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Review Article

Evaluating the effect of exercise-based interventions on functioning in people with transdiagnostic depressive symptoms: A systematic review of randomised controlled trials

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ABSTRACT

Background: Depressive symptoms are associated with various conditions and can exacerbate the outcome of somatic diseases. Transdiagnostic symptom-based approaches provide treatment flexibility, and exercise has demonstrated benefits beyond clinical symptoms. This work aimed to synthesise and establish the effects of exercise-based interventions on global functioning and quality of life in adults with transdiagnostic depressive symptoms, as well as their impact on clinical symptoms.

Methods: A systematic review was conducted following PRISMA guidelines. PubMed, Scopus and PsycINFO databases were searched from inception to April 2023. Eligibility criteria included randomised controlled trials involving adults with transdiagnostic depressive symptoms who received exercise-based interventions and provided details of the interventions. Comparators included treatment as usual or other active control groups. The Cochrane quality assessment tool was used for quality assessment.

Results: Fifteen articles involving 2064 participants were included. Data on study design, sample, intervention characteristics, and outcomes were extracted. Several trials demonstrated the expected positive effects of exercise on functioning (7/15). Most results supported the benefits of adjunctive exercise interventions on illness outcomes.

Limitations: The studies had methodological limitations, including small sample sizes and an underrepresentation of somatic diseases.

Conclusions: The functional consequences of exercise-based interventions targeting depressive symptoms are often understudied. Incorporating exercise routinely as an add-on treatment for transdiagnostic depressive symptoms could improve overall functioning, quality of life, and symptom severity. There is a need to expand the focus of exercise-based interventions to incorporate functional outcomes. Future research should address the methodological limitations and include a wider range of participants, including those with somatic diseases.

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1. Background

Among mental disorders, depression has been associated with most disability-adjusted life years and depressive symptoms are a major contributor to worldwide disease burden with >264 million people affected (James et al., 2018). Even mild episodes can negatively affect quality of life and are associated with functional impairment, an increase in mortality and risk of worsening to severe depression and suicidal behaviour (Gotlib et al., 1995; Judd et al., 1997; Bachmann, 2018).

Depressive symptoms can be present in several disorders, conditions, and illnesses. In some of these, they play a primary role, constituting a more or less stable category of diagnosis known as depressive or affective disorders. However, "secondary" depressive symptomatology can be present in virtually every psychiatric disorder and may worsen the outcome of somatic diseases –from cardiovascular conditions to respiratory problems, from neurodegenerative disorders or Parkinson to cancer (Hirschfeld, 2001; Häfner et al., 2005; Riglin et al., 2021; Lai et al., 2015; Krishnan et al., 2002; Steffen et al., 2020; Krebber et al., 2014).

The prevalence of current depressive disorder has been estimated at 6.4 % of the population (Arias-de la Torre et al., 2021). Depressive disorders are particularly prevalent in primary care settings; about 3.2 % to 27.2 % of primary care outpatients are likely to meet the criteria for major depressive disorder (Craven and Bland, 2013; Mitchell et al., 2009). Beside the impact on people's well-being, depression also constitutes a substantial economic burden in Europe, being among the costliest of brain conditions (Gustavsson et al., 2011).

Also, individuals with bipolar disorder (BD) spend an average of 47.3 % of their time unwell long-term, whose symptomatic course is dominated by depressive symptoms and accounts for one-third of their lives (Judd et al., 2002; Judd et al., 2003).

All of the above are major psychiatric conditions in which depressive symptoms are a core and constitutional ingredient. The same applies to other less severe affective conditions such as adjustment disorder. Following with this chronic but mild-moderate depressive symptomatology, current classifications describe persistent depressive disorder, previously consolidated under the umbrella term dysthymic disorder (American Psychiatric Association, 2013), whose lifetime prevalence ranges between 3.3 and 15.2 % (Vandeleur et al., 2017). Individuals with persistent depressive disorder can experience significant job productivity loss and tend to have less stable work histories when compared with controls (Adler et al., 2004).

However, depressive symptoms are even more prevalent, and worsen the clinical and functional outcomes, when they are present as a secondary symptom to another major condition. Severity of depressive symptoms was strongly associated with having more medical conditions that worsen some conditions such as heart disease, migraine, and eyesight difficulties (Niles et al., 2015). A recent systematic review with >100,000 participants concluded that there is a strong -and bidirectional- relationship between depressive symptoms and unfavourable cardiovascular health (Ogunmoroti et al., 2022). Depressive symptoms are also more prevalent among people suffering epilepsy (Scott et al., 2020), Parkinson's disease -with up to one of three sufferers presenting depressive symptomatology as well (Reijnders et al., 2008), dementia (Savva et al., 2009) and cancer (Hartung et al., 2017). Moreover, participants underreporting depressive symptoms is one of the biggest issues researchers face when dealing with them (Tam et al., 2020).

