Effectiveness of web-based and mobile health interventions designed to enhance adherence to physical activity for people with inflammatory arthritis: a systematic review

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Abstract

**Objective:** The aim of this systematic review was to assess the evidence from randomised controlled trials (RCT) and cohort studies for the effectiveness of digital interventions designed to enhance adherence to physical activity (PA) for people with inflammatory arthritis (IA) and describe the intervention content using established coding criteria.

**Methods:** Six electronic databases were searched for published and unpublished studies. Independent data extraction and quality assessment (Cochrane risk of bias II or ROBIN I) were conducted by two reviewers. The primary outcome was self-reported adherence to PA post-intervention. Secondary outcomes included self-reported adherence to PA at other timepoints, level of PA or engagement with intervention at any follow-up timepoint. Intervention content was assessed using the Consensus on Exercise Reporting Template and the Behaviour Change Techniques taxonomy version 1.

**Results:** From 11,136 reports, four moderate risk of bias studies (three RCTs, one cohort study) including 1,160 participants with rheumatoid arthritis or juvenile inflammatory arthritis were identified. Due to heterogeneity of outcomes, a narrative synthesis was conducted. Only one RCT reported a small between group difference in adherence to PA [mean difference (95% confidence intervals) -0.46 (-0.82. -0.09)] in favour of the intervention. There were no between group differences in any secondary outcomes. Interventions included between 3-11 behaviour change techniques but provided minimal exercise prescription information.

**Conclusion:** There is currently limited moderate quality evidence available to confidently evaluate the effect of web-based and mobile health interventions on adherence to PA or level of PA post intervention in people with IA.
Keywords: Systematic review, inflammatory arthritis, digital health interventions, adherence, physical activity, exercise

Key messages

- Digital interventions to support adherence to physical activity in people with inflammatory arthritis seem promising.
- There is insufficient evidence to confidently evaluate the effect of digital interventions on physical activity.
- Future studies need to report intervention content in line with standardised reporting guidelines.

Introduction

Physical activity (PA) is a key management strategy for people with inflammatory arthritis (rheumatoid arthritis, psoriatic arthritis, axial spondyloarthritis, juvenile inflammatory arthritis) (IA). Guidance suggests that people with IA should complete at least 150 minutes of moderate intensity PA or equivalent per week and strengthening and flexibility exercises twice a week. The importance of PA was reinforced by World Health Organisation during the current Covid-19 pandemic, but adherence to PA in people with IA tends to be low. There are complex and distinctive barriers which hampers PA participation and makes the adoption and adherence to new health behaviours challenging, without appropriate support. However, restricted resources and increasing demand means access to face-to-face healthcare interventions to support PA uptake and maintenance is limited and this is exacerbated by social distancing requirements due to the COVID-19 pandemic. To address this need, there
has been a rapid reconfiguration of services and adoption and scale up of remote patient care including novel ways to increase and support adherence to PA.\textsuperscript{12-14}

Interventions that employ digital technologies (e.g. mobile apps, websites and wearable devices) that can be delivered across a range of telecommunication devices (e.g. smartphones, tablets) offer a potential solution to supporting people with IA adhere to PA recommendations.\textsuperscript{15,16}

However, changing PA behaviour can be complex and theory and evidence-based principles are recommended, when designing and implementing interventions.\textsuperscript{17-20} Previous reviews of the evidence for the effectiveness of digital interventions to support PA in people with IA highlight the limited number and low methodological quality of studies and poor integration or reporting of evidence-based intervention content.\textsuperscript{22-24} One narrative synthesis of four RCTs (492 participants with IA) identified no evidence of effect of interactive digital interventions on objectively measured PA and reported limited evidence of effect on self-reported PA.\textsuperscript{23} However, only evidence from RCTs were included, potentially missing evidence of effect from other study designs. Another systematic review including six studies (567 participants with Rheumatoid Arthritis (RA)) found limited evidence for the effectiveness for web-based rehabilitation interventions on self-management, health information and/or PA.\textsuperscript{22} This review only focused on people with RA which limits the generalisability of the findings to the IA population, and did not report the theoretical underpinning or assess intervention content for the inclusion of BCTs. Neither of the previous reviews assessed the content of the exercise prescriptions against established guidelines.
Consequently, whilst digital interventions appear promising, the effectiveness of interventions to support PA in people with IA is unclear. Thus, an up to date review is required, that also includes the evaluation of PA prescription and behavioural change techniques using standardized approaches such as the Consensus on Exercise Reporting Template (CERT)\textsuperscript{21} and behaviour change techniques taxonomy (BCTTv1).\textsuperscript{20} This will help healthcare professionals to identify the specific characteristics, or active ingredients associated with effectiveness in interventions.\textsuperscript{25,26}

