Part two: strengthening exercise programs. *Clin Rehabil* 2017;31:596–611.

60 Brossseau L, Wells GA, Pugh AG, et al. Ottawa panel evidence-based clinical practice guidelines for therapeutic exercise in the management of hip osteoarthritis. *Clin Rehabil* 2016;30:935–46.

61 Briani RV, Ferreira AS, Pazzinatto MF, et al. What interventions can improve quality of life of psychosocial factors of individuals with knee osteoarthritis? A systematic review with meta-analysis of primary outcomes from randomised controlled trials. *Br J Sports Med* 2018;52:1031–8.

62 Hurley M, Dickson K, Hallett R, et al. Exercise interventions and patient beliefs for people with hip, knee or hip and knee osteoarthritis: a mixed methods review. *Cochrane Database Syst Rev* 2018;4:CD010842.

63 Sampath KK, Mani R, Miyamori T, et al. The effects of manual therapy or exercise therapy or both in people with hip osteoarthritis: a systematic review and meta-analysis. *Clin Rehabil* 2016;30:1141–55.

64 Bertozzi L, Valdes K, Vanti C, et al. Investigation of the effect of conservative interventions in thumb carpometacarpal osteoarthritis: systematic review and meta-analysis. *Disabil Rehabil* 2015;37:2025–43.

65 Desvauzau I, Beauchamp M, Goldstein R, et al. Community-based exercise programs as a strategy to optimize function in chronic disease: a systematic review. *Med Care* 2014;52:216–26.

66 Ferreira GE, Robinson CC, Wiebusch M, et al. The effect of exercise therapy on knee adduction moment in individuals with knee osteoarthritis: a systematic review. *Clin Biomech* 2015;30:521–7.

67 Fehring TK, Fehring K, Odum SM, et al. Physical therapy mandates for Medicare accountable care organizations: effective or wasteful? *J Arthroplasty* 2013;28:1459–62.

68 Zhang Y, Huang L, Su Y, et al. The effects of traditional Chinese exercise in treating knee osteoarthritis: a systematic review and meta-analysis. *PLoS One* 2017;12:e0170237.

Gwinnutt JM, et al. RMD Open 2022;8:e002168. doi:10.1136/rmdopen-2021-002168
Chen Y-W, Hunt MA, Campbell KL, et al. The effect of Tai Chi on four chronic conditions-cancer, osteoarthritis, heart failure and chronic obstructive pulmonary disease: a systematic review and meta-analyses. Br J Sports Med 2016;50:397–407.

Van J-H, Gu W, Kao J, et al. Efficacy of Tai Chi on pain, stiffness and function in patients with osteoarthritis: a meta-analysis. PLoS One 2013;8:e61672.

Brosseau L, Taki J, Desjardins B, et al. The Ottawa panel clinical practice guidelines for the management of knee osteoarthritis, Part one: introduction, and mind-body exercise programs. Clin Rehabil 2017;31:582–95.

Wang Y, Lu S, Wang R, et al. Integrative effect of yoga practice in patients with knee arthritis: a PRISMA-compliant meta-analysis. Medicine 2018;97:e11742.

Lairmer H, Lau F, Langhorst J, et al. Yoga for rheumatic diseases: a systematic review. Rheumatology 2013;52:2025–30.

Kan L, Zhang J, Yang Y, et al. The effects of yoga on pain, mobility, and quality of life in patients with knee osteoarthritis: a systematic review. Evid Based Complement Alternat Med 2016;2016:6016532.

Rongen-van Dael SAA, Repping-Wuts H, Flendrie M, et al. Effect of aerobic exercise training on fatigue in rheumatoid arthritis: a meta-analysis. Arthritis Care Res 2015;67:1054–62.

Hernández-Hernández MV, Díaz-González F. Role of physical activity in the management and assessment of rheumatoid arthritis patients. Reumatol Clin 2017;13:214–20.

Siegel T, Tencza M, Apodaca B, et al. Effectiveness of occupational therapy interventions for adults with rheumatoid arthritis: a systematic review. Am J Occup Ther 2017;71:10118050.

Larkin L, Klevlund A. Correlation of physical activity in adults with rheumatoid arthritis: a systematic review. J Phys Act Health 2014;11:1248–61.

Baillot A, Zeboulou N, Gosses L, et al. Efficacy of cardiorespiratory aerobic exercise in rheumatoid arthritis: meta-analysis of randomized controlled trials. Arthritis Care Res 2010;62:884–92.

Kat P, Margarettten M, Gregorich S, et al. Physical activity to reduce fatigue in rheumatoid arthritis: a randomized controlled trial. Arthritis Care Res 2018;70:1–10.

Baxter SV, Hale LA, Stebbins B, et al. Walking is a feasible physical activity for people with rheumatoid arthritis: a feasibility randomized controlled trial. Musculoskeletal Care 2016;14:47–56.

Feldhusen C, Dean E, Forsblad-d’Elia H, et al. Effects of Person-Centered physical therapy on Fatigue-Related variables in persons with rheumatoid arthritis: a randomized controlled trial. Arch Phys Med Rehabil 2014;95:1867–75.

Sjöquist ES, Brodin N, Lampa J, et al. Physical activity Coaching of patients with rheumatoid arthritis in everyday practice: a long-term follow-up. Musculoskeletal Care 2011;9:75–85.

Brodin N, Eurenius E, Jensen I, et al. Coaching patients with early rheumatoid arthritis to healthy physical activity: a multicentre, long-term, randomized, controlled study. Arthritis Rheum 2008;59:325–31.

Li LC, Davis AM, Lineker SC, et al. Longterm physical fitness and work capacity in women with rheumatoid arthritis. Scand J Rheumatol 1994;23:1189–95.

Häkkinen A, Sokka T, Hannonen P. A home-based two-year strength training period in early rheumatoid arthritis led to good long-term compliance: a five-year follow-up. Arthritis Rheum 2004;51:56–62.

Häkkinen A, Sokka T, Kautiainen H, et al. Sustained maintenance of exercise induced muscle strength gains and normal bone mineral density in patients with early rheumatoid arthritis: a 5 year follow-up study. Arthritis Rheum 2014;66:9310–6.

de Jong Z, Munnene M, Zwinderman AH, et al. Long term high intensity exercise and damage of small joints in rheumatoid arthritis. Ann Rheum Dis 2004;63:1399–405.

Häkkinen A, Sokka T, Hannonen P. A home-based two-year strength training period in early rheumatoid arthritis led to good long-term compliance: a five-year follow-up. Arthritis Rheum 2004;51:56–62.

Häkkinen A, Sokka T, Kautiainen H, et al. Sustained maintenance of exercise induced muscle strength gains and normal bone mineral density in patients with early rheumatoid arthritis: a 5 year follow-up study. Arthritis Rheum 2014;66:9310–6.

de Jong Z, Munnene M, Zwinderman AH, et al. Is a long-term high-intensity exercise program effective and safe in patients with rheumatoid arthritis? Results of a randomized controlled trial. Arthritis Rheum 2003;48:2415–24.

Westby MD, Wade JP, Rangno KK, et al. A randomized controlled trial to evaluate the effectiveness of an exercise program in women with rheumatoid arthritis taking low dose prednisone. J Rheumatol 2000;27:1674–80.