Transdiagnostic symptom-based approaches study the underlying cognitive and behavioural processes and/or common maintaining mechanisms in different disorders and are often suggested as a solution to the limitations of disorder-specific treatments, providing more adaptable interventions. These transcend categorical models and seek integration with dimensions, which is the axis of the functional treatment approach. Furthermore, transdiagnostic approaches synthesise the underlying theoretical constructs and view cognitive and behavioural processes as a base and/or common maintenance for mental disorders. For example, the National Institute of Mental Health has shifted its interest towards Research Domain Criteria, assuming that mental health comprehension should be led by biology and symptoms and acknowledging that dimensions can occur across disorders (Cuthbert and Insel, 2013). This approach makes room for more flexibility regarding treatment options, as it does not target specific diagnoses and allows individual differences to be respected.

Despite the wide range of existing effective treatment options, there is a gap in access to mental health services (Thornicroft et al., 2017). Barriers including mental healthcare staff shortages, high out-of-pocket cost, and stigma (Clement et al., 2015; World Health Organization, 2022; National Alliance on Mental Illness, 2021) contribute to this gap. In the search for new therapeutic strategies, physical activity- any form of movement that requires energy expenditure- has a large and significant effect on depressed subjects' physical health, improving cardiorespiratory capacity and decreasing the risk of metabolic disorders (Schuch et al., 2016), which are substantially prevalent among them. Physical activity also modulates the body's response to stress and optimises its antioxidant capacity. Since the relationship between mood disorders and inflammation is well supported (Valkanova et al., 2013; Serafini et al., 2013), the anti-inflammatory effects of exercise may play a relevant role (Kucyi et al., 2010). In line with this, recent research suggested a link between physical activity and a higher risk of mental disorders such as depression and bipolar disorder (Firth et al., 2020).

Exercise- a subset of physical activity typically structured, planned, and repetitive - has proven to have a positive anxiolytic effect and may even reduce depressive symptoms and suicidal ideation (Vancampfort et al., 2018; Rosenbaum et al., 2014). Furthermore, exercise represents an outstanding opportunity for efficiently reducing the high incidence of cardio-metabolic health problems associated with depressive symptomatology, which is a leading contributor to the premature mortality gap in people with depression compared to the general population (Walker et al., 2015).

At the biological level, several studies have documented that moderate exercise programs positively influence mood by increasing levels of neurotransmitters, cortisol, beta-endorphins, and neurotrophic factors such as brain-derived neurotrophic factor (Phillips, 2017). Interaction between these mechanisms explains how exercise reduces symptoms of mood disorders and the recurrence rates, thereby improving the quality of life in patients (Melo et al., 2016). Even the effect of exercise has been suggested to be comparable to antidepressant medication and psychotherapy for mild to moderate depression, whereas for severe depression exercise seems to be a beneficial adjunctive therapy to treatment as usual (Knapen et al., 2015). Exercise is associated with a greater reduction in depression symptoms compared with no treatment, placebo, or active control interventions (Cooney et al., 2013). However, analysis of high-quality studies alone suggests only small benefits.

While symptom reduction is an important goal, it is equally crucial to examine whether treatment improvements translate into meaningful changes in an individual's daily functioning and quality of life, as mental health is not solely about symptom reduction but also encompasses broader aspects of life. Given the substantial effect that depressive symptoms have on function and their association with high levels of suffering, the need to entirely understand their impact and treatment effects on overall functioning - understood as the difficulties experienced in participating in and maintaining daily or social activities- is noteworthy (Greer et al., 2010). That is, are people who experience depressive symptoms more functionally capable after exercise-based treatment? This efficacy measure would result in a lesser impact of depressive symptomatology in life and reflects a more holistic approach to its treatment. Therefore, the present systematic review aims to synthesise the effect of exercise-based interventions on global functioning and quality of life in the adult population with transdiagnostic depressive symptoms. Secondarily, it will synthesise the impact of exercise on clinical symptoms.

2. Methods

We registered the review in PROSPERO (CRD42020186480) and followed the procedures outlined in the Preferred Reporting items for Systematic Reviews and Meta-Analysis guidelines (Page et al., 2021) (Appendix A).

2.1. Search strategy

We performed the literature search in PubMed, Scopus and PsycInfo for records from database inception through April 2023. We used the following query to conduct the search: (((depressive symptoms) OR (depression) OR (depressive disorders) OR (major depressive disorders)) