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Efficacy of home-based physical activity interventions in patients with autoimmune rheumatic diseases: a systematic review and meta-analysis

Sofia Mendes Sieczkowska[1,2], Fabiana Infante Smaira[1,2], Bruna Caruso Mazzolani[1,2], Bruno Gualano[1, 2], Hamilton Roschel[1,2] , Tiago Peçanha [1,2]

Affiliations:

[1]Applied Physiology & Nutrition Research Group, School of Physical Education and Sport, Rheumatology Division, Faculdade de Medicina FMUSP, Universidade de Sao Paulo, SP, Brazil. Laboratory of Assessment and Conditioning in Rhematology, Faculdade de Medicina FMUSP, Disciplina de Reumatologia, Universidade de Sao Paulo, Sao Paulo, SP, Brazil Av. Dr. Arnaldo, 455, ZIP code: 01246-903, Sao Paulo-SP, Brazil;

[2] Rheumatology Division, Hospital das Clinicas HCFMUSP, Faculdade de Medicina, Universidade de São Paulo, São Paulo, Brazil;

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Corresponding author and address for reprints:

Dr Tiago Peçanha. Tiago Peçanha. Applied Physiology and Nutrition Research Group, School of Physical Education and Sport, Rheumatology Division, Faculty of Medicine FMUSP, University of São Paulo, Av. Dr. Arnaldo, 455-Cerqueira César, São Paulo, Brazil. Zipcode: 01246-903. Phone/Fax: + 55 11 30618789. E-mail address: tiagopecanha@usp.br

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Abstract

Introduction: Physical activity (PA) has been receiving increasing interest in recent years as an adjuvant therapy for autoimmune rheumatic disease (ARDs), but there is scarce information about the efficacy of home-based PA for patients with ARDs. Objective: To perform a systematic review and meta-analysis on the efficacy of home-based physical activity (PA) interventions in improving health-related quality of life, functional capacity, pain, and disease activity in patients with ARDs. Methods: Searches were performed in PubMed, Web of Science, Scopus, Cochrane, CINAHL database and Sport Discus. Trials were considered eligible if they included a home-based physical activity intervention. The population included adults with autoimmune rheumatic diseases (e.g., rheumatoid arthritis, systemic lupus erythematosus, idiopathic inflammatory myopathies, systemic sclerosis and ankylosing spondylitis), comparisons included non-physical activity control or centre-based interventions (i.e., interventions performed on a specialized exercise centre) and the outcomes were quality of life, pain, functional capacity, disease activity and inflammation. Results: Home-based physical activity improved quality of life ($p<0.01$; $g = 0.69$; IC95%, 0.61 to 1.07) and functional capacity ($p=0.04$; $g = -0.51$; IC95%, -0.86; -0.16), and reduced disease activity ($p=0.03$; $g = -0.60$; IC95%, -1.16; -0.04) and pain ($p=0.01$; $g = -1.62$; IC95%, -2.94 to -0.31) compared to the non-physical activity control condition. Additionally, home-based physical activity interventions were as effective as centre-based interventions for all investigated outcomes. Conclusions: Home-based PA is an efficacious strategy to improve disease control and aleviate symptoms in ARD.

Keywords: exercise, rheumatology, pain, fitness

Trial Registration Number: PROSPERO CRD42020183378

Abbreviation list:

ARDs, autoimmune rheumatic diseases; AS, ankylosing spondylitis; BAT, before vs. after trial ; IIM, idiopathic inflammatory myopathies; non-RCT, non-randomised controlled trials PA, physical activity; QOL, quality of life; RA, rheumatoid arthritis; RCT, randomised controlled trials RT, randomized trial; SLE, systemic lupus erythematosus; SMD, standardized mean differences; SpA, spondyloarthritis; SSc, systemic sclerosis.

1. Introduction

Autoimmune rheumatic diseases (ARDs) are a group of systemic autoimmune disorders that mainly affect joint, bones and soft tissues and are associated with substantial morbidity and mortality [1]. These diseases are characterized by systemic inflammation and share common clinical features, including chronic pain, reduced physical fitness, and, as a consequence, poor health-related quality of life [2–5]. The most common ARDs include rheumatoid arthritis (RA), systemic lupus erythematosus (SLE), idiopathic inflammatory myopathies (IIM), systemic sclerosis (SSc), and ankylosing spondylitis (AS).

Physical activity (PA) has been receiving increasing interest in recent years as an adjuvant therapy for ARDs [6,7]. However, current estimates indicate that ~60% of the patients with ARDs do not achieve the recommended amount of weekly PA (i.e., 150 min/week of moderate-to-vigorous PA)[8]. Physical inactivity in ARDs may be related to generic and disease-related barriers to PA, such as lack of time and motivation, high costs and limited access to specialized facilities, pain, fatigue, fear of aggravating the disease, among others [9–12]. Also, the COVID-19 pandemic has imposed additional challenges to the adoption of PA in patients with ARDs [13,14] due to the requirements of self-isolation and home quarantine for this infection-prone population [15–17]. In conjunction, this information underscores the importance of investigating the efficacy of alternative approaches to upregulate PA in ARDs that may circumvent some of the perceived and contextual barriers to PA in this population.

Recently, home-based PA has emerged as a potential clinically- and cost-effective strategy to increase PA levels and improve disease control and general health across multiple clinical conditions, such as cardiometabolic diseases [18–20], women under cancer treatment [21], patients with pulmonary diseases [22], as well as in older adults [23]. Recent literature has also advocated for the use of home-based PA as a strategy to maintain PA levels during COVID-19 pandemic, with a special focus in at-risk populations [13,24].

There is scarce information about the efficacy of home-based PA for patients with ARDs, with equivocal data about its effects on functional status, health-related quality of life and pain in this population [25–27]. Additionally, there is no summarized information about the existing home-based PA intervention protocols for ARDs. As these may differ in respect of its delivery strategy (e.g., supervised vs. unsupervised), PA protocol, and supporting tools (e.g., educational material, eHealth technology, exercise equipment), there is a need to better describe the current home-based interventions availabe to patients with ARDs and investigate their feasibility. Finally, as

safety concerns may hamper the adoption of home-based PA in ARDs [9–12], it is essential to review data on the safety of home-based PA interventions.

Thus, the purpose of this study was to perform a systematic review and meta-analysis on the efficacy of home-based PA interventions in improving health-related quality of life, functional capacity, pain, and disease activity in ARDs. Comparisons were performed against a non-physical activity control condition and against centre-based interventions (i.e., interventions performed on an exercise centre). As a secondary goal, this review also intended to describe the characteristics of existing home-based PA programmes for ARDs and review data on adherence and safety.

2. **Methods**

2.1 Registration

The present study followed the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses; see the Appendix A for a filled-in PRISMA checklist) guidelines [28] and was registered in the International Prospective Register of Systematic Reviews database (PROSPERO, CRD42020183378).

2.2 Search strategy and study selection

Searches were performed in six electronic databases (PubMed, Web of Science, Scopus, Cochrane, CINAHL database and Sport Discus via EBSCOhost) by two members of the study team (FIS and SMS), in May of 2020. There were no restrictions on date of publication or language. The descriptors used for the searches were defined using the Medical Subject Headings (whenever possible) and were related to the population ("autoimmune rheumatic diseases" OR "rheumatoid arthritis" OR "systemic lupus erythematosus" OR "Sjogren syndrome" OR gout OR "ankylosing spondylitis" OR myositis OR "systemic sclerosis" OR "idiopathic inflammatory myopathies") and intervention ("home based program" OR "home based exercises" OR "telerehabilitation" OR "home based rehabilitation" OR "home based training" OR "tele exercise" OR " unsupervised exercise programs" OR "home based physical activity" OR "active games" OR "wii intervention" OR "wii fit" OR "exergames" OR "online exercises" OR "fitness apps" OR "physical activity apps"). To identify other relevant study data, we also screened

reference lists from the selected studies and review articles. The PubMed search strategy is provided in the Appendix B (Table B.1).

Eligibility criteria was developed using the PICO framework [28,29]. To be included, the studies needed to: (1) be conducted on adults (≥ 18 years) with a clinical diagnosis of one of the following conditions: SLE, RA, spondyloarthritis (SpA), Sjögren's syndrome, SSc, AS, IIM or systemic vasculitis; (2) include an arm with a home based PA intervention, which was considered any PA intervention occurring predominantly at home (i.e., > 90% of the sessions being undertaken at home); and (3) include assessments of at least 1 of the following: quality of life, functional capacity, pain, inflammation (e.g., C-reactive protein), disease activity and adherence. For the study design, we included randomised controlled trials (RCTs), non-RCTs, randomised uncontrolled trials (RT), or uncontrolled trials (i.e., before vs. after trial [BAT]). For comparison, we considered both non-PA control groups and interventions involving centre-based exercise (i.e., performed on a specialized exercise centre). Studies were excluded if they were protocol studies, observational studies, acute exercise studies or studies involving pediatric rheumatic diseases.

On completion of the searches, two members of the study team (FIS and SMS) independently selected the manuscripts using a 2-stage strategy, namely: (1) Title and abstract screen and (2) Full text review. Any discrepancies were resolved through discussion, or third-party mediation, if required.

2.3 Data extraction

Data were extracted and verified by three authors (BCM, FIS and SMS) using a standardized spreadsheet and following the PICO framework [30]. Study authors were contacted to request additional or missing data, if required, and authors were given one month to respond (if necessary, an additional e-mail was sent two weeks after the first one to reinforce the request). The following characteristics were extracted from each selected study: (1) author (data); (2) participant information (e.g., number, mean age, age range, gender, disease condition); (3) characteristics of the intervention (e.g., description of the intervention, comparison, delivery of the intervention, exercise type, volume and intensity); (4) outcome data; (5) study design.

2.4 Assessment of risk of bias

Study quality was appraised using the Cochrane Revised Cochrane risk-of-bias tool for randomized trials [31], by two authors (SMS and FIS). This tool has 5 domain (randomization process, deviations from the intended interventions, missing outcomes, measurement of the outcome and selection of reported results) and an overall bias analysis. All studies were analyzed with this tool, even non-randomized and BAT studies, assuming that they would already be at high risk due to their design. Studies were assigned either as "high risk", "low risk" or with "some concerns". Risk of bias judgements were summarized across all studies for each of the domains listed. We chose to label all studies as low risk in blinding of participants and providers domain, as blinding is difficult, if not impossible, in PA trials.

2.5 Data analysis: Systematic Review

A narrative synthesis was performed to describe and explore the data from the studies. Studies were described in the text and tables and were organized by key details, such as study design, summary of the population (sample size, age range, gender, disease condition), intervention, and the following outcomes: (1) quality of life (through generic or disease-specific questionnaires), (2) functional capacity, (3) pain, (4) disease activity, and (5) c-reactive protein.

Home-based exercise interventions were described in terms of exercise type, frequency, duration and intensity. Intensity was defined based on subjective (e.g., authors' description of the intervention) or objective (e.g., achieved heart rate or effort perception rated by the participants) information provided by the authors in the papers, and was classified as high-, moderate- or low-intensity. In the absence of sufficient information about exercise intensity, we used The 2011 Compendium of Physical Activities [32] to define activity-specific metabolic equivalents (METS) and classify the exercises as low intensity (1.6–2.9 MET), moderate intensity (3–5.9 MET), and high intensity (>6 MET) [33].

Aspects related to the delivery of the intervention, such as supervision, monitoring and use of support components were also summarized. Interventions were defined as supervised if there was a professional accompanying (either presential or online) the execution of the exercises in real time. Monitoring was defined as any attempt to monitor the execution (adherence) of the exercise sessions (e.g., emails sent to the participants; periodical telephone calls to check compliance; exercise logs; heart rate logs). The support components were any strategy employed to support and guide the home-based intervention, such as initial or periodical sessions with professionals to guide the intervention and teach the exercises, educational materials (e.g., PA booklets; DVD), eHealth tools (e.g., website, emails) and exercise equipment.

In addition, we also reported data on the participants' adherence to the interventions (i.e., the degree of compliance to the exercise sessions or PA interventions), and on the safety of the interventions (i.e., the occurrence of any health-related complications as a result of the intervention, such as disease relapses, acute flare-ups, cardiovascular complications; increase in disease activity or in pain; *etc*).

2.6 Data analysis: Meta-Analysis

Data analysis was performed using random-effects models. After data extraction, weighting, and missing data imputation (according to Cochrane Handbook for Systematic Reviews of Interventions) [34], the meta-analysis was performed on each of the following outcomes: (1) quality of life, (2) functional capacity, (3) pain, (4) disease activity, (5) inflammation. Quality of life was analyzed using two separate metrics: (1) by performing a weighted average of all of the Short Form Health Survey 36 (SF-36) domains (i.e., QOL_generic) and; (2) by aggregating disease-specific questionnaires of quality of life (e.g ASQOL - Ankylosing Spondylitis Quality of Life questionnaire, RAQoL - Rheumatoid Arthritis Quality of Life Questionnaire, BAS-G - Bath Ankylosing Spondylitis Global Index). Functional capacity was extracted from the studies that presented the total value of the questionnaires Bath Ankylosing Spondylitis Functional Index (BASFI) and Health Assessment Questionnaire Disability Index (HAQ). Pain was extracted from studies that presented the values of visual analogue scale, and disease activity was extracted from disease activity specific scores (e.g., BASDAI - Bath Ankylosing Spondylitis Disease Activity Index, DAS28 - Disease Activity Score 28). Inflammation was assessed by serum C-reactive protein.

Meta-analyses were performed considering the following comparisons: (1) home-based interventions vs. control (i.e., usual care or no intervention) and; (2) home-based interventions vs. centre based. The uncontrolled trials (i.e., BAT) were not included in the meta-analyses, but were qualitatively described along the manuscript. Meta-analyses were only performed if there were at least 3 studies including the outcome within each comparison. For this reason, for QOL_generic and QOL_disease-specic, meta-analyses were performed only for the comparison between home-based PA and control. No meta analysis was conducted for C-reactive protein as only two studies provided this outcome.

The analyses were conducted according to Schwarzer [35]. The effects of home-based interventions on each outcome were calculated as the standardized mean differences (SMD). The

SMDs were calculated as the difference between the intervention and control group (absolute pre-to-post changes), divided by the pooled standard deviation for the changes. For the outcome QOL_generic, we used only the post-intervention data due to the absence of absolute change scores in some studies [26,36–38]. Studies were combined using random-effects meta-analysis, which was conducted using Hedge's g [39]. To estimate the between-study variance, we used Restricted maximum-likelihood estimator [40]. The convention proposed by Cohen [41] was used for the interpretation of the effect magnitude: trivial <0.2, small ≥ 0.20, medium ≥ 0.50 and large ≥ 0.80. Meta-analyses were performed in RStudio version 4.02, using the 'metacont' function of the meta package.

3. Results

3.1 Literature search

The search of the databases identified 151 studies, and we also included three studies from other sources, [42–44] totaling 154 studies. Following removal of duplicates (n=73), 81 publications were screened for inclusion. Of these, 42 were excluded after reviewing the title and abstract. The remaining 39 papers were selected for full reading and 18 were excluded because they did not include a home-based PA intervention (n=8) or any outcome of interest (n=4), or were not intervention studies (n=6). Therefore, 21 studies were included in the review and are listed in the qualitative analysis. Among these, 16 studies were suitable for meta-analysis; however, we were unable to obtain relevant data from 2 studies [45,46] (i.e., data were presented graphically only or without mean difference and standard deviation, and authors did not respond to the emails soliciting the required data). Therefore, 14 studies were included in the meta-analysis (Figure 1).

***Figure 1. ***

3.2 Study characteristics

Among the 21 included studies, 6 were RCT, 5 were RT, 5 were non-RCT and 5 were BAT. In total, these studies enrolled 1797 patients (725 men and 1072 women), with the vast majority of studies being conducted with young to middle-aged adults (i.e., 25 and 59 years), and one study being conducted with elderly participants (age > 60 years). Thirteen out of the 21 studies

investigated participants with AS, 5 studies included participants with RA, 2 included participants with SLE and 1 included participants with SSc (Table 1).

Table 1

3.3 Risk of bias

Overall, 66.7% of the studies were classified as high risk of bias (Figure 2; Appendix C, Figure C.1). Most of the methodological issues arose from the 'randomisation process' (10 studies were non-RCT or BAT, and 5 of the randomised studies did not have a clear description of the randomisation process) and 'measurement of the outcome' (in 11 studies no information about blinding was provided or no blinding of the outcome assessors was conducted). In the domain 'selection of the reported result', 19 studies did not report a pre-specified analysis. In the domain 'deviations from intended intervention', 5 studies used 'per-protocol' analyses and presented >5% drop out rates. In the domain 'missing outcome data', few studies were judged as 'high risk', as they did not present reasons for the missing data.

***Figure 2 ***

3.4 Intervention characteristics

Interventions lasted an average of ~ 17 weeks (range 4 to 96 weeks). The majority of the studies (15 out of 21) employed a mixed home-based exercise routine, usually combining flexibility and strengthening exercises (n=11), occasionally added to aerobic (n=4), respiratory (n=10) and posture (n=6) exercises. One study employed only resistance exercises, [46] 1 study used calisthenic and relaxation exercises [47], and 1 study used a specific protocol of hand exercises [27].Two studies used exergames as a PA intervention [48,49], with mixed aerobic and strength exercise routines. Interventions were performed, on average, ~ 5 (range 2 to 7) times per week, with an average duration of ~ 40 minutes (range 20 to 60 minutes) per session. Exercises were either of low (12 out of 21 studies) or moderate intensity (6 studies). Most studies (16 out of 21) did not report the number of exercises included in the protocol, with few studies reporting an

average of 13 exercises (range 5 to 20). Finally, one study did not provide details about the intervention [50].

Most PA interventions (19 out of 21) were not supervised. Two studies performed in-home supervision at the beginning of the intervention (i.e., first 2 weeks), with no supervision afterwards. Seventeen studies reported some strategy to monitor the intervention, with phone calls and exercise logs being the most used ones. Overall, studies used several support components. Fifteen studies employed face-to-face sessions with a health professional (usually a physiotherapist) for the demonstration of the exercises and provision of general health instructions. Other frequent support tools included the use of PA booklets, educational materials, and exercise equipment (e.g., elastic bands, dumbbells, cuff weights, and static bikes). Details of home-based interventions are summarized in Table 2.

Table 2

3.5 Quality of life and functional capacity

Quality of life was assessed in 12 studies, using generic (e.g , SF-36, NHP - Nottingham Health Profile)[26,27,36–38] or disease-specific questionnaires [25,47,50–53]. Six (out of 6) studies reported improvements in the QOL_generic and 4 (out of 6) reported improvements in the QOL_specific after home-based PA (Appendix D, Table D.1). The overall analysis revealed a medium significant improvement in quality of life measured by SF-36 in favor of the home-based intervention when compared with the control condition (Figure 3a [p =0.0004, g = 0.69; IC95%, 0.61 to 1.07]). However, no differences between home-based PA and control were found for disease-specific questionnaires of quality of life (Figure 3b [p =0.09; g = -0.26; IC95%, -0.57 to 0.05]).

Functional capacity was assessed in 16 studies using BASFI or HAQ, among which 10 reported improvements in this outcome after home-based PA [26,36,38,42–46,51] (Appendix D, Table D.1). A medium significant improvement in functional capacity was observed after home-based intervention when compared with the control condition (Figure 4 [p = 0.04; g = - 0.51; IC95%, -0.86; -0.16]). In addition, no differences in functional capacity were found between home- and centre-based PA (Figure 4 [p = 0.38 ; g = 0.12; IC95%, -0.15 to 0.40])

***Figure 3 ***

Figure 4

3.6 Disease activity

Disease activity was assessed in 14 studies [25,26,52–54,36–38,43,46,47,50,51] using disease-specific questionnaires (i.e BASDAI and DAS28), among which 11 studies observed a reduction in this outcome after home-based PA [26,36–38,43,46,51–54] (Appendix D, Table D.1). In the meta-analysis, a medium significant reduction in disease activity was observed after home-based intervention when compared with the control condition (Figure 5 [p = 0.03; g = - 0.60; IC95%, -1.16; -0.04]), with no differences between home- and centre-based PA (Figure 5 [p =0.36; g = 0.13; IC95%, -0.34 to 0.59])

Figure 5

3.7 Pain and C-reactive protein

Pain was assessed using standardized pain scales in ten studies (11 trials), [26,27,37,45,46,49–51,53,55] among which 8 (9 trials) reported a reduction in pain after home-based PA [26,27,45,46,49,51,53] (Appendix D, Table D.1). The overall analysis revealed a large significant reduction in pain in the home-based PA compared with the control (Figure 6 [p =0.01; g = -1.62; IC95%, -2.94 to -0.31]). In addition, there were no differences in pain between home- and centre-based PA (Figure 6 [p = 0.19; g = 0.53; IC95%, -0.26 to 1.32]).

Only two studies assessed CRP [44,47], both comparing home based intervention to centre-based interventions, with no difference between groups in any of the studies (Appendix D, Table D.1).

Figure 6

3.8 Adherence and safety

Most studies did not report data on adherence to the PA interventions. Adherence details were reported only in six studies (four with percentage of attendance of all sessions and two with mean attendance per week), with most of them presenting low to moderate rates. Berg et al.[52] reported only 34% of adherence of an individualized home-based PA programme in patients with RA. Slightly higher adherence rates were reported by Rodriguez-Lozano et al. (54.6%) [53] and Yuen et al. (63.9%) [49]. A more recent study with exergames reported 79% of attendance to the sessions in patients with SLE [48]. Two studies reported only mean attendance per week, one with an average of 2.8 times per week (~ 40%) [56] and the other with an average attendance of 1.4 times per week (~70%) [46].

Four studies reported no adverse [27,44,48,49] or serious adverse effects [56] related to the home-based PA interventions. Importantly, the remaining studies did not report data on related adverse effects.

4. Discussion

This systematic review and meta-analysis evaluated the efficacy of home-based PA interventions in patients with ARDs. Data revealed that home-based interventions are efficacious in improving quality of life and functional capacity, and reducing disease activity and pain in this population, when compared to the non-physical activity control condition. However, no benefits were found for inflammation. When comparing with centre-based interventions (the active comparison), no difference was found between groups for any outcome, suggesting that home-based interventions are as efficacious as centre-based interventions for patients with ARDs.

This is the first systematic review and meta-analysis to assess the efficacy of home-based PA in a collective of ARDs patients, with two previous studies being restricted to AS patients only [57,58]. The beneficial effect of home-based PA on disease activity strengthens the central role of PA in the management of ARDs [59]. With the introduction of synthetic and biologic disease-modifying drugs, the treat-to-remission strategy has become the new paradigm for the treatment of ARDs [60,61]. However, not all patients achieve complete remission with the stand-alone pharmacological treatment [62]. In this scenario, PA emerges as a potentially impactful strategy to complement the effects of pharmacological therapy upon disease control in ARDs.

Benefits on pain, functional capacity and quality of life underpin the broad effects of PA beyond disease control. Pain has been recognized as one of the most disabling symptoms in patients with

AS [63], RA [64] and SLE [65], and is one of the strongest predictors of poor quality of life in these diseases. Functional incapacity has also been shown to be associated with reduced quality of life, as it is directly linked with activities of daily living (e.g., get in/out of bed, take a bath and shopping) [66]. Therefore, it is not surprising that home-based PA was also efficacious in improving generic measures of quality of life in ARDs, reinforcing the effects of PA across multiple life domains in this population.

The results of the present review are in consonance with previous reviews assessing the effects of predominantly centre-based PA interventions for individuals with ARDs [67–70]. Baillet et al. [70] reported beneficial effects of aerobic exercise in quality of life, functional capacity and pain in RA patients. A later study from the same group extended these findings by showing that strength exercises were efficacious in improving functional capacity and reducing inflammation in this same population [71]. Similar results were found by Pécourneau et al.[67] that reported reduction in disease activity and improvements in functional capacity promoted by a wide range of PA programmes in AS patients. A recent review including 1286 patients with inflammatory rheumatic diseases substantiated previous findings by showing beneficial effects of PA on disease activity, pain and joint damage [68]. It is worth mentioning that most of these reviews included exercise programmes conducted in exercise centres with specialized equipment, including gym machines, exercise ergometers and swimming pools, and supervision by health professionals. While the results of these studies hold merit for showing the therapeutic effects of exercise training in ARDs, some of these settings may be difficult to implement at the community level and in low- to middle-income countries where resources are scarce. In the present study, home-based PA, which may be an easier strategy to be implemented from a public health perspective, was as efficacious as centre-based PA in promoting benefits in quality of life, funcional capacity, pain and disease activity. This indicates that home-based exercises should be more often considered in the clinical practice to promote PA among patients with ARDs. That being said, adoption to home-based PA requires individuals to have both a home situation and the cognitive, emotional and health capabilities to adhere to a home-based programme. For some individuals, a centre-based or a hybrid programme (i.e., initial group introduction in an exercise center, followed by a home-based PA programme) could be the best options.

In the present review, the majority of home-based PA interventions employed combined exercise protocols, with a focus on stretching, strengthening and respiratory exercises. Weekly volume of PA was ~ 200 min/week and exercises were of low-to-moderate intensity. Recent PA guidelines for clinical populations [73] and for ARDs [59] recommend 150-300 min/week of moderate-to-

vigorous aerobic PA complemented by 2-3 days a week of strengthening, flexibility and balance exercises. Therefore, the reviewed home-based PA protocols only partially comply with existing public health recommendations of PA. The increased focus on stretching and strengthening activities may be explained by specific aspects of the investigated populations (*i.e.*, populations with severe joint impairment and loss of strength and functionality) and of the interventions (*i.e.*, a mix of rehabilitation and preventive PA). The use of lower exercise intensities may be a precautionary measure to account for the lack of supervision and monitoring during the home-based sessions. Despite recent studies reporting on the safety of high intensity exercises in ARDs [74–76], further studies are warranted to determine its feasibility, safety and efficacy when part of a home-based intervention.

Home-based interventions reviewed herein were mostly unsupervised, but monitoring was performed by means of periodical phone calls and PA logs. Interventions were supported by the use of PA booklets, educational materials and exercise equipment. Interestingly, even with these support components, adherence to home-based PA was moderate at its best (34-70%), raising questions on the feasibility of these interventions in their current state. The low adherence to the reviewed home-based PA programmes may be explained by the lack of a behavioural component to support the interventions, lack of supervision, superficial monitoring and excessive number of exercises [77–80]. Indeed, recent studies have advocated for the use of theory-informed behavioral interventions integrated with behavioral change techniques to support the delivery of PA interventions, with evidence that theory-informed behavioral interventions are better accepted for individuals exercising remotely [80]. In addition, home visits to supervise the first exercise sessions may enhance perception of safety and efficacy of home-based PA [36,46,55]. On top of that, the use of up-to-date technologies, such as video-calling applications, PA tracking and other wearable devices, may increase the prospects of delivering and monitoring home-based PA, therefore improving the experience of home-based PA [81]. Finally, an excessive number of exercises may challenge the adoption of home-based PA, with evidence showing increased adherence when a reduced number of exercises is proposed [77]. In the present review, the vast majority of the home-based interventions were neither backed by behavioural techniques nor supported by up-to-date technologies. Additionally, although underreported, the average number of exercises was 13, which may be excessive for ARDs. Interestingly, the study that showed the highest adherence employed exergames [48], which may be seen as simple technological intervention naturally embebbed with behavioural change techniques (e.g. gamification, feedback on performance and goal setting) [82,83]. Next studies should actively incorporate

these behavioural elements and technologies as they may increase the motivation to engage in home-based exercise programs and consequently improve the adherence to the intervention [48,49].

4.1 Risk of bias

The generalisability of the present findings are limited by the quality of the included studies. In this regard, almost half of the reviewed evidence come from non-randomised studies or studies that did not present a control group or active comparison. Statistical analyses were also poorly described or followed unorthodox practices, with some studies employing separate group analysis (e.g., separate paired t-tests in the intervention and control groups) instead of more robust analyses controlling for the effects of different conditions and times. Additionally, absence of prior protocol study or clinical trial registration for the majority of the studies questions the transparency of the reported data and limits the reviewers' ability to determine if data was produced according to a pre-specified plan. Finally, the outcome assessors were not blinded to the intervention assignment in most of the reviewed studies, which may have caused the outcomes to be affected by expectations about the intervention. Notably, most of the present review outcomes were participant-reported outcomes (e.g., pain scales and questionnaires), and in these cases the participant is considered the outcome assessor, which impose an additional challenge to prevent the influence of awareness about the intervention in the measured outcomes. Overall, the high-risk of bias presented by two third of the studies included in this review points to the urgent need of well-designed RCTs, with pre-specified plan and proper statistical analysis, including ITT, and blinding of most of the personnel involved in the study.

4.2 Limitations

This review is not without limitations. Firstly, this review involved only 4 ARDs (AS, RA, SLE and SSc) and most of the reviewed studies presented relatively small sample sizes and reduced follow-up periods of PA. Therefore, caution should be taken when generalizing study findings to other ARDs and to long-term PA settings. Secondly, due to the reduced number of studies, it was not possible to perform sensitivity or meta-regression analyses to test the robustness of the observed outcomes and the potential effects of moderators (e.g., PA intensity, type, duration) on the review outcomes. Thirdly, some outcomes such as adherence and adverse effects were

reported only by a few studies, which hampers more definite conclusions on feasibility and safety of home-based PA interventions. Finally, the description of home-based PA interventions was poor in most of the reviewed studies, challenging the summarization of the existing home-based PA protocols for ARDs.

4.3 Summary

Individuals with ARDs are usually physically inactive, which has been attributed to multiple barriers to PA, such as lack of time and motivation, cost of exercise, and difficulties in accessing equipment or facilities [9,10]. The COVID-19 pandemic has also imposed an additional challenge to the adoption of physical activity in patients with ARDs given the requirements of self-isolation [13]. The results of the present review indicate that home-based PA may provide an effective platform to enable PA and improve the disease management in ARDs. The findings of the present review support the use of combined exercise protocols, including aerobic, strengthening and stretching exercises in patients with ARDs. Health professionals may use different strategies to monitor and support ARDs patients under a home-based PA programme, including regular phone calls, PA logs and booklets, educational materials, and exercise equipment. The results provided by the present review must be confirmed by larger and more rigorous RCTs. Additionally, next studies should try to incorporate sound behavioural techniques and up-to-date technologies in order to improve the delivery and monitoring of home-based PA, aimed at increasing adherence to this type of intervention.

5. Conclusion

The results of the present review provide novel evidence on the beneficial impact of home-based PA in ARDs. Given that physical inactivity is highly prevalent among patients with ARDs and this seems to be aggravated by the COVID-19 pandemic [14], home-based PA may provide a sensible platform to promote PA and to help improving disease control and symptoms in patients with ARDs. However, there is still need for studies with robust designs, rigorous methodological approaches and with detailed description of home-based PA interventions.

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manuscript and agree to be accountable for all aspects of the work. All persons designated as authors qualify for authorship, and all those who qualify for authorship are listed.

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476 **Figure legends**

477 Figure 1. Flow-chart of the systematic review

478 Figure 2. Risk of bias of the included studies. Overall percentage of 'low risk', 'some concerns'
479 and 'high risk' of bias in each of the bias domain.

480 Figure 3. Effects of physical activity on quality of life. Panel 3a presents the effects on generic
481 questionnaires of quality of life (QOL_generic), panel 3b presents the effects on disease-specific
482 questionnaires of quality of life (QOL_disease-specific). CI, confidence interval; SMD,
483 standardised mean difference; SD, standard deviation.

484 Figure 4. Effects of physical activity on functional capacity. CI, confidence interval; HB, home
485 based intervention; CB, centre based; CG, control group; SMD, standardised mean difference;
486 SD, standard deviation.

487 Figure 5. Effects of physical activity on disease activity. CI, confidence interval; HB, home based
488 intervention; CB, centre based; CG, control group; SMD, standardised mean difference; SD,
489 standard deviation.

490 Figure 6. Effects of physical activity on pain. CI, confidence interval; HB, home based
491 intervention; CB, centre based; CG, control group; SMD, standardised mean difference; SD,
492 standard deviation.

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Figure 1

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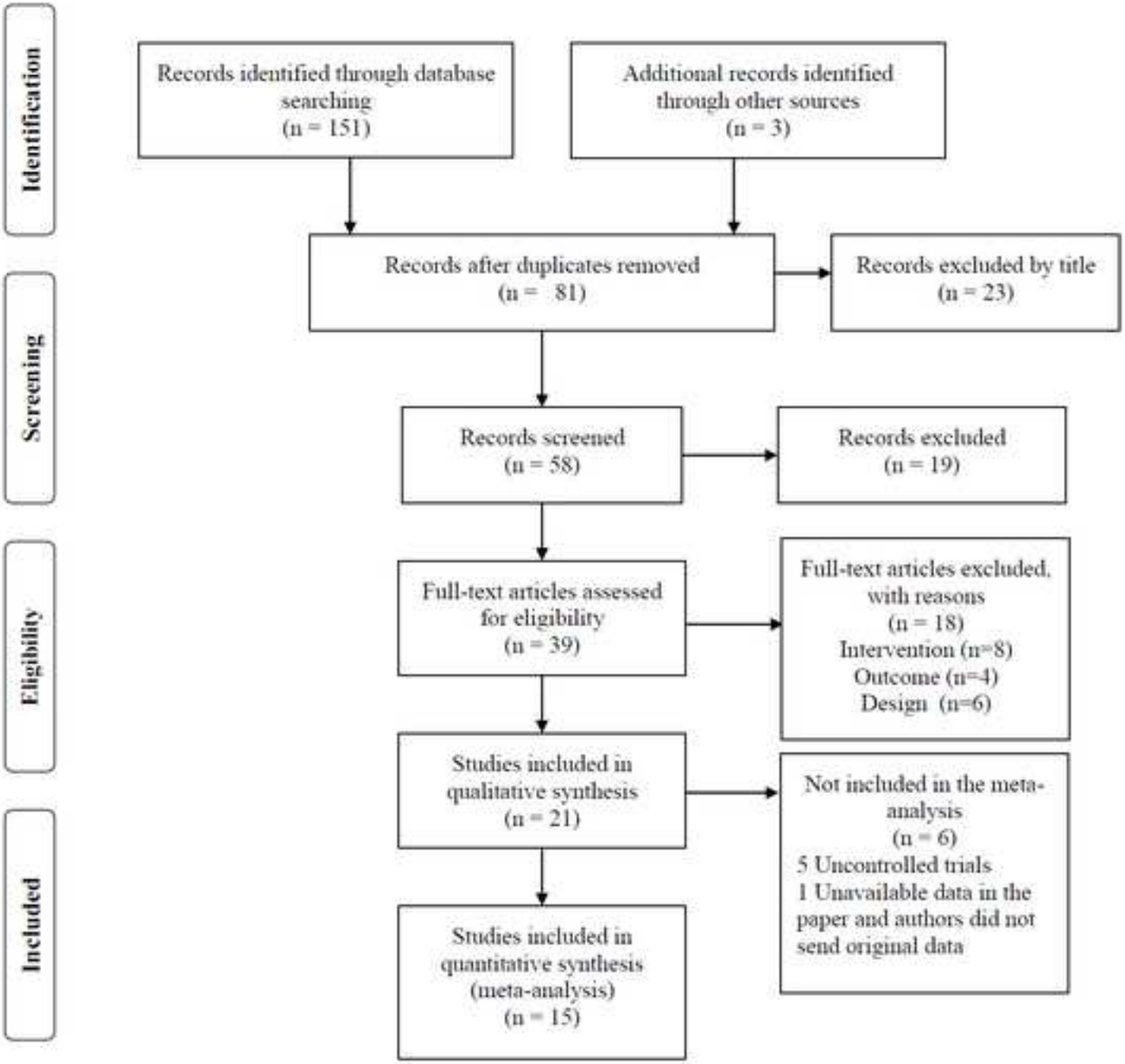

Figure 2

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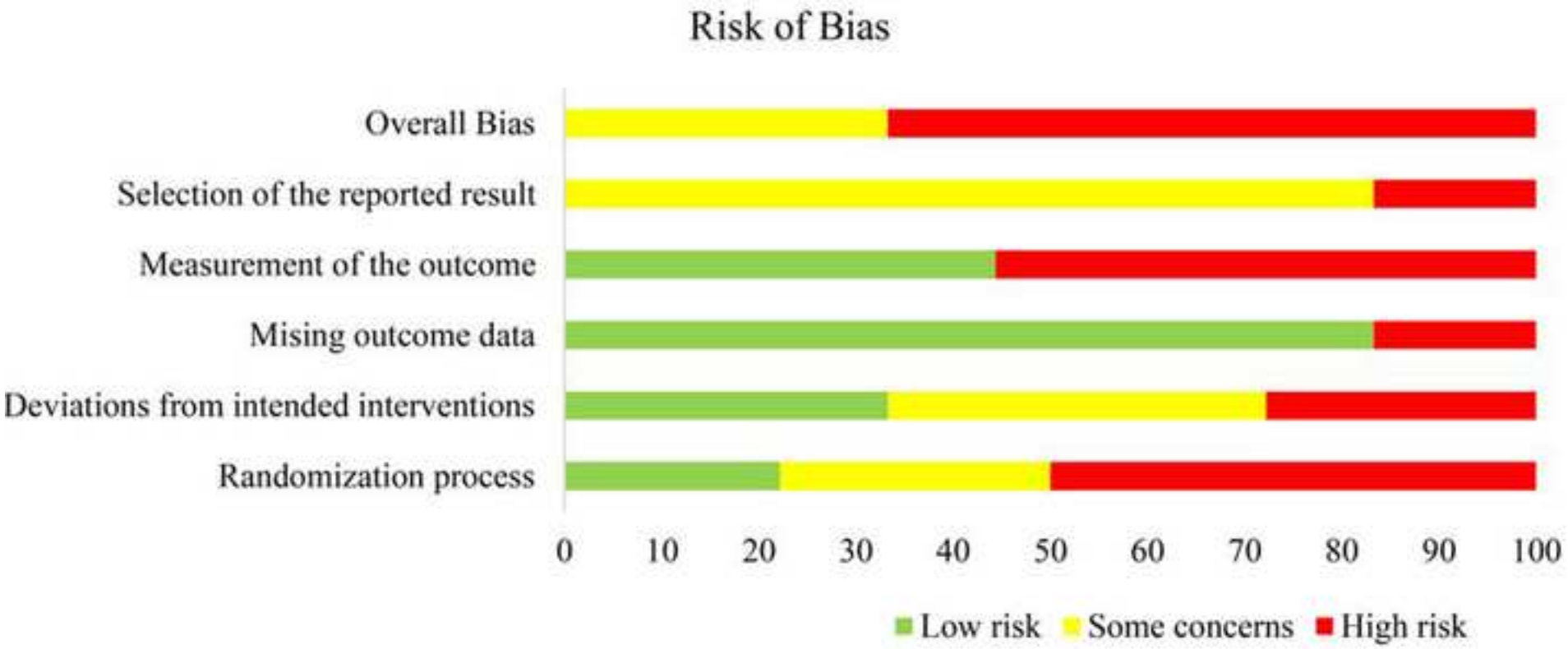

Figure 3

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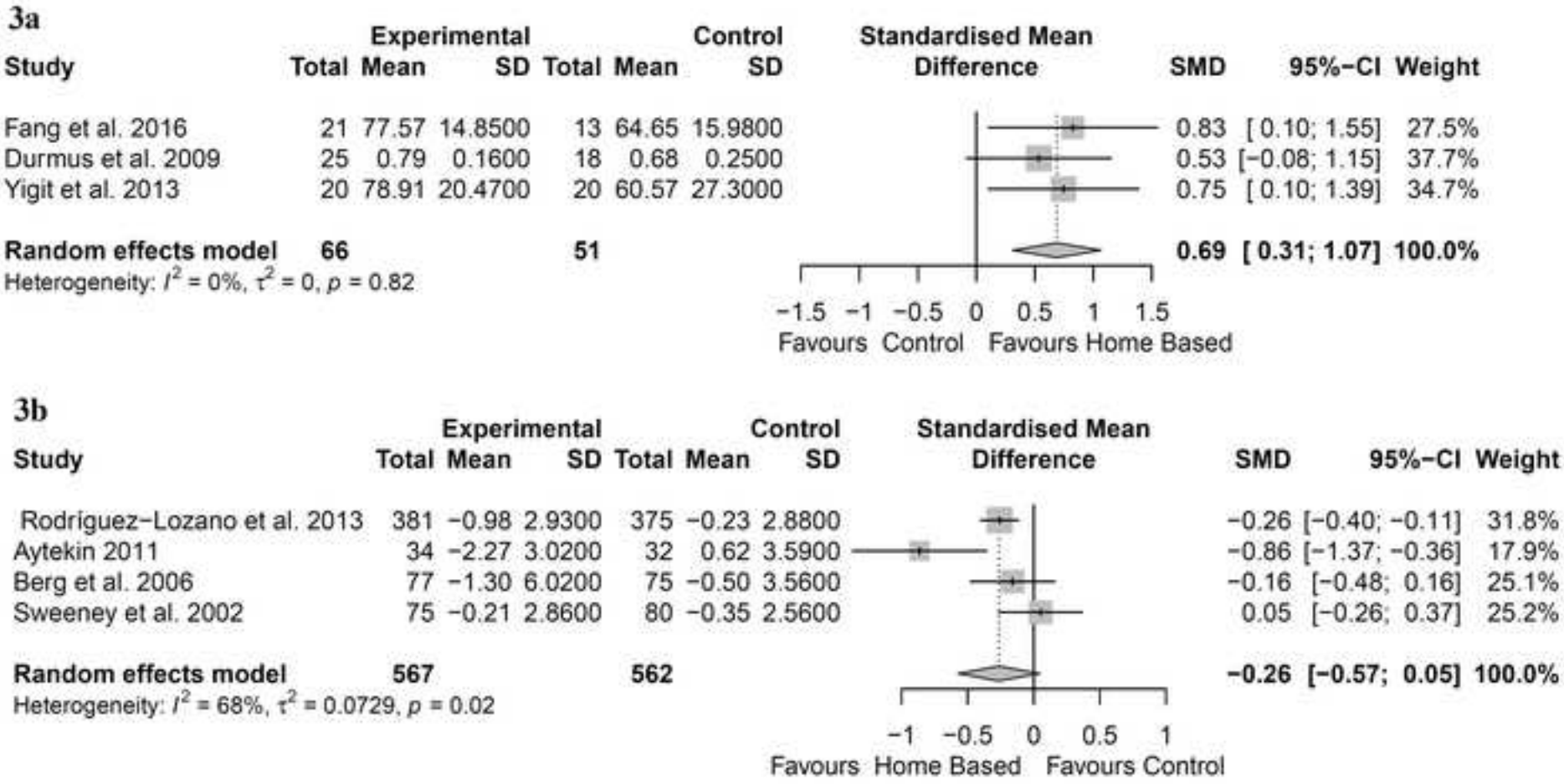

Figure 4

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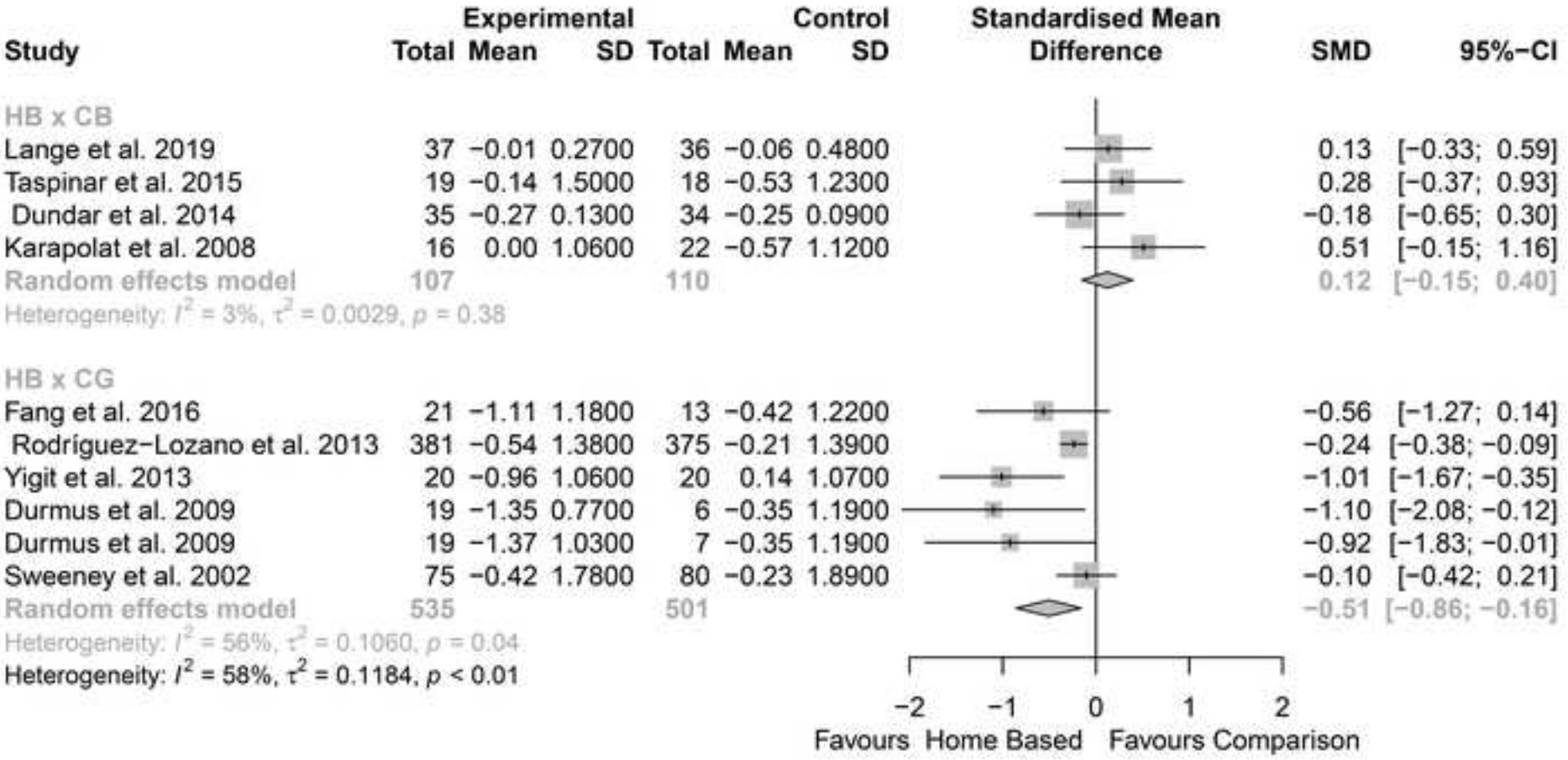