Häkkinen A, Sokka T, Kotaniemi A, et al. Dynamic strength training in patients with early rheumatoid arthritis increases muscle strength but not bone mineral density. J Rheumatol 1999;26:1257–63.

Lyngberg KK, Harreby M, Bentzen H, et al. Elderly rheumatoid arthritis patients on steroid treatment tolerate physical training without an increase in disease activity. Archr Phys Med Rehabil 1994;75:1189–95.

Ek dah C, Andersson SI, Moritz U, et al. Dynamic versus static physical training in patients with rheumatoid arthritis. Scand J Rheumatol 1990;19:17–26.

Lyngberg K, Dannesiold-Samsoe B, Halskov O. The effect of physical training on patients with rheumatoid arthritis: changes in disease activity, muscle strength and aerobic capacity. A clinically controlled minimised cross-over study. Clin Exp Rheumatol 1988;6:253–60.

Nordemar R, Ekblom B, Zachrisson L, et al. Physical training in rheumatoid arthritis: a controlled long-term study. I. Scand J Rheumatol 1981;10:17–23.
Nordemar R. Physical training in rheumatoid arthritis: a controlled long-term study. II. Functional capacity and general attitudes. *Scand J Rheumatol* 1981;10:25–30.

Stavropoulos-Kalinoglou A, Metssios GS, Veldhuizen van Zanten JJJCS, et al. Individualised aerobic and resistance exercise training improves cardiovascular fitness and reduces cardiovascular risk in patients with rheumatoid arthritis. *Ann Rheum Dis* 2013;72:1819–25.

Löfgren M, Opava CH, Demmelmaier I, et al. Long-term, health-enhancing physical activity is associated with reduction of pain but not pain sensitivity or improved exercise-induced hypealgiesia in persons with rheumatoid arthritis. *Arthritis Res Ther* 2018;20:262.

Nordgren B, Friden C, Demmelmaier I, et al. An outsourced health-enhancing physical activity programme for people with rheumatoid arthritis: exclusion of adherence and response. *Rheumatology* 2015;54:1065–73.

Di Gioia L, Zincarelli C, Di Minno MND, et al. Effectiveness of a rehabilitative programme in improving fatigue and function in rheumatoid arthritis patients treated with biologics: a pilot study. *Clin Exp Rheumatol* 2013;31:285–8.

Strasser B, Leeb G, Strehclow C, et al. The effects of strength and endurance training in patients with rheumatoid arthritis. *Clin Rheumatol* 2011;30:623–32.

van der Giesen FJ, van Lankveld W, et al. Progressive resistance training program for patients with rheumatoid arthritis. *Clin Rheumatol* 2009;28:663–71.

van den Ende CH, Hazes JM, le Cessie S, vanden Ende CH, Briddon M, et al. Effects of home hand exercise programme in early rheumatoid arthritis of the hand. Results of a randomised clinical trial. *Arthritis Care Res* 2013;33:2625–30.

Baillet A, Payraud E, Niderprim V, et al. A dynamic exercise programme to improve patients’ disability in rheumatoid arthritis: a prospective randomised controlled trial. *Rheumatology* 2009;48:410–5.

Masiero S, Boniolo A, Wassermann L, et al. Effects of an educational-behavioral joint protection program on people with moderate to severe rheumatoid arthritis: a randomized controlled trial. *Rheumatology* 2007;26:2043–50.

O’Brien AV, Jones P, Mullis R, et al. Conservative hand therapy treatments in rheumatoid arthritis—a randomised controlled trial. *Rheumatology* 2006;45:577–83.

Bujina AL, Taljanovic MS, Avdic DM, et al. Physical and exercise therapy for treatment of the rheumatoid hand. *Arthritis Rheum* 2001;45:392–7.

Scholten C, Brodowicz T, Graninger W, et al. Persistent functional and social benefit 5 years after a multidisciplinary arthritis training program. *Arch Phys Med Rehabil* 1999;80:1282–7.

Boström C, Härms-Ringdahl K, Karrekkos H, et al. Effects of static and dynamic shoulder rotator exercises in women with rheumatoid arthritis: a randomised comparison of impairment, disability, handicap, and health. *Scand J Rheumatol* 1998;27:281–90.

Komatchedy RR, Leitch RW, Cella K, et al. Efficacy of low load resistive muscle training in patients with rheumatoid arthritis functional class II and III. *J Rheumatol* 1997;24:1531–9.

Hoenig H, Frief DJ, Groff G, Pratt K, et al. A randomized controlled trial of home exercise on the rheumatoid hand. *J Rheumatol* 1993;20:785–9.

Dehlgård B, Wollersjö I, Bjele A. Effect of active hand exercise and wax bath treatment in rheumatoid arthritis patients. *Arthritis Care Res* 1992;5:287–92.

Lemmey AB, Lonnqvist J, Mäkelä M, et al. Supervised aerobic exercise without hand exercises in patients with rheumatoid arthritis. *J Rehabil Med* 2009;41:332–7.

Seneca T, Hauge EM, Maribo T. Comparable effect of partly supervised and self-administered exercise programme in early rheumatoid arthritis—a randomised, controlled trial. *Dan Med J* 2015;62:A1278.

Hsieh LF, Chen S-C, Chung C-C, et al. Supervised aerobic exercise is more effective than home aerobic exercise in female Chinese patients with rheumatoid arthritis. *J Rehabil Med* 2009;41:332–7.

Höfling CH. Home exercise in rheumatoid arthritis functional class II: goal setting versus pain attention. *J Rheumatol* 1994;21:627–34.

Williams MA, Srikessavan C, Heine PJ, et al. Exercise for rheumatoid arthritis of the hand. *Cochrane Database Syst Rev* 2018;7:CD003832.

Ballant A, Vaillant M, Guinot M, et al. Efficacy of resistance exercises in rheumatoid arthritis. Evid based-analysis of randomized controlled trials. *Rheumatol* 2012;51:519–27.

Daien CI, Hua C, Combe B, et al. Non-pharmacological and pharmaceutical interventions in patients with early arthritis: a systematic literature review informing the 2016 update of EULAR recommendations for the management of early arthritis. *RMD Open* 2017;3:e000404.

Bergstra SA, Murgia A, Te Velde AF, et al. A systematic review into the effectiveness of hand exercise therapy in the treatment of rheumatoid arthritis. *Clin Rheumatol* 2014;33:1539–48.

Lo-C N, Xia G, Leung BP. The effect of nerve mobilization exercise in patients with rheumatoid arthritis: a pilot study. *Rheumatism* 2017;69:111–8.

Williamson E, McConkey C, Heine P, et al. Hand exercises for patients with rheumatoid arthritis: an extended follow-up of the SARAH randomised controlled trial. *BMJ Open* 2017;7:e013121.

Lourenzi FM, Jones A, Pereira DF, et al. Effectiveness of an overall progressive resistance strength program for improving the functional capacity of patients with rheumatoid arthritis: a randomized controlled trial. *Clin Rehabil* 2017;31:1482–91.

Lamb SE, Williamson EM, Heine PJ, et al. Hand exercises to improve function of the rheumatoid hand (SARAH): a randomised controlled trial. *Lancet* 2015;385:421–9.

Manning VL, Hurley MV, Scott DL, et al. Education, self-management, and upper extremity exercise training in people with rheumatoid arthritis: a randomized controlled trial. *Arthritis Care Res* 2014;66:217–27.

Dogu B, Sirzai H, Yilmaz F, et al. Effects of isotonic and isometric hand exercises on pain, hand functions, dexterity and quality of life in women with rheumatoid arthritis. *Rheumatol Int* 2013;33:2625–30.

No authors listed. Effectiveness of an educational program in a temperate pool for patients with rheumatoid arthritis. *J Phys Med Rehabil* 2007;8:23.

Baillet A, Locher C, Müller A, et al. Home exercise in rheumatoid arthritis functional class II—effectiveness of hand exercises in patients with rheumatoid arthritis. *Arthritis Res Ther* 2015;17:380.
Lee H-Y, Hale CA, Hemingway B, et al. Tai Chi exercise and auricular acupressure for people with rheumatoid arthritis: an evaluation study. J Clin Nurs 2012;21:2812–22.

Uhlig T, Fongen C, Steen E, et al. Exploring Tai Chi in rheumatoid arthritis: a quantitative and qualitative study. BMC Musculoskelet Disord 2010;11:43.

Ward L, Stebbings S, Athens J, et al. Yoga for the management of pain and sleep in rheumatoid arthritis: a pilot randomized controlled trial. Musculoskeletal Care 2018;16:39–47.

Evans S, Moieni M, Lung K, et al. Impact of iyengar yoga on quality of life in young women with rheumatoid arthritis. Clin J Pain 2013;29:988–97.

Singh VK, Bhandari RB, Rana BB. Effects of a one-week team intervention on disease activity and quality of life in young women with rheumatoid arthritis. J Rheumatol 2013;40:1226–32.

Lee H-K, Kim H, Kim S, et al. Effects of a one-year yoga intervention on disease activity and quality of life in patients with ankylosing spondylitis. Clin Rheumatol 2018;37:1151–60.

Lee H-O, Park Y, Lee J, et al. Effect of yoga on disease activity and quality of life in patients with ankylosing spondylitis: a randomized controlled trial. J Phys Ther Sci 2016;28:723–7.

Karanavan AH, Tok F, Yildrim P, et al. The effectiveness of Exergames in patients with ankylosing spondylitis: a randomized controlled trial. Adv Clin Exp Med 2016;25:931–6.

Jennings F, Oliveira HA, de Souza MC, et al. Effects of aerobic training in patients with ankylosing spondylitis. J Rheumatol 2015;42:2347–53.

Niedermann K, Sidelnikov E, Muggli C, et al. Effect of cardiovascular training on fitness and perceived disease activity in people with ankylosing spondylitis. Arthritis Care Res 2013;65:1844–52.

Sweeney S, Taylor G, Calin A. The effect of a home based exercise intervention package on outcome in ankylosing spondylitis: a randomized controlled trial. J Rheumatol 2002;29:763–6.

Ajeanana S, Winnett M, Hafström I. A four-week team-rehabilitation programme in a warm climate decreases disability and improves health and body function for up to one year: a prospective study in Swedish patients with inflammatory joint diseases. J Rehabil Med 2016;48:711–8.

Brophy S, Cooksey R, Davies H, et al. The effect of physical activity and motivation on function in ankylosing spondylitis: a cohort study. Semin Arthritis Rheum 2013;42:619–26.

Ward MM. Predictors of the progression of functional disability in patients with ankylosing spondylitis. J Rheumatol 2002;29:1420–5.

Uhrin Z, Kurz S, Ward MM. Exercise and changes in health status in patients with ankylosing spondylitis. Arch Intern Med 2000;160:2696–75.

Pécourneau V, Degbôé Y, Barnette T, et al. Effectiveness of exercise programs in ankylosing spondylitis: a meta-analysis of randomized controlled trials. Arch Phys Med Rehabil 2018;99:383–9.

Chang W, Tsou Y, Lee C. Comparison between specific exercises and physical therapy for managing patients with ankylosing spondylitis: a meta-analysis of randomized controlled trials. J Int Commun Sports 2016;10:17029.

Millner JR, Barron JS, Beinke KM, et al. Exercise for ankylosing spondylitis: an evidence-based consensus statement. Semin Arthritis Rheum 2016;45:411–27.

Liang H, Zhang H, Ji H, et al. Effects of home-based exercise intervention on health-related quality of life for patients with ankylosing spondylitis: a meta-analysis. Clin Rheumatol 2015;34:1737–44.

Liang H, Li W-R, Zhang H, et al. Concurrent intervention with exercises and stabilized tumor necrosis factor inhibitor therapy reduced the disease activity in patients with ankylosing spondylitis: a meta-analysis. Medicine 2015;94:e2254.

Martins NA, Furtado GE, Campos MJ, et al. Exercise and ankylosing spondylitis with New York modified criteria: a systematic review of controlled trials with meta-analysis. Acta Reumatol Port 2017;42(3):293–9.

Sharan D, Rajkumar JS. Physiotherapy for ankylosing spondylitis: systematic review and a proposed rehabilitation protocol. Curr Rheumatol Rev 2017;13:121–5.

Sveaas SH, Bilberg A, Uij J, et al. Intensity exercise for 3 months reduces disease activity in axial spondyloarthritis (axSpA): a multicentre randomised trial of 100 patients. Br J Sports Med 2020;54:292–7.

Sveaas SH, Bilberg A, Fongen C, et al. High-intensity cardiorespiratory and strength exercises reduced emotional distress and fatigue in patients with axial spondyloarthritis: a randomized controlled pilot study. Scand J Rheumatol 2018;47:117–21.

Aydın T, Taspinar Özgür, Sarynlıdz I, et al. Evaluation of the effectiveness of home based and hospital based calisthenic exercises in patients with ankylosing spondylitis. J Back Musculoskelet Rehabil 2016;29:723–30.

Roşu MO, Topa I, Chirieac R, et al. Effects of Pilates, McKenzie and Hecksher training on disease activity, spinal mobility and pulmonary function in patients with ankylosing spondylitis: a randomized controlled trial. Rheumatol Int 2014;34:367–72.

Sveaas SH, Bilberg A, Prován SA, et al. Efficacy of high intensity exercise on disease activity and cardiorespiratory risk in active axial spondyloarthritis: a randomized controlled pilot study. PLoS One 2014;9:e108868.

Kjeken I, Bo I, Ronningen A, et al. A three-week multidisciplinary in-patient rehabilitation programme had positive long-term effects.
in patients with ankylosing spondylitis: randomized controlled trial. J Rehabil Med 2013;45:260–7.

207 Anlay Y, Ozcan E, Karan A, et al. The effectiveness of intensive group exercise on patients with ankylosing spondylitis. Clin Rehabil 2013;27:1753–61.

208 Hidding A, van der Linden S, Gielkens L, et al. Continuation of group physical therapy is necessary in ankylosing spondylitis: results of a randomized controlled trial. Arthritis Care Res 1994;7:90–6.

209 Hidding A, van der Linden S, Boers M, et al. Is group physical therapy superior to individualized therapy in ankylosing spondylitis? A randomized controlled trial. Arthritis Care Res 1993:6:117–25.

210 Kraag G, Stokes B, Grob J, et al. The effects of comprehensive home physiotherapy and supervision on patients with ankylosing spondylitis—a randomized controlled trial. J Rheumatol 1999;26:2203–33.

211 Levitova A, Hulejova H, Spiritovic M, et al. Clinical improvement and reduction in serum calprotectin levels after an intensive exercise programme for patients with ankylosing spondylitis and non-radiographic axial spondyloarthritis. Arthritis Res Ther 2016;18:275.

212 Aytekio E, Caglar NS, Ozgonenel L, et al. Home-based exercise therapy in patients with ankylosing spondylitis: effects on pain, mobility, disease activity, quality of life, and respiratory functions. Clin Rheumatol 2012;31:91–7.

213 Vitanen JV, Heikkilä S. Functional changes in patients with spondylarthropathy. A controlled trial of the effects of short-term rehabilitation and 3-year follow-up. Rheumatol Int 2001;20:211–4.

214 Lubrano E, D’Angelo S, Parsons WJ, et al. Effectiveness of rehabilitation in active ankylosing spondylitis assessed by the ASAS response criteria. Rheumatology 2007;46:1672–5.

215 Band DA, Jones SD, Kennedy LG, et al. Two exercise interventions for the management of patients with ankylosing spondylitis: a randomized controlled trial. J Am Phys Med Rehabil 2005;84:407–19.

216 Kraag G, Stokes B, Grob J, et al. The effects of comprehensive home physiotherapy and supervision on patients with ankylosing spondylitis—an 8-month followup. J Rheumatol 1994;21:261–3.

217 Vitanen JV, Lehtinen K, Suri J, et al. Fifteen months’ follow-up of intensive inpatient physiotherapy and therapy in ankylosing spondylitis. Clin Rheumatol 1995;14:413–9.

218 Hsieh LF, Chuang C-C, Tseng C-S, et al. Combined home exercise is more effective than range-of-motion home exercise in patients with ankylosing spondylitis: a randomized controlled trial. Biomed Res Int 2014;2014:936190.

219 Rodríguez-Lozano C, Juanola X, Cruz-Martínez J, et al. Outcome of an education and home-based exercise programme for patients with ankylosing spondylitis: a nationwide randomized study. Clin Exp Rheumatol 2013;31:739–48.

220 Lim H-J, Moon J, Lee MS. Effects of home-based daily exercise therapy on joint mobility, daily activity, pain, and depression in patients with ankylosing spondylitis. Rheumatol Int 2005;25:225–9.

221 Yigit S, Sahin Z, Demir SE, et al. Home-based exercise therapy in ankylosing spondylitis: short-term prospective study in patients receiving tumor necrosis factor alpha inhibitors. Rheumatol Int 2013;33:71–7.

222 Durmus D, Alaylı G, Gür E, et al. Effects of a home-based exercise program on quality of life, fatigue, and depression in patients with ankylosing spondylitis. Rheumatol Int 2005;25:225–9.

223 Yigit S, Sahin Z, Demir SE, et al. Home-based exercise therapy in ankylosing spondylitis: short-term prospective study in patients receiving tumor necrosis factor alpha inhibitors. Rheumatol Int 2013;33:71–7.

224 Durmus D, Alaylı G, Uzun O, et al. Effects of two exercise interventions on pulmonary functions in the patients with ankylosing spondylitis. J Bone Spine 2009;76:150–5.

225 Karapolat H, Aksoy M, Birtane M, et al. The effectiveness of structured group education on ankylosing spondylitis patients. J Clin Rheumatol 2017;23:138–43.

226 Rosu OM, Ancuta C, McKenzie training in patients with early stages of ankylosing spondylitis: results of a 24-week controlled study. Eur J Phys Med Rehabil 2015;51:261–8.

227 Masiero S, Poll P, Bonaldo L, et al. Supervised training and home-based rehabilitation in patients with stabilized ankylosing spondylitis on TNF inhibitor treatment: a controlled clinical trial with a 12-month follow-up. Clin Rehabil 2014;28:562–72.

228 Altman L, Korkmaz N, Ozdoğan N, et al. Effect of Pilates training on people with ankylosing spondylitis. Rheumatol Int 2012;32:2093–9.

229 Masiero S, Bonaldo L, Pigatto M, et al. Rehabilitation treatment in patients with ankylosing spondylitis stabilized with tumor necrosis factor inhibitor therapy: a randomized controlled trial. J Rheumatol 2011;38:1335–42.

230 Souza MCde, Jennings F, Morimoto H, et al. Swiss ball exercises improve muscle strength and walking performance in ankylosing spondylitis: a randomized controlled trial. Rev Bras Reumatol Em Ed 2017;57:45–55.

231 Gaspozoglou Aksoy M, Birtane M, Tastekin N, et al. Effects of concurrent training in patients with ankylosing spondylitis. A randomized controlled trial. J Rheumatol 2013;20:138–43.

232 Fujimura T, Hata T, Torii T, et al. Efficacy of supervised training and concurrent training in systemic sclerosis. Clin Exp Rheumatol 2013;31:855–62.

233 Fujimura T, Hata T, Torii T, et al. No effect of exercise on the serum levels of adipocytokines in patients with ankylosing spondylitis. Rheumatol Int 2012;32:3931–6.

234 Orantci O, Sarikaya S, Sapmaz P, et al. The effect(s) of a six-week home-based exercise programme on the respiratory muscle and functional status in ankylosing spondylitis. J Rheumatol 2010;37:895–900.

235 Roger-Silva D, Natour J, Moreira E, et al. A resistance exercise programme improves functional capacity of patients with psoriatic arthritis: a randomized controlled trial. Clin Rheumatol 2018;37:389–95.

236 Chimenti MS, Triggiani P, Conigliaro P, et al. Self-reported adherence to a home-based exercise program among patients affected by psoriatic arthritis with minimal disease activity. Drug Dev Res 2014;75(Suppl 1):S57–9.

237 Antonioli CM, Bus G, Frigè A, et al. An individualized rehabilitation program in patients with systemic sclerosis may improve quality of life and hand mobility. Clin Rheumatol 2009;28:159–65.

238 Moran ME. Scleroderma and evidence based non-pharmaceutical treatment modalities for digital ulcers: a systematic review. J Wound Care 2014;23:510–6.

239 Rannou F, Bouttiaux D, Mouthon L, et al. Personalized physical therapy versus usual care for patients with systemic sclerosis: a randomized controlled trial. Arthritis Res Ther 2017;19:1050–9.

240 Schoufter AA, Nabiner MK, Beaart-van de Voorde LJ, et al. Randomized comparison of a multidisciplinary team care program with usual care in patients with systemic sclerosis. Arthritis Care Res 2011;63:909–17.

241 Pinto ALS, Oliveira NC, Guabano B, et al. Efficacy and safety of concurrent training in systemic sclerosis. J Strength Cond Res 2011;25:1423–8.

242 Maddali Bongi S, Del Rosso A, Galluccio F, et al. Efficacy of a tailored rehabilitation program for systemic sclerosis. Clin Exp Rheumatol 2009;27:44–50.

243 Stefanantonio K, Sbarra I, Ianacte N, et al. Occupational therapy integrated with a self-administered stretching program on systemic sclerosis patients with hand involvement. Clin Exp Rheumatol 2016;34(Suppl 100):157–61.

244 Horváth J, Bálint Z, Szép E, et al. Efficacy of intensive hand physical therapy in patients with systemic sclerosis. Clin Exp Rheumatol 2011;29:673–7.

245 Mugii N, Matsushita T, Hata T, et al. Comparison of home-based exercise programs on pulmonary functions in the patients with ankylosing spondylitis. Mod Rheumatol 2019;29:484–90.

246 Landim SF, Barroli MB, Marcatto de Abreu MF, et al. The evaluation of a home-based program for hands in patients with systemic sclerosis. J Hand Ther 2019;32:313–21.
The arthritis, diet, and activity promotion trial. *Arthritis Rheum* 2004;50:1501–10.

275 Rejeski WJ, Focht BC, Messier SP, et al. Obese, older adults with knee osteoarthritis: weight loss, exercise, and quality of life. *Health Psychol* 2009;28(12):1419–26.

276 Messier SP, Loeser RF, Mitchell MN, et al. Exercise and weight loss in obese older adults with knee osteoarthritis: a preliminary study. *J Am Geriatr Soc* 2000;48:1062–72.

277 Toda Y. The effect of energy restriction, walking, and exercise on lower extremity lean body mass in obese women with osteoarthritis of the knee. *J Orthop Sci* 2001;6:148–54.

278 Huang MH, Chen CH, Chen TW, et al. The effects of weight reduction on the rehabilitation of patients with knee osteoarthritis and obesity. *Arthritis Care Res* 2000;13:398–405.

279 Bartholdy C, Christensen R, Kristensen LE, et al. Association between weight loss and spontaneous changes in physical inactivity in overweight/obese individuals with knee osteoarthritis: an 8-week prospective cohort study. *Arthritis Care Res* 2020;72:397–404.

280 Aree-Ue S, Saraboon Y, Belza B, Long-Term adherence and effectiveness of a multicomponent intervention for community-dwelling overweight Thai older adults with knee osteoarthritis: 1-year follow up. *J Gerontol Nurs* 2017;43:40–8.

281 Atukorala I, Makovey J, Lawler L, et al. Is there a dose-response relationship between weight loss and symptom improvement in persons with knee osteoarthritis? *Arthritis Care Res* 2016;68:1106–14.

282 Bartels EM, Christensen R, Christensen P, et al. Effect of a 16 weeks weight loss program on osteoarthritis biomarkers in obese patients with knee osteoarthritis. *A prospective cohort study*. *Osteoarthr Cartil* 2014;22:1817–25.

283 Paans N, van den Akker-Scheek I, Dilling RG, et al. Effect of exercise and weight loss in people who have hip osteoarthritis and are overweight or obese: a prospective cohort study. *Phys Ther* 2015;95:698–706.

284 Gudbergsson H, Boesen M, Lohmander LS, et al. Weight loss is effective for symptomatic relief in obese subjects with knee osteoarthritis independently of joint damage severity assessed by high-field MRI and radiography. *Osteoarthr Cartil* 2012;20:493–500.

285 Bihlet AR, Byrjalsen I, Bay-Jensen AC, et al. Identification of pain categories associated with change in pain in patients receiving placebo: data from two phase 3 randomized clinical trials in symptomatic knee osteoarthritis. *BMC Musculoskelet Disord* 2018;19:17.

286 Han A, Gelhorn AC. Trajectories of quality of life and associated risk factors in patients with knee osteoarthritis: findings from the osteoarthritis initiative. *Am J Phys Med Rehabil* 2018;97:820–7.

287 Jacobs CA, Power M, Wang Y, et al. Effect of weight loss on the progression of knee pain and osteoarthritis biomarkers greatest for patients with combined obesity and depression: data from the osteoarthritis initiative. *Cartilage* 2020;11:38–46.

288 Pelletier J-P, Rainer JD, Abram F, et al. Exploring determinants predicting response to intra-articular hyaluronic acid treatment in symptomatic knee osteoarthritis: 9-year follow-up data from the osteoarthritis initiative. *Arthritis Res Ther* 2018;20:40.

289 Eymard F, Chevalier X, Conrozier T. Obesity and radiological severity are associated with viscosupplementation failure in patients with knee osteoarthritis. *J Orthop Res* 2015;33:2269–74.

290 Moyer R, Worth W, Eckstein F. Longitudinal changes in magnetic resonance imaging-based measures of femoral cartilage thickness as a function of alignment and obesity: data from the osteoarthritis initiative. *Arthritis Care Res* 2017;69:959–65.

291 Bierstedt AN, Verkleij SP, Donnen K, et al. Defining hip pain trajectories in early symptomatic hip osteoarthritis—5 year results from a nationwide prospective cohort study (CHECK). *Osteoarthr Cartil* 2016;24:768–75.

292 de Rezende MU, Hessadomi MI, de Campos GC, et al. One-year results of an educational program on osteoarthritis: a prospective randomized controlled trial in Brazil. *Geriatr Orthop Surg Rehabil* 2016;7:86–94.

293 Beavers KM, Beavers DP, Newman JJ, et al. Effects of total and regional fat loss on plasma CRP and IL-6 in overweight and obese, older adults with knee osteoarthritis. *Osteoarthr Cartil* 2015;23:249–56.

294 Chatterjee D, McGee A, Strauss E, et al. Subchondral calcium phosphate is ineffective for bone marrow edema lesions in adults with advanced osteoarthritis. *Clin Orthop Relat Res* 2015;473:2394–400.

295 Karsdal MA, Bihlet A, Byrjalsen I, et al. OA phenotypes, rather than disease stage, drive structural progression—identification of
structural progressors from 2 phase III randomized clinical studies with symptomatic knee OA. Osteoarthritis Cartilage 2015;23:550–8.

Kobayashi N, Inaba Y, Yukizawa Y, et al. Use of 18F-fluoride position emission tomography as a predictor of the hip osteoarthritis progression. Mod Rheumatol 2015;25:925–30.

297 Magnusson K, Slatkowsky-Christensen B, van der Heijde D, et al. Body mass index and progressive hand osteoarthritis: data from the Oslo hand osteoarthritis cohort. Scand J Rheumatol 2015;44:331–6.

298 Gudbergsen H, Boesen M, Christensen R, et al. Changes in bone marrow lesions in response to weight-loss in obese knee osteoarthritis patients: a prospective cohort study. BMC Musculoskelet Disord 2013;14:106.

299 Perrot S, Bertin P. "Feeling better" or "feeling well" in usual care of hip and knee osteoarthritis pain: determination of cutoff points for patient acceptable symptom state (PASS) and minimal clinically important improvement (MCII) at rest and on movement in a national multicenter cohort study of 2414 patients with painful osteoarthritis. Pain 2013;154:248–56.

300 Cofman CJ, Allen KD, Woolson RF. Mixed-effects regression modeling of real-time momentary pain assessments in osteoarthritis (OA) patients. Health Serv Outcomes Res Method 2012;12:200–18.

301 Miyazaki T, Uchida K, Sato M, et al. Knee laxity after staircase exercise predicts radiographic disease progression in medial compartment knee osteoarthritis. Arthritis Rheim 2012;64:3908–16.

302 Rabago D, Zgierska A, Fortney L, et al. Hypertonic dextrose injections (prolotherapy) for knee osteoarthritis: results of a single-arm, uncontrolled study: 1 year follow-up. J Altern Complement Med 2012;18:408–14.

303 Sands GH, Brown PB, Essex MN. The Efficacy of Continuous Versus Intermittent Ceteoloxib Treatment in Osteoarthritis Patients with Body Mass Index >30 and <30 kg/m(2). Open Rheumatol J 2013;7:32–7.

304 Bartlett SJ, Ling SM, Mayo NE, et al. Identifying common trajectories of joint space narrowing over two years in knee osteoarthritis. Arthritis Care Res 2011;63:1722–8.

305 Bingham CO, Smugar SS, Wang H, et al. Predictors of response to cyclo-oxygenase-2 inhibitors in osteoarthritis: pooled results from two identical trials comparing etoricoxib, celecoxib, and placebo. Pain Med 2011;12:352–61.

306 Nishimura A, Hasegawa M, Kato K, et al. Risk factors for the incidence and progression of radiographic osteoarthritis of the knee among Japanese. Int Orthop 2011;35:839–43.

307 Richette P, Poitou C, Garnarro P, et al. Benefits of massive weight loss on symptoms, systemic inflammation and cartilage turnover in obese patients with knee osteoarthritis. Ann Rheum Dis 2011;70:139–44.

308 Woolard JD, Gil AB, Sparto P, et al. Change in knee cartilage volume in individuals completing a therapeutic exercise program for knee osteoarthritis. J Orthop Sports Phys Ther 2011;41:708–22.

309 Yusuf E, Bijsterbosch J, Slagboom PE, et al. Body mass index and alignment and their interaction as risk factors for progression of knee with magnetic signs of osteoarthritis. Osteoarthritis Cartilage 2011;19:1117–22.

310 Shea MK, Houston DK, Nicklas BJ, et al. The effect of randomization to weight loss on total mortality in older overweight and obese adults in the ADAP study. J Gerontol A Biol Sci Med Sci 2010;65:519–25.

311 Eckstein F, Maschek S, Wirth W, et al. One year change of knee cartilage morphology in the first release of participants from the osteoarthritis initiative progression subcohort: association with sex, body mass index, symptoms and radiographic osteoarthritis status. Ann Rheum Dis 2010;68:674–9.

312 Le Graverand M-P, Brandt K, Mazzuca SA, et al. Progressive increase in body mass index is not associated with a progressive increase in joint space narrowing in obese women with osteoarthritis of the knee. Ann Rheum Dis 2009;68:1734–8.

313 Botha-Scheepers S, Dougados M, Ravaud P, et al. Effect of medial tibial plateaux saggital alignment on serial radiographs on the capacity to predict progression of knee osteoarthritis. Osteoarthritis Cartilage 2008;16:272–6.

314 Davies-Tuck M, Wluka AE, Wang Y, et al. The natural history of cartilage defects in people with knee osteoarthritis. Osteoarthritis Cartilage 2008;16:337–46.

315 Pelletier J-P, Raynauld J-P, Berthiaume M-J, et al. Risk factors associated with the loss of cartilage volume on weight-bearing areas in knee osteoarthritis patients assessed by quantitative magnetic resonance imaging: a longitudinal study. Arthritis Res Ther 2007;9:R74.

316 Reijman M, Plos HAP, Bergink AP, et al. Body mass index associated with onset and progression of osteoarthritis of the knee but not of the hip: the Rotterdam study. Ann Rheum Dis 2007;66:158–62.

317 Raynauld J-P, Martel-Pelletier J, Berthiaume M-J, et al. Long term evaluation of disease progression through the quantitative magnetic resonance imaging of symptomatic knee osteoarthritis patients: correlation with clinical symptoms and radiographic changes. Arthritis Res Ther 2006;8:R21.

318 Wluka AE, Forbes A, Wang Y, et al. Knee cartilage loss in symptomatic knee osteoarthritis over 4.5 years. Arthritis Res Ther 2006;8:R90.

319 Sharma L, Cahue S, Song J, et al. Physical functioning over three years in knee osteoarthritis: role of psychosocial, local mechanical, and neuromuscular factors. Arthritis Rheum 2003;48:3339–70.

320 Cicuttini F, Wluka A, Wang Y, et al. The determinants of change in patella cartilage volume in osteoarthritic knees. J Rheumatol 2002;29:2615–9.

321 Wolfe F, Lane NE. The longterm outcome of osteoarthritis: rates and predictors of joint space narrowing in symptomatic patients with knee osteoarthritis. J Rheumatol 2002;29:139–46.

322 Detora LM, Krupa D, Bolognese J, et al. Rofecoxib shows consistent efficacy in osteoarthritis clinical trials, regardless of specific patient demographic and disease factors. J Rheumatol 2001;28:2494–503.

323 Cooper C, Snow S, McAlindon TE, et al. Risk factors for the incidence and progression of radiographic knee osteoarthritis. Arthritis Rheim 2000;43:995–5.

324 Harris PA, Hart DJ, Dacre JE, et al. The progression of radiological hand osteoarthritis over 2 years: a clinical follow-up study. Osteoarthritis Cartilage 1994;2:247–52.

325 Ledingham J, Dawson S, Preston B, et al. Radiographic progression of hospital referred osteoarthritis of the hip. Ann Rheum Dis 1993;52:263–7.

326 Schouten JS, van den Ouweland FA, Valkenburg HA. A 12 year follow-up study in the general population on prognostic factors of cartilage loss in osteoarthritis of the knee. Ann Rheum Dis 1992;51:932–7.

327 Berkhouit B, Macfarlane JD, Cats A. Symptomatic osteoarthritis of the knee: a follow-up study. Br J Rheumatol 1985;24:40–5.

328 Ahn JH, Kang HW, Yang TY, et al. Risk factors for radiographic progression of osteoarthritis after meniscus allograft transplantation. Arthroscopy 2016;32:2539–46.

329 Liu Y, Hazlewood GS, Kaplan GS, et al. Impact of obesity on remission and disease activity in rheumatoid arthritis: a systematic review and meta-analysis. Arthritis Res Ther 2017;19:65–75.

330 Lupoli R, Pizzicato P, Scalara A, et al. Impact of body weight on the achievement of minimal disease activity in patients with rheumatic diseases: a systematic review and meta-analysis. Arthritis Res Ther 2016;18:297.

331 Baghdadi LR, Woodman RJ, Shanahan EM, et al. The impact of traditional cardiovascular risk factors on cardiovascular outcomes in patients with rheumatoid arthritis: a systematic review and meta-analysis. PLoS One 2015;10:e0117952.

332 Baker JF, Stokes A, Nils TR, et al. Current and early life weight and associations with mortality in rheumatoid arthritis. Clin Exp Rheumatol 2019;37:768–73.

333 Hirose W, Harigai M, Uchiyama T, et al. Low body mass index and lymphocytopenia associate with Mycobacterium avium complex pulmonary disease in patients with rheumatoid arthritis. Mod Rheumatol 2019;29:105–12.

334 Lechtenboehmer CA, Jaeger VK, Kyburz D, et al. Brief report: influence of disease activity in rheumatoid arthritis on radiographic progression of concomitant interphalangeal joint osteoarthritis. Arthritis Rheumatol 2019;71:43–9.

335 England BR, Baker JF, Sayers H, et al. Body mass index, weight loss, and cause-specific mortality in rheumatoid arthritis. Arthritis Care Res 2018;70:11–18.

336 Nikiforou E, North S, Young A, et al. The association of obesity with disease activity, functional ability and quality of life in early rheumatoid arthritis: data from the early rheumatoid arthritis Study/Early rheumatoid arthritis network UK prospective cohorts. Rheumatology 2018;57:1194–202.

337 Ruddy E, Forslund K, Nilsson Jan-Åke, et al. Smoking, body mass index, disease activity, and the risk of rapid radiographic progression in patients with early rheumatoid arthritis: results from a multicenter prospective cohort study. Arthritis Care Res 2018;70:1185–91.
Smolen JS, Szumski A, Koenig AS, et al. Predictors of remission with etanercept-methotrexate induction therapy and loss of remission with etanercept maintenance, reduction, or withdrawal in moderately active rheumatoid arthritis: results of the PRESERVE 17 trial. *Arthritis Rheum* 2018;70:16–29.

Sparks JA, Chang S-C, Nguyen U-S, et al. Weight change during the early rheumatoid arthritis period and risk of subsequent mortality in women with rheumatoid arthritis and matched comparators. *Arthritis Rheumatol* 2018;70:290–8.

van der Heijde D, Durez P, Schett G, et al. Structural damage progression in patients with early rheumatoid arthritis treated with methotrexate, baricitinib, or baricitinib plus methotrexate based on clinical response in the phase 3 RA-BEGIN study. *Clin Rheumatol* 2018;37:2381–90.

Ford P, Nicholls D, Barrett R, et al. Longitudinal study of clinical prognostic factors in patients with early rheumatoid arthritis: the PREDICT study. *Int J Rheum Dis* 2017;20:460–8.

D’Agostino M, et al. Association of obesity with worse disease severity in rheumatoid arthritis as well as with comorbidities: a long-term followup from disease onset. *Arthritis Care Res* 2013;65:78–87.

Sandberg MEC, Bengtsson C, Källberg H, et al. Overweight decreases the chance of achieving good response and low disease activity in early rheumatoid arthritis. *Ann Rheum Dis* 2013;72:50–5.

Ajeanova S, Andersson ML, Hafström I, et al. Association of obesity with worse disease severity in rheumatoid arthritis as well as with comorbidities: a prospective observational cohort study. *Clin Rheumatol* 2014;33:477–83.

Kanecki K, Tyszko P, Włosiowska M, et al. Preliminary report on a study of health-related quality of life in patients with rheumatoid arthritis. *Rheumatol Int* 2013;33:429–34.

D’Agostino M, et al. Association of obesity with worse disease severity in rheumatoid arthritis as well as with comorbidities: a long-term followup from disease onset. *Arthritis Care Res* 2013;65:78–87.

Sandberg MEC, Bengtsson C, Källberg H, et al. Overweight decreases the chance of achieving good response and low disease activity in early rheumatoid arthritis. *Ann Rheum Dis* 2013;72:50–5.

Kanecki K, Tyszko P, Włosiowska M, et al. Preliminary report on a study of health-related quality of life in patients with rheumatoid arthritis. *Rheumatol Int* 2013;33:429–34.

D’Agostino M, et al. Association of obesity with worse disease severity in rheumatoid arthritis as well as with comorbidities: a long-term followup from disease onset. *Arthritis Care Res* 2013;65:78–87.

Sandberg MEC, Bengtsson C, Källberg H, et al. Overweight decreases the chance of achieving good response and low disease activity in early rheumatoid arthritis. *Ann Rheum Dis* 2013;72:50–5.
Factors associated with toxicity, final dose, and efficacy of methotrexate in patients with rheumatoid arthritis. *Ann Rheum Dis* 2003;62:423–6.

Kristnan E, Lingala B, Bruce B, et al. Disability in rheumatoid arthritis in the era of biological treatments. *Ann Rheum Dis* 2012;71:213–8.

Kreps DJ, Halperin F, Desai SP, et al. Association of weight loss with improved disease activity in patients with rheumatoid arthritis: a retrospective analysis using electronic medical record data. *Int J Clin Rheum Dis* 2018;13:1–10.

Mori S, Yoshitama T, Idaka T, et al. Comparative risk of hospitalized infection between biological agents in rheumatoid arthritis patients: a multicenter retrospective cohort study in Japan. *PLoS One* 2017;12:e0179179.

Ashish N, Lin AT, Aranda G, et al. Rates, factors, reasons, and economic impact associated with switching in rheumatoid arthritis patients newly initiated on biologic disease modifying anti-rheumatic drugs in an integrated healthcare system. *J Med Econ* 2016;19:568–75.

Ottaviani S, Gardette A, Roy C, et al. Body mass index and response to rituximab in rheumatoid arthritis. *Joint Bone Spine* 2015;82:432–6.

Ottaviani S, Gardette A, Tubach F, et al. Body mass index and response to infliximab in rheumatoid arthritis. *Clin Exp Rheumatol* 2015;33:478–83.

Sparks JA, Halperin F, Karlson JC, et al. Impact of bariatric surgery on patients with rheumatoid arthritis. *Arthritis Care Res* 2015;67:1619–26.

Gonzalez A, Maradit Kremers H, Crowson CS, et al. Do cardiovascular risk factors confer the same risk for cardiovascular outcomes in rheumatoid arthritis patients as in non-rheumatoid arthritis patients? *Ann Rheum Dis* 2008;67:64–9.

Kent PD, Lurtha HS, Michet C. Risk factors for methtoxetrate-induced abnormal laboratory monitoring results in patients with rheumatoid arthritis. *J Rheumatol* 2004;31:1727–31.

Figueiredo-Braga M, Cornaby C, Bernardes M, et al. Correlation between physical markers and psychiatric health in a Portuguese systemic lupus erythematosus cohort: the role of suffering in chronic autoimmune disease. *PLoS One* 2018;13:e0195579.

Jacobs J, Korponay-L A, Schilder AM, et al. Six-year follow-up study of bone mineral density in patients with systemic lupus erythematosus. *Osteoporos Int* 2013;24:1827–33.

Katz P, Yazdany J, Julian L, et al. Impact of obesity on functioning among women with systemic lupus erythematosus. *Arthritis Care Res* 2011;63:1357–64.

Chaimmura S, Bertoli AM, Fernández M, et al. The impact of increased body mass index on systemic lupus erythematosus: data from LUMINA, a multiethnic cohort (LUMINA XLVI) [corrected]. *J Clin Rheumatol* 2007;13:128–33.

Chaimmura S, Bertoli AM, Roseman JM, et al. African-American and Hispanic ethnicities, renal involvement and obesity predispose to hypertension in systemic lupus erythematosus: results from LUMINA, a multiethnic cohort (LUMINA XLV). *Ann Rheum Dis* 2007;66:618–22.

Utaratanawong S, Deesonchok U, Hiransuttikul N, et al. Four years follow-up of bone mineral density change in premenopausal women with systemic lupus erythematosus. *J Med Assoc Thai* 2004;87:1374–9.

Bruce IN, Gilman DD, Urowitz MB. Detection and modification of risk factors for coronary artery disease in patients with systemic lupus erythematosus: a quality improvement study. *Clin Exp Rheumatol* 1998;16:435–40.

Petri M, Perez-Gutthann S, Spence D, et al. Risk factors for coronary artery disease in patients with systemic lupus erythematosus. *Arthritis Care Res* 1992;5:513–9.

Hernández-Breijo B, Plascencia-Rodríguez C, Navarro-Compañ V, et al. Association between concomitant csDMARDs and clinical response to TNF inhibitors in overweight patients with axial spondyloarthritis. *Arthritis Res Ther* 2019;21:86.

Jeong H, Eun YH, Kim IY, et al. Effect of tumor necrosis factor α inhibitors on spinal radiographic progression in patients with anklosing spondylitis. *Int J Rheum Dis* 2018;21:1098–105.

Pedersen SJ, Weber U, Said-Nahal R. Structural progression rate decreases over time on serial radiography and magnetic resonance imaging of sacroiliac joints and spine in a five-year follow-up study of patients with anklosing spondylitis treated with tumour necrosis factor inhibitor. *Scand J Rheumatol* 2018;1–13.

Maas F, Arends S, Wink FR, et al. Anklosing spondylitis patients at risk of poor radiographic progression on long-term treatment with TNF-α inhibitors. *PLoS One* 2017;12:e0177231.

Maas F, Spoorenberg A, van der Sluij BPG, et al. Clinical risk factors for the presence and development of vertebral fractures in patients with ankylosing spondylitis. *Arthritis Care Res* 2017;69:694–702.

Michieli R, Hebeisen M, Wildi LM, et al. Impact of obesity on the response to tumor necrosis factor inhibitors in axial spondyloarthritis. *Arthritis Res Ther* 2017;19:164.

Hwang J, Kim H-M, Jeong H, et al. Higher body mass index and anti-drug antibodies predict the discontinuation of anti-TNF agents in Korean patients with spondyloarthritis. *Rev Bras Reumatol Engil Ed* 2017;57:311–9.

van Weely SFE, Kneepkens EL, Nurmohamed MT, et al. Continuous improvement of physical functioning in ankylosing spondylitis patients by tumor necrosis factor inhibitors: three-year follow-up results and predictors. *Arthritis Care Res* 2016;68:1229–35.

Maas F, Spoorenberg A, Brouwer E, et al. Spinal radiographic progression in patients with ankylosing spondylitis treated with TNF-α blocking therapy: a prospective longitudinal observational cohort study. *PLoS One* 2015;10:e0122693.

Grenesse E, Bernardi S, Bonazza S, et al. Body weight, gender and response to TNF-α blockers in axial spondyloarthritis. *Rheumatology* 2014;53:875–81.

Ottaviani S, Allanore Y, Tubach F, et al. Body mass index affects the response to infliximab in ankylosing spondylitis. *Arthritis Res Ther* 2012;14:R115.

Di Minno MND, Peluso R, Iervolino S, et al. Weight loss and achievement of minimal disease activity in patients with psoriatic arthritis starting treatment with tumour necrosis factor α blockers. *Ann Rheum Dis* 2014;73:1157–62.

Kooby B, Birkenhöfer E, Bilberg S, et al. Weight loss improves disease activity in patients with psoriatic arthritis and obesity: an interventional study. *Arthritis Res Ther* 2019;21.

Polacheck A, Li S, Chandran V, et al. Clinical Enthesitis in a prospective longitudinal psoriatic arthritis cohort: incidence, prevalence, severity characteristics, and outcome. *Arthritis Care Res* 2017;69:1685–91.

Hoigard P, Glintborg B, Kristensen LE, et al. The influence of obesity on response to tumour necrosis factor-α inhibitors in psoriatic arthritis: results from the DANBIO and ICEBIO registries. *Rheumatology* 2017;56:2191–9.

Eder L, Thavaneswaran A, Chandran V, et al. Obesity is associated with a lower probability of achieving sustained minimal disease activity state among patients with psoriatic arthritis. *Ann Rheum Dis* 2015;74:817–20.

Mease PJ, Collier DH, Saunders KC, et al. Comparative effectiveness of biologic monotherapy versus combination therapy for patients with psoriatic arthritis: results from the Corona registry. *RMD Open* 2015;1:e000181.

Di Minno MND, Peluso R, Iervolino S, et al. Obesity and the prediction of minimal disease activity: a prospective study in psoriatic arthritis. *Arthritis Care Res* 2013;65:141–7.

Iannone F, Fanizzzi R, Scioscia C, et al. Body mass does not affect the remission of psoriatic arthritis patients on anti-TNF-α therapy. *Scand J Rheumatol* 2014;43:241–5.

Haddad A, Thavaneswaran A, Tolzoa S, et al. Diffuse idiopathic skeletal hyperostosis in psoriatic arthritis. *J Rheumatol* 2013;40:1367–73.

Marini C, Formichi B, Bauleo C, et al. Survival protection by bodyweight in isolated femoral head pulmonary artery hypertension. *Intern Emerg Med* 2016;11:941–52.

Assassi S, Del Junco D, Sutter K, et al. Clinical and genetic factors predictive of mortality in early systemic sclerosis. *Arthritis Rheum* 2009;61:1403–11.

Nielsen SM, Bartels EM, Henriksen M, et al. Weight loss for overweight and obese individuals with gout: a systematic review of longitudinal studies. *Ann Rheum Dis* 2017;76:1870–82.

Dessein PH, Shipton EA, Stanwix AE, et al. Beneficial effects of weight loss associated with moderate calorie/carbohydrate restriction, and increased proportional intake of protein and unsaturated fat on serum urate and lipoprotein levels in a pilot study. *Ann Rheum Dis* 2000;59:539–43.

Nguyen U-SDT, Zhang Y, Louie-Gao Q, et al. Obesity paradox in recurrent attacks of gout in observational studies: clarification and remedy. *Arthritis Care Res* 2017;69:561–6.

Romero-Talamás H, Daigle CR, Aminian A, et al. The effect of bariatric surgery on gout: a comparative study. *Surg Obes Relat Dis* 2014;10:1161–5.

Su BY-L, Lai H-M, Chen C-J, et al. Ischemia heart disease and greater waist circumference are risk factors of renal function deterioration in male gout patients. *Clin Rheumatol* 2008;27:581–6.
Abhishek A, Valdes AM, Zhang W, et al. Association of serum uric acid and disease duration with frequent gout attacks: a case-control study. *Arthritis Care Res* 2016;68:1573–7.

Alvarez-Nemegyi J, Cen-Pisté JC, Medina-Escobedo M, et al. Factors associated with musculoskeletal disability and chronic renal failure in clinically diagnosed primary gout. *J Rheumatol* 2005;32:1923–7.

Gwinnutt JM, Verstappen SM, Humphreys JH. The impact of lifestyle behaviours, physical activity and smoking on morbidity and mortality in patients with rheumatoid arthritis. *Best Pract Res Clin Rheumatol* 2020;34:101562.

Gwinnutt JM, Alsafar H, Hyrich KL, et al. Do people with rheumatoid arthritis maintain their physical activity level at treatment onset over the first year of methotrexate therapy? *Rheumatology* 2021;60:4633–42.

Klein-Wieringa IR, van der Linden MPM, Knevel R, et al. Baseline serum adipokine levels predict radiographic progression in early rheumatoid arthritis. *Arthritis Rheum* 2011;63:2567–74.

Shin A, Shin S, Kim JH, et al. Association between socioeconomic status and comorbidities among patients with rheumatoid arthritis: results of a nationwide cross-sectional survey. *Rheumatology* 2019;58:1617–22.

Björk M, Dragioti E, Alexandersson H, et al. Inflammatory arthritis and the effect of physical activity on quality of life and self-reported function: a systematic review and meta-analysis. *Arthritis Care Res* 2022;74:31–43.

Ortolan A, Lorenzin M, Felicetti M, et al. Do obesity and overweight influence disease activity measures in axial spondyloarthritis? A systematic review and meta-analysis. *Arthritis Care Res* 2021;73:1815–25.