**Aims and objectives**

In this study, we aimed to (1) systematically identify and quality appraise the evidence from studies evaluating the effectiveness of digital interventions (web-based and mobile applications (apps)) on PA for people with IA conditions; (2) identify and describe the content of PA interventions using standardised reporting formats and (3) identify whether behavioural theory has been applied to underpin intervention development.

**Materials and Methods**

This review was conducted in accordance with the Cochrane Handbook for Systematic Reviews of Interventions, the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) statement (see Supplementary Data S1, available at *Rheumatology Advances in Practice* online), and Synthesis Without Meta-Analysis (SWiM) reporting guidelines.\textsuperscript{27,28} The protocol was prospectively registered on the international prospective register of systematic reviews, PROSPERO: CRD35019129341.
Eligibility criteria

Types of studies: We included RCTs, quasi-experimental trials, prospective cohort studies, retrospective cohort analyses, before-after trials, which reported baseline and follow-up measurements of adherence to PA or PA levels in at least two groups.

Types of participants: Participants with IA diagnosed according to established criteria were included, i.e., adults ≥ 18 years old with rheumatoid arthritis, psoriatic arthritis, axial spondylarthritides or children with juvenile inflammatory arthritis. Data from studies evaluating several rheumatic populations were included if data from different clinical populations were reported separately.

Types of interventions: All types of clinician guided, or self-directed digital interventions were included. We defined digital interventions as interventions delivered via the internet (static or interactive websites, or web-based apps), personal computers, social media, or smartphones (mobile websites or smartphone apps).

Types of comparison: The study comparison groups comprised either: interventions not including digital technologies, usual/standard care, information only or waiting list comparisons.

Types of outcomes: The primary outcome of interest was self-reported measure of adherence to PA at the end of the intervention. Outcomes could be reported as exercise diaries, questionnaires and self-reported data uploaded to an app (i.e. user recording exercise completion data). Secondary outcomes included: Self-reported measures of adherence to PA at any other follow up timepoint, levels of PA by any validated measure e.g. monitoring.
device (i.e. step-count, accelerometer) or engagement (i.e. actual usage of intervention, reported via number of times participant logged in, minutes active on webpage) at the end of intervention or any other follow-up timepoint, if available.

**Search strategy**

Search terms included MeSH, keyword and wild-card terms located in the title or abstract that reflected disease type, intervention (e.g. web-based, mobile app) and outcome (e.g. self-reported activity) (full search strategy in Supplementary Table S1, available at Rheumatology Advances in Practice online). Studies were retrieved by: (1) searching electronic databases [MEDLINE, CINAHL, PsychINFO, EMBASE, PEDro, Cochrane Central Register of Controlled Trials (CENTRAL), Opengrey]; (2) cross-referencing from retrieved studies, previous relevant systematic reviews and meta-analyses; and (3) soliciting studies from experts in the field and authors who have published studies of web-based and mobile applications interventions. Databases were searched from January 2005- June 2019. The final search was completed on 28th June 2019.

**Study selection**

The search results were exported to an online platform designed to facilitate systematic and transparent management of reviews- Covidence (http://www.covidence.org). Following de-duplication all retrieved titles and abstracts were examined by two independent reviewers against eligibility criteria. Conflicts were resolved by consensus. A third reviewer acted as arbiter if necessary. Reviewers were not masked to the name(s) of the study author(s), institution(s) or publication source. Authors were contacted when full-text manuscripts were not available or when additional information was needed.
Data extraction

Coding and data extraction from the full text of eligible studies were conducted by two trained reviewers independently (bespoke data extraction tool available on request). Conflicts were resolved by discussion and a third reviewer acted as an arbitrator if necessary.

Information was extracted regarding:

1) study characteristics (i.e. author, year of publication, study design, sample size);
2) characteristics of populations (i.e., number of patients included in each study, type of IA condition);
3) intervention details (i.e. type of intervention- web-based, mobile type, duration of intervention;
4) outcomes of interest (i.e. self-reported measure of adherence, levels of adherence and engagement (e.g. number of log ins/ access to webpages) at each assessment time point.
5) The content of the intervention. This included:

(i) theoretical underpinning of interventions (i.e. authors explicitly stated/ reported use of theory in manuscript, (yes/no)),
(ii) coding to identify the presence of BCTs. The BCT Taxonomy V1 presents 93 discrete BCTs that are “observable, replicable and irreducible component of an intervention designed to alter or redirect causal processes that regulate behavior.” (yes/no)
(iii) Completeness of reporting of the exercise prescriptions (Consensus of Exercise Reporting Template (CERT). The CERT consists of 16 items across seven domains applied to evaluate the reporting of exercise interventions. (yes/no/not applicable)
**Risk of bias**

Full texts were assessed for risk of bias by two independent reviewers. The risk of bias tool 2, developed by the Cochrane collaboration was used to assess RCTs. This tool comprises five domains: randomisation process, deviations from intended interventions, missing data, measurement of the outcome and selection of the reported results and is classified as having either the presence or potential presence of a source of bias (Yes), no risk of bias (No) or some concerns.

The Risk Of Bias in Non-randomized Studies - of Interventions (ROBINS-I) tool was applied to non-randomised controlled trials. This tool includes seven domains: bias due to cofounding, bias in selection of participants into the study, bias in classification of interventions, bias due to deviations from intended interventions, bias due to missing data, bias in measurement of outcomes and bias in selection of the reported results. Risk of bias was evaluated as being ‘low risk’, ‘moderate risk’, ‘serious risk’ or ‘critical risk’. Any disagreements were resolved through discussions with a third reviewer.

**Data Analysis**

We grouped studies according to type of study design (RCT, cohort), mode of intervention delivery (via intervention website, internet webpage) and population. Standardised Mean Differences (SMD) for within and between group differences on the primary outcome (self-reported adherence to PA) for all RCTs were calculated using Cochrane Review Manager (RevMan version 5.41). For SMDs, effect sizes were interpreted as 0.20 = small effect, 0.50 = moderate effect, and 0.80 = large effect. Studies with multiple interventions were grouped together and combined as recommended in the Cochrane handbook for systematic
reviews of interventions. In studies that reported *median* and *interquartile range*, we calculated the *mean* and *standard deviation* as recommended in Cochrane Handbook for Systematic Reviews of Interventions reporting the conversion in line with published recommendations. We assessed clinical heterogeneity by inspecting the type of participants, interventions and outcomes of each study. Due to the clinical and methodological heterogeneity, results could not be reliably combined to complete a meta-analysis. Therefore, a narrative synthesis without meta-analysis (SWIM) of all studies (RCTs and cohort studies) was conducted. Intervention engagement data (e.g., usage data) was reported as mean and standard deviation for the number of times participants logged into the intervention.

**Results**

*Articles identified*

Figure 1 presents a flow diagram of study selection. We identified 11,136 studies. After deduplication (n= 3,615) 7,521 titles and abstracts were screened for eligibility and 33 manuscripts progressed to full review. Four publications reporting three trials and one cohort study were included. No unpublished studies were included.

*General characteristics of included studies and population*

The characteristics of included studies are presented in Table 1. Included studies were published between 2008-2016. The RCTs were completed in Switzerland, the Netherlands, and USA and the cohort study was conducted in the Canada.

The review included a total of 1,160 participants (1,061 participants in three RCTs, and 99 participants in one cohort study). One RCT included adults with rheumatoid arthritis, one
trial included people with rheumatoid arthritis, osteoarthritis and fibromyalgia, but the results were reported separately for each condition at baseline 6 month and 12 month follow up\(^4^3\) and one trial included children with JIA.\(^4^2\) No studies included people with psoriatic arthritis or ankylosing spondylitis. The cohort study included adults with rheumatoid arthritis and osteoarthritis, and the results were presented separately for each condition at baseline and three months follow up.\(^4^4\) Sample size ranged from 49\(^\text{42}\) to 855 participants\(^4^3\) and the mean age of participants ranged from 10.6 years\(^4^2\) to 56.4 years.\(^4^4\)

Self-reported adherence to PA was measured in the three RCTs. Two RCTs\(^4^1,4^3\) employed the Exercise Behaviours Scale\(^4^2\) and another trial used an activity diary post intervention.\(^4^2\) One trial measured self-reported PA immediately after intervention delivery\(^4^1\) and a further trial assessed self-reported PA after intervention delivery, and at 12 month follow up.\(^4^2\) One trial did not assess self-reported adherence to PA post intervention but assessed it at 6 months and delivery and 12 months post-intervention.\(^4^3\)

One trial assessed moderate to vigorous physical activity (MVPA) post intervention and at 12 month follow up using an accelerometer during a seven-day period.\(^4^2\) One cohort study assessed the percentage of RA participants intention to apply exercises two weeks post intervention, and assessed the percentage of participants that applied the exercises at three-month follow up.\(^4^4\)

**Characteristics of intervention and comparators**

All studies investigated interventions delivered via the internet and no studies evaluated interventions delivered via mobile applications (Table 1). Intervention duration ranged from 2 weeks\(^4^4\) to 14 weeks.\(^4^2\) Interventions included in one RCT\(^4^3\) and one cohort study\(^4^4\) were
delivered remotely. One RCT evaluated an intervention which included access to an online support forum as part of the intervention\textsuperscript{41} and another RCT investigated a digital intervention for JIA participants that was supplemented with four group sessions.\textsuperscript{42} Comparisons groups consisted of usual care with no access to the web-based interventions in two trials \textsuperscript{41,43} and in another trial the control group received standard care and were not restricted in any activities.\textsuperscript{42}

**Risk of bias**

Figure 2 summarises the sources of risk of bias for included RCT studies. There were three moderate risk of bias RCTs. \textsuperscript{41-43} Table 2 provides details for the one moderate risk bias cohort study.\textsuperscript{44} Specifically, the measurement bias, classification bias, and intended intervention bias was unclear due to the lack of reporting of relevant details. All RCTs reported appropriate methods for randomisation. Since it is not possible to blind participants to the nature of the intervention, risk of bias from this source was universally high and this domain was excluded from the rating of overall study quality. An appropriate analysis for estimating the effect of assignment (intention-to-treat analysis, ITT) was performed in two trials.\textsuperscript{41,43} High dropout rate (72-78\%) was present in one RCT, contributing to the missing data bias, and this study also did not report the blinding of the assessor.\textsuperscript{43} The pre-planned analysis was not published and described in detail before the start of all three trials. Thus, the main sources of bias include deviations from intended intervention for two trials;\textsuperscript{41,42} missing outcome data and measurement of outcome for one trial;\textsuperscript{43} and selection of reported bias for all three trials.\textsuperscript{41-43}

**Effect of adherence to physical activity**
Table 3 displays the between and within group differences for our primary outcome (adherence to PA post intervention) and secondary outcome (PA level) for included studies. There was a small between group difference in adherence to PA at the end of the intervention in one moderate risk of bias trial (-0.46 (95% C.I. -0.82, -0.09) where four interventions were combined and compared to a single comparator group, favouring the intervention. However, there were no differences in individual intervention group compared to the comparison group in this trial. There was a substantial baseline difference between the control group and intervention groups.

Similarly, there were no between group differences in self-reported adherence to PA in two other moderate risk of bias trials post intervention, at 6 month follow up or at 12 month follow up.

For all three moderate risk of bias trials, no within group differences were identified. The moderate risk of bias cohort study found that 74% of RA participants had the intention to use a specific self-management technique relating to strengthening exercises for the hand, two weeks after accessing the online Facebook page. At three months post intervention, 78% of participants followed through on completing the hand strengthening exercises.

**Effect on physical activity levels**

Only one trial measured PA level. Post intervention there were no within or between group differences in objectively measured PA levels post intervention in one moderate risk of bias trial. Only participants randomised to the intervention group were followed up at 12 months and no within group difference in objectively measured PA levels was identified.
Engagement

Two trials reported data on intervention engagement (usage data).\textsuperscript{42,43} In one moderate risk of bias trial, 24/355 participants randomised to the ASMP intervention group did not engage with the web-based intervention (11 participants dropped out from the study before being assigned to a group session and 13 participants did not log in after being assigned).\textsuperscript{43} A total of 409 participants logged in 31.6 (24.5) (mean (SD) times (range 1–220) over 6 weeks, and 25/355 participants generated between 400-600 posts on the bulletin board.\textsuperscript{43}

In another trial, all participants randomised to the intervention group logged in to the intervention 53.7 (93.1) mean (SD) times.\textsuperscript{42} Participants within the gaming, and social support plus gaming groups accessed the website mean (SD) 66.8 (112.4) times, whereas participants in the information, and information plus social support groups accessed the website less frequently (mean (SD) 26.2 (27.1) times).\textsuperscript{42}

Theoretical underpinning of intervention and behaviour change techniques

Three studies explicitly reported a theory or model to underpin the design of the interventions.\textsuperscript{42-44} One trial\textsuperscript{42} was based on Pender’s Health Protection Model\textsuperscript{46} and another trial\textsuperscript{43} was underpinned by self-efficacy theory.\textsuperscript{47} The included cohort study\textsuperscript{44} was underpinned by the knowledge to action cycle.\textsuperscript{48,49}

BCTs were identified in all interventions and, ranged from 3 BCTs\textsuperscript{44} to 11 BCTs.\textsuperscript{42} (Table 1). There was no single BCT applied across all four studies. The most commonly included BCT in three interventions included problem solving \textsuperscript{41-43} and prompts and ques.\textsuperscript{42-43} Most studies
shared a minimum of two BCTs, these included information about health consequences,\textsuperscript{41,42} credible source\textsuperscript{41,44} as well as goal setting and action planning.\textsuperscript{42,43} Only one trial\textsuperscript{43} applied one BCT (material reward) to the control group.

**Consensus on Exercise Reporting Template (CERT)**

None of the RCTs\textsuperscript{41-43} provided sufficient details to be coded against the CERT.\textsuperscript{21} Only the included cohort study\textsuperscript{44} provided details on the non-exercise components (item 10) and information regarding the setting in which the exercises are to be performed (item 12) resulting in a total CERT score of 2/16. (Supplementary Table S2 and Supplementary Data S2, available at *Rheumatology Advances in Practice* online).

**Discussion**

This systematic review shows that there is currently limited moderate quality evidence available to confidently evaluate the effect of web-based and mobile health interventions on adherence to PA post intervention in people with RA and JIA. Only one of three trials found a small improvement in adherence to PA post intervention. Similarly, there is insufficient evidence of the effects of digital interventions on PA level at any time point, as few studies evaluated this outcome. No studies evaluated the effect of PA mobile applications designed for people with IA, and, surprisingly, no studies evaluated the impact of web-based interventions in people with PsA or AS.

Our findings broadly concur with the findings from previous reviews of web-based interventions in people with IA\textsuperscript{23} and in people with RA.\textsuperscript{22} One narrative synthesis identified no trials that reported any significant between group differences in objectively measured PA and only one low risk of bias trial found a significant between group difference in self-
reported vigorous but not moderate PA in people with IA\textsuperscript{23}. Another systematic review including six studies also found limited evidence for the effectiveness for web-based rehabilitation interventions on self-management, health information and/or PA in people with RA\textsuperscript{22}.

Our review updates and extends these findings by including a broad range of IA populations, study designs and intervention content evaluation. Despite the fast-paced development of digital interventions, broad review eligibility criteria and updated, comprehensive searches our review only included four studies and confirmed that there is a paucity of high-quality evidence evaluating web-based and mobile health interventions on PA adherence or activity level in people with IA. However, the COVID-19 pandemic has accelerated the adoption and evaluation of digital interventions so more evidence may become available\textsuperscript{50}.

Surprisingly, our review did not include any studies that investigated mobile applications to support adherence to PA. Mobile apps that aim to support adherence to PA are available for people with IA conditions\textsuperscript{51-55} although app content and quality is heterogeneous and integrated measures to assess PA are often not evidence based\textsuperscript{24}. A recent review identified one high quality mobile app that was designed for people with RA although its effectiveness has not been established\textsuperscript{24}.

To our knowledge, our review is one of the first reviews to also synthesise findings on user engagement with digital interventions. Whilst no within or between group differences were detected in our included studies, in one RCT, intervention groups with access to social support had a greater number of logins to the web-based intervention\textsuperscript{41}. This suggests interventions that includes a component of social support, may enhance participation and
interaction with the intervention itself.  

For example, in a self-management PA mobile internet service co-designed by people with RA, the inclusion of an interactive forum also enhanced participant engagement with the intervention. 

Whilst three studies investigated interventions that were underpinned by theory, the trial that showed a small effect on adherence to physical activity was not underpinned by theory. 

The application of theory is strongly advocated to underpin an intervention, because theory provides guidance on what should be the targeted focus of an intervention (i.e. behavioural determinant) and guidance on how to target the specified behavioural determinants (e.g. what constructs would be most effective, or application of BCTs). However, our findings suggests that identifying the most appropriate theory that effectively targets determinants that influence adherence to PA is challenging and no included studies described how theory was applied during the development of the digital intervention investigated.

All interventions in the studies included in our review incorporated between 3 BCTs and 11 BCTs. The most commonly reported BCTs was problem solving included in all three RCTs. In this review, the intervention with the small effect included a total of seven BCTs. Whilst there is limited evidence with regards to the optimum number of BCTs and dosage to support adherence to PA a recent review suggested interventions with less than seven BCTs are most effective at enhancing adherence to prescribed exercise in individuals with musculoskeletal conditions.

We evaluated the explicit reporting of PA intervention content using a standardised tool, (CERT) for the first time. Only one cohort study provided some limited details of the intervention PA content. This was disappointing and was predominantly because the
intervention descriptions did not provide specific details of intervention delivery, exercise
dosage or adaptations.

It is crucial that future digital interventions include evidence–based PA prescriptions that are
aligned to public health guidance and the European League for Rheumatology (EULAR)\textsuperscript{2} for
people with inflammatory arthritis recommendations (i.e. at least 150 minute of moderate
PA/week and twice weekly strengthening and flexibility exercises)\textsuperscript{3} Exercises formats and
dosages should be accurately described and the options for tailoring, progression and
regression of exercises highlighted so that they can be safely replicated.\textsuperscript{3,62} Interventions
should also optimise an individual’s capacity, motivation, and opportunity to adhere to PA.
Evidence informed BCTs such as goal setting, instruction and demonstration of appropriate
PA, strategies to facilitate regular practice and social support should be incorporated.

This review has a number of methodological considerations. Our review included a
comprehensive search strategy and broad eligibility criteria were applied, thus extending and
updating previous reviews.\textsuperscript{22,23} A rigorous assessment of risk of bias of studies\textsuperscript{28, 34} was
completed and intervention content was described via a recognised taxonomy\textsuperscript{20} and exercise
reporting template.\textsuperscript{21}

However, the findings of this review are compromised by the paucity and quality of the
included studies e.g. measures of PA adherence were often self-reported. The only study that
reported an intervention effect had a substantial between group difference at baseline and this
may have masked the true impact of the intervention.\textsuperscript{41} Our review included a wide range of
IA populations to try to estimate the effect of digital interventions on PA. However, this
resulted in a substantial age heterogeneity in the population of participants in our included
studies. This may have influenced our interpretation of the effect of digital interventions on PA because children and young people might find hand-held mobile devices easier to use and be more inclined to engage with digital interventions than other generations. Children and adults may also have different life commitments that could impact on adherence to PA. However, because there is only limited research on the effect of digital interventions on PA in people with IA, we were unable to explore this aspect within our review. Whilst we reported some data on intervention engagement, this review did not consider whether participants were involved in the development of the web-based interventions or extracted data on the participant experience and acceptability of the interventions.

**Conclusion**

Our review findings indicate that there is limited evidence evaluating the effect of digital interventions on adherence to PA in people with IA. The available evidence suggests that there is likely to be no effect of digital interventions on adherence to PA post intervention or other follow up timepoints. Consequently, clinicians do not have an evidence base to help them select digital interventions to support PA. Future trials need to ensure that the content of web-based and mobile health interventions are reported in line with standardised reporting guidelines, report the specific exercise prescriptions, and apply validated measures for PA adherence (e.g. Exercise Adherence Reporting Scale (EARS) and objective measures for PA level (e.g. accelerometers).
Conflict of interest

The authors have declared no conflicts of interest.

Funding statement

No specific funding was received from any funding bodies in the public, commercial or not-for-profit sectors to carry out the work described in this manuscript.

Data availability

All data are incorporated into the article and its online supplementary material.
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Figure 1. Flow diagram illustrating study selection.

Figure 2. Risk of bias for included randomised controlled trials.
| Author, year, country | Study design | Population | Sample size | Mean age years (S.D), % male | Intervention group (n) and description intervention | Comparator group (n) and description of intervention | Intervention duration | Length of follow up | Measure adherence to PA | Measure of Levels of PA | Theory, BCTs (n) |
|-----------------------|-------------|------------|-------------|-----------------------------|-------------------------------------------------|-------------------------------------------------|----------------------|----------------------|----------------------|----------------------|----------------------|
| Allam et al., 2015, Switzerland | RCT | Rheumatoid Arthritis | 157 | 53.46 (9.96) 54% | Information (n=30); Information and social support (n=29); Gaming (n=28); Social support and gaming (n=28) | Information on RA management delivered via the web page; Social support provided via online forum | Control group (n=40) | No access to website | 8 weeks | 2 months (post-intervention) | Self-report completion of exercise (mins/week) | N/A | No theory reported |
|                        |             |            |             |                             | Intervention group (n=115) | Comparator group (n=115) | Intervention duration | Length of follow up | Measure adherence to PA | Measure of Levels of PA | Theory, BCTs (n) |
| Armbrust et al, 2017, Netherlands | RCT | Juvenile idiopathic Arthritis | 49 | 10.2 (9-10.8) 43% | Intervention group (n=28) | Web-based cognitive behavioural program to improve physical activity. Combination of internet based and individual instruction, | Standard care (n=21) | Standard care, not restricted in any activities | 14 weeks | 14 weeks (post-intervention) | Self-report 7-day activity diary, moderate to vigorous physical activity duration (mins/week) | Accelerometer readings over 7 days moderate to vigorous physical activity duration (mins/week) | Pender's Health Protection Model (ref: ) Goal setting (behaviour), information about health consequences, problem solving, social support (practical) (n=7) |
| Study                          | Design | Condition | Sample Size | Intervention Detailed Description                                                                                                                                                                                                 | Comparison | Duration | Outcomes | Other Details |
|-------------------------------|--------|-----------|-------------|------------------------------------------------------------------------------------------------------------|------------|----------|----------|---------------|
| Lorig et al., 2008† USA       | RCT    | Intervention group (n=425) | 855 | The Internet Arthritis Self-Management Programme (ASMP): interactive, Web-based instruction; Web-based bulletin board discussion; individually tailored tools, such as exercise logs, medication diaries, and an exercise program | Usual care (n=441) | 6 weeks | 6 months | Self-report aerobic exercise (mins/week) |
| Brosseau et al., 2014† Canada | Cohort | Intervention group (n=99) | N/A | Online educational programme. Focusing on self-management in RA delivered via Facebook | N/A | 2 weeks | 2 weeks (post intervention) | Self-reported intention to use s. to complete hand strengthening exercises, (%) |

BCT: behaviour change technique

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### Table 2: ROBIN -I risk of bias for included cohort studies

| Author, year          | Bias due to cofounding | Bias in selection of participants into the study | Bias in classification of interventions | Bias due to deviations from intended outcomes | Bias due to missing data | Bias in measurement of outcomes | Bias in selection of related result |
|-----------------------|------------------------|-----------------------------------------------|----------------------------------------|-----------------------------------------------|--------------------------|---------------------------------|------------------------------------|
| Brosseau et al., 2014* | Moderate risk          | Low risk                                      | Unclear risk                           | Unclear risk                                  | Low risk                  | Unclear risk                     | Low risk                           |

*Downloaded from https://academic.oup.com/rheumap/advance-article/doi/10.1093/rap/rkab016/6157732 by guest on 23 March 2021
Table 3: Baseline, Post-intervention, between and within group differences for primary and secondary outcome

| Author, year | Intervention description | Measures | Assessment time point | Baseline | Follow up | Between group difference | Within-group difference |
|--------------|--------------------------|----------|-----------------------|----------|----------|--------------------------|------------------------|
|              |                          |          |                       | Intervention group | Control group | Intervention group | Control group | SMD (95% CI) | SMD (95% CI) |
|              |                          |          |                       | N         | N         | N           | N             |             |             |
|              |                          |          | 2 months              |           |           |             |             | -0.45       | -0.12       |
| Allam et al., 2015⁴¹ | Information | Adherence to PA: Self-report completion of exercise (minutes per week) | 30 | 30.67 (23.13) | 40 | 50.5 (22.03) | 29 | 33.36 (26.55) | 40 | 44.12 (29.69) | -0.45 (-0.93; 0.04) | -0.12 (-0.63, 0.39) |
| Allam et al., 2015⁴¹ | Information and Social support | Adherence to PA: Self-report completion of exercise (minutes per week) | 29 | 32.41 (31.92) | 40 | 50.5 (22.03) | 29 | 28.10 (29.68) | 40 | 44.12 (29.69) | -0.64 (-1.13; -0.15) | 0.14 (-0.38, 0.65) |
| Allam et al., 2015⁴¹ | Gaming | Adherence to PA: Self-report completion of exercise (minutes per week) | 28 | 33.57 (32.59) | 40 | 50.5 (22.03) | 28 | 33.30 (32.43) | 40 | 44.12 (29.69) | -0.41 (-0.90; 0.08) | 0.01 (-0.52, 0.53) |
| Allam et al., 2015⁴¹ | Social support and gaming | Adherence to PA: Self-report completion of exercise (minutes per week) | 28 | 26.96 (27.10) | 40 | 50.5 (22.03) | 28 | 28.21 (27.39) | 40 | 44.12 (29.69) | -0.66 (-1.16; -0.17) | -0.05 (-0.57, 0.48) |
| Allam et al., 2015⁴¹ | Intervention groups combined | Adherence to PA: Self-report completion of exercise (minutes per week) | 115 | 30.91 (28.60) | 40 | 50.5 (22.03) | 114 | 30.8 (31.4) | 40 | 44.12 (29.69) | -0.46 (-0.82, -0.09) | 0.00 (-0.26, 0.26) |
| Lorig et al., 2008⁴³ | The Internet Arthritis Self-Management Programme (ASMP) | Adherence to PA: Self-report aerobic exercise (minutes per week) | 441 | 99.1 (104) | 425 | 88.5 (100) | 310 | 103 (102.7) | 331 | 90.5 (93.9) | -0.13 (-0.29, 0.02) | -0.04 (-0.19, 0.10) |
|              |                          |          | 12 months             |           |           |             |             |             |             |             |             |
|              |                          |          | 6 months              |           |           |             |             | -0.13       | -0.04       |
|              |                          |          | 12 months             |           |           |             |             |             |             |             |             |
|              |                          |          | 6 months              |           |           |             |             | -0.13       | -0.04       |
|              |                          |          | 12 months             |           |           |             |             |             |             |             |             |

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| Study                                           | Intervention                                                                 | Adherence to PA                                                                 | Physical Activity level                                                                 |
|------------------------------------------------|-------------------------------------------------------------------------------|--------------------------------------------------------------------------------|----------------------------------------------------------------------------------------|
| Armbrust et al, 2017[42]                       | Web-based cognitive behavioural program                                       | 14 weeks<br>28 58.73 (38.04) 21 70.9 (25.60) 28 82.8 (51.24) 21 77.6 (65.35) | 14 weeks<br>28 44.04 (18.44) 21 41.24 (20.43) 28 41.52 (18.44) 21 51.71 (21.94)         |
|                                                |                                                                              | 12 months<br>22 58.89 (40.34) N/A 22 93.85 (73.31) N/A N/A N/A N/A                  | 12 months<br>21 43.92 (19.64) N/A 21 43.67 (18.76) N/A N/A N/A N/A                  |
| Brosseau et al., 2014[44]                      | Self-management in RA delivered via Facebook                                 | Adherence to PA<br>Self-reported intention to complete hand strengthening exercises, (%) and actual follow through on using techniques (%) | 2 weeks (intention)<br>% self-reported intention to complete strengthening exercises for the hand<br>74% |
|                                                |                                                                              |                                                                                          | 3 months (follow through)<br>% followed through on intention to use strengthening exercises for the hand<br>78% |

SD = Standard Deviation; % = Percentage; SMD = Standard Mean Difference; CI = Confidence Intervals; N/A = not applicable
Figure 1. Flow diagram illustrating study selection.
Figure 2. Risk of bias for included randomised controlled trials.