Figure 5

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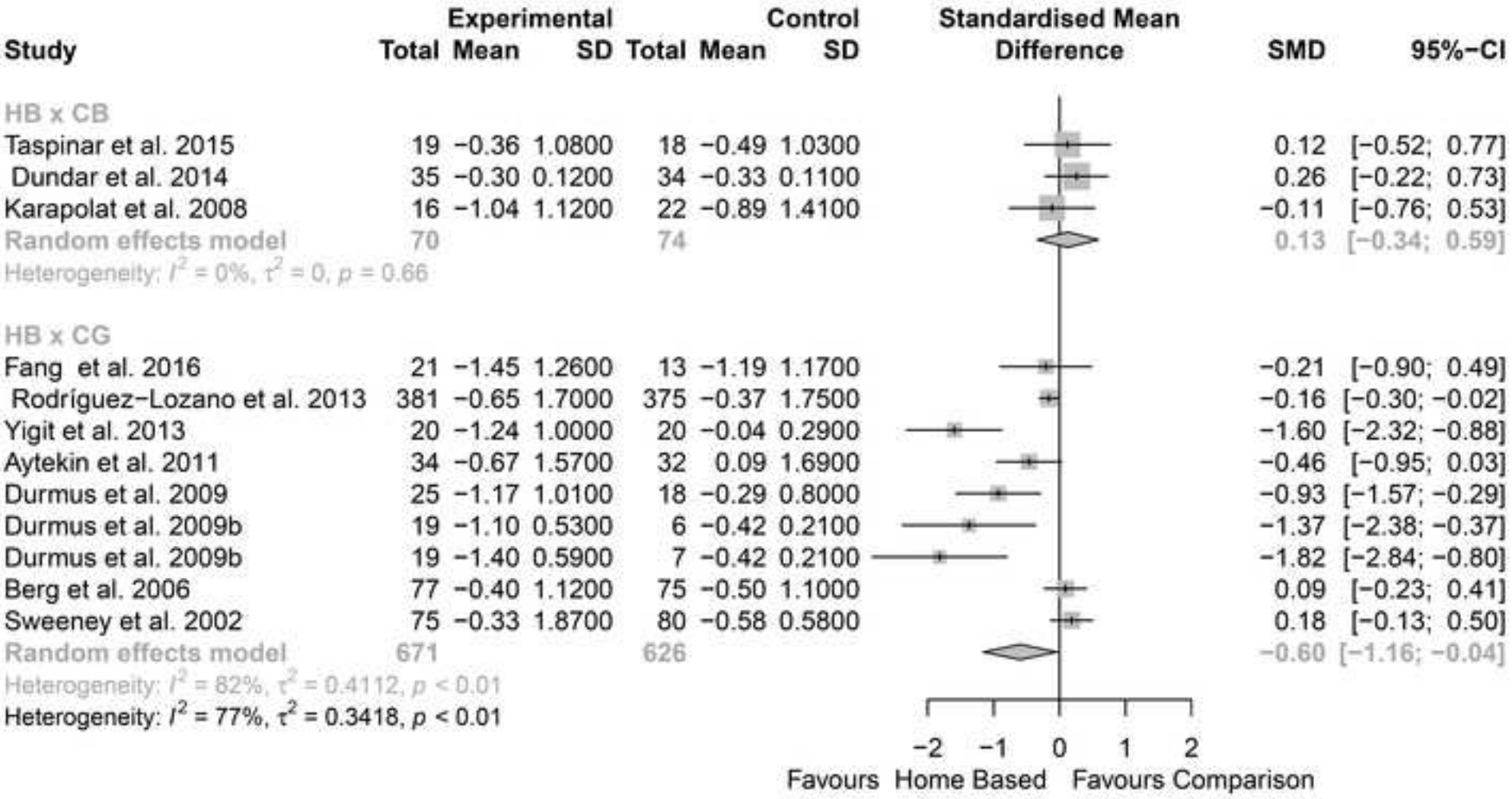

Figure 6

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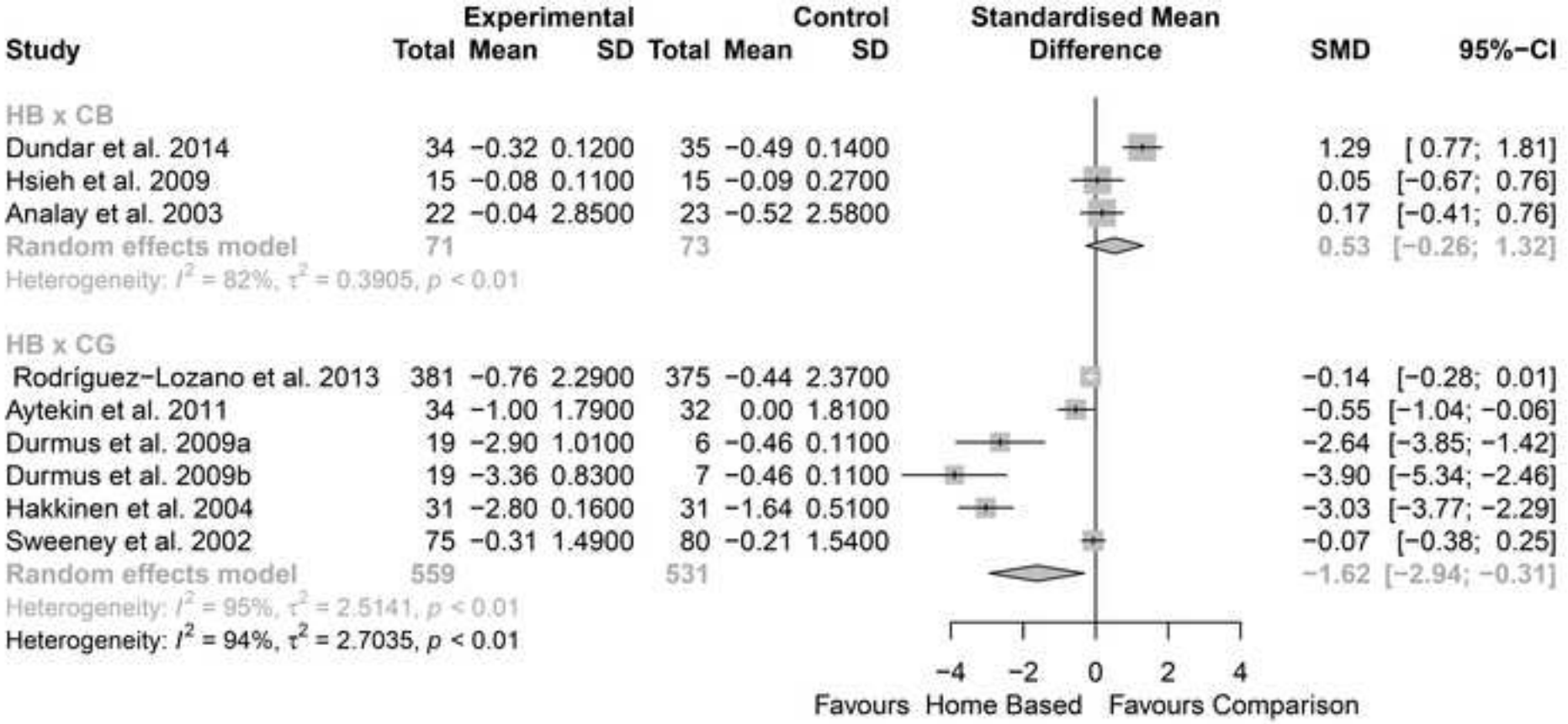

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Table 01 - Methodological characteristics of studies included

Author (data)	Population				Intervention type	Comparison	Outcomes *	Study design	Adverse effects
	n	Disease	Gender	Age (weighted mean ± SD)			Instruments		
Lange et al. (2019)	73	Patients with RA	♀♂	69.64 ± 2.45	Resistance training	Centre-based	HAQ	RT	None
Landim et al. (2019)	22	Patients with Ssc	♀♂	48.09 ± 11.67	Hands exercises	None	Pain (VAS), SF36, HAQ.	BAT	None
Fang et al. (2016)	34	Patients with AS	♀♂	26.56 ± 5.51	Combined exercise	Control Group	BASFI, SF36, BASDAI, BASMI?	RCT	NR
Taspinar et al. (2015)	37	Patients with AS	♀♂	35.83±8.08	Combined exercise	Centre-based	ASQOL, BASFI, BASDAI, CRP	RT	NR
Dundar et al. (2014)	69	Patients with AS	♀♂	42.69 ± 11.50	Combined exercise	Centre-based	BASFI, BASDAI, SF36, Pain (VAS)	RT	NR
Yuen et al. (2013)	15	Patients with SLE	♀	46.7±14.4	Wii fit	None	Adherence	BAT	None
Rodríguez-Lozano et. al. (2013)	756	Patients with AS	♀♂	45.49 ± 11.51	Combined exercise	Control Group	BASDAI, BASFI, Pain (VAS), ASQoL	RCT	NR
Yigit et. al. (2013)	40	Patients with AS	♀♂	38.38 ± 7.62	Combined exercise	Control Group	BASDAI, BASFI, SF-36	NRCT	NR
Yuen et. al. (2011)	15	Patients with SLE	♀	46.7±14.4	Wii fit	None	Pain (SF-MPQ)	BAT	None
Aytekin et al. (2011)	66	Patients with AS	♀♂	36.0±8.14	Combined exercise	Control Group	Pain (VAS), BASDAI, BASFI, ASQoL	NRCT	NR
Karatepe et. al. (2011)	28	Patients with RA	♀♂	52.9 ± 8.6	Combined exercise	None	HAQ, RAQol.	BAT	NR
Durmus et. al. (2009)	43	Patients with AS	♀♂	39.42 ±7.69	Combined exercise	Control group	BASFI, BASDAI, SF-36	NRCT	NR

Durmus et al. (2009)	51	Patients with AS	♀♂	38.66 ± 8.72	Combined exercise	Control Group	BASFI, BASDAI, pain (VAS)	NRCT	NR
Ortancil et al. (2009)	22	Patients with AS	♀♂	42.4 ± 9.9	Combined exercise	None	BASFI	BAT	NR
Hsieh et al. (2009)	30	Patients with RA	♀	52.65 ± 10.15	Combined exercise	Centre-based	HAQ, pain (VAS), CRP	RT	None
Karapolat et a. (2008)	38	Patients with AS	♀♂	47.13 ± 13.03	Combined exercise	Centre-based	BASFI; BASDAI; BASMI; NHP	NRCT	NR
Berg et al. (2006)	152	Patients with RA	♀♂	49.65 ± 13.39	Combined exercise	Control Group**	RAQol; HAQ; DAS28	RCT	NR
Lim et al. (2005)	50	Patients with AS	♀♂	28.45 ± 8.40	Combined exercise	Control group	BASFI and Pain (VAS)	RCT	NR
Hakkinen et al.(2004)	62	Patients with RA	♀♂	49.00 ± 10.49	Resistance training	Control group	DAS28, Pain (VAS), HAQ,	RCT	NR
Analay et al. (2003)	45	Patients with AS	♀♂	36.05 ± 9.70	Combined exercise	Centre-based	Pain (VAS), BASFI	RT	NR
Sweeney, Taylor and Calin (2002)	200	Patients with AS	♀♂	47.00 ± 9.89	No details	Control group	BASFI, BASDAI, BAS-G, SES	RCT	NR

Legend: ♀ - female; ♂- male; AS - ankylosing spondylitis; ASQOL- AS Quality of Life questionnaire; BASFI- Bath ankylosing spondylitis Functional Index, BASDAI - Bath ankylosing spondylitis; Disease Activity Index; BAS-G - Bath ankylosing spondylitis Global Index; CRP - C-reactive protein; DAS28 - Disease Activity Score 28; HAQ - Health Assessment Questionnaire disability index, SF36 - Short form health survey 36 , SF-MPQ – Short Form McGill Pain Questionnaire, Ssc - systemic sclerosis ; m – months; min – minutes; n – number of subjects; NHP - Nottingham Health Profile; NR- not reported; RA - rheumatoid arthritis; SES - Stanford Self-Efficacy Scale, SLE- systemic lupus erythematosus; VAS – visual analogue scale. *Outcomes analyzed by the review team; ** In the Berg et al. [52] study, we considered as "control group", the group that received general information about home-based exercises. 'Combined exercise' usually involved a mix of flexibility and strengthening exercises (for more information about the interventions, see Table 2).

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Table 2 – Characteristics of the home-based exercise interventions

Study	Type of exercise	Frequency (session/w)	Time (min)	Intensity	Supervision	Monitoring	Support components
Lange et al. (2019)	Flexibility, strength and balance exercises	7	NR	LI*	NS	- PA logs	- One session with a physiotherapist to set goals and receive exercise instructions
Landim et al. (2019)	Hand exercises	7	NR	LI**	NS	None	- Educational and PA booklet - DVD with exercises
Fang et al. (2016)	Flexibility exercises	≥3	60	LI**	NS	- Biweekly phone calls	- Monthly sessions with a physiotherapist to receive exercise instructions
Taspinar et al. (2015)	Calisthenic and relaxation exercises	5	20-60	MI**	NS	- Daily phone calls	None
Dundar et al. (2014)	Muscle relaxation, flexibility, respiratory and strength exercises	7	60	LI**	NS	- Weekly phone calls	- One session with a physiotherapist to receive exercise instructions -PA booklet
Yuen et al. (2013)	Exergames	≥3	30	MI (11-13 RPE_1)	PS	- Weekly phone calls - Wii Fit PA logs	- In-home training on the Wii Fit system - Wii Fit - Wii Fit user guide and list of exercises
Rodríguez-Lozano et al. (2013)	Flexibility and respiratory exercises	NR	NR	LI**	NS	- Monthly phone calls - PA logs	- One educational session with the healthcare team - One session with a physiotherapist to receive exercise instructions - Educational andPA booklet - DVD with exercises
Yigit et al. (2013)	Muscle relaxation, flexibility, strength, posture and respiratory exercises	5	30	LI**	NS	None	- One educational session with a practical demonstration of the exercises -PA booklet - CD with exercises
Yuen et al. (2011)	Exergames	≥3	30	MI (11-13 RPE_1)	PS	- Weekly phone calls - Wii Fit PA logs	- In-home training on the Wii Fit system - Wii Fit - Wii Fit user guide and list of exercises
Aytekin et al. (2012)	Flexibility, strength, posture and respiratory exercises	5	30	LI**	NS	- PA logs	- One session with a physiotherapist to receive exercise instructions -PA booklet
Karatepe et al. (2011)	Strength and flexibility exercises	10 (2 per day)	NR	NR	NS	- PA logs - Weekly phone calls	- One session with one of the researchers to receive exercise instructions -PA booklet with daily exercise chart
Durmus et al. (2009)	Muscle relaxation, flexibility, strength, posture and respiratory exercises	7	NR	LI**	NS	- Weekly phone calls	- One session with a physiotherapist to receive exercise instructions
Durmus et al. (2009)	1- Flexibility and respiratory exercises 2- Strength, flexibility, posture and respiratory exercises	7	NR	LI**	NS	- Weekly phone calls	- One session with a physiotherapist to receive exercise instructions -PA booklet
Ortancil et al. (2009)	Respiratory and flexibility exercises	21 (3 per day)	10	LI**	NS	- Weekly phone calls	- One instruction session - Incentive spirometer
Hsieh et al. (2009)	Flexibility and aerobic exercises	3	60	MI (50-80% VO_{2peak})	NS	- PA logs - Biweekly phone calls	- One session with a physiotherapist to receive exercise instructions

Karapolat et al. (2008)	Strength, flexibility and respiratory exercises, and walking	3	45	MI**	NS	None	- Educational sessions and individual counselling with a physiatrist - Demonstration of the exercises by a physiotherapist -PA booklet - Dumbbells and ankle cuff weights
Berg et al. (2006)	Strength and flexibility exercises, and cycling on a bicycle ergometer	5	NR	MI (60-80% HR_{max}; 4-5 RPE_2)	NS	- Weekly emails - PA logs - Web site logging	- Personalized exercise information in a personal Web page, - Elastic band, wooden exercise stick, cycle ergometer, HR monitor.
Lim et al. (2005)	Muscle relaxation, flexibility, strength, posture and respiratory exercises	7	30	LI**	NS	- Daily phone calls	- Demonstration of the exercises by an expert -PA booklet
Hakkinen et al. (2004)	Strength exercises	2	NR	MI (50-70% 1RM)	NS	- PA logs	- Three face-to-face sessions with a physiotherapist to receive exercise instructions - Rubber bands, dumbbells.
Analay et al. (2003)	Flexibility, strength, posture and respiratory exercises, and cycling on a bicycle ergometer	3	50	LI*	NS	- Weekly phone calls	- One educational session about the disease and purposes of the exercises - One face-to-face session with a physiotherapist to receive exercise instructions - Cycle ergometer
Sweeney, Taylor and Calin (2002)	NR	NR	NR	NR	NS	None	- Exercise and educational video - Educational booklet - Exercise progress wall chart - Exercise reminder stickers

1RM = one repetition maximum load; HR = heart rate; HR_{max} = maximal heart rate; LI = low-intensity;; MI = moderate intensity; NR = non-reported; NS = non-supervised; PA = physical activity; PS = partially supervised; RPE_1 = Rating of Perceived Exertion 6-20 scale; RPE_2 = Rating of Perceived Exertion 0-10 scale; w= week . * reported by the authors; ** based in The 2011 Compendium of Physical Activities [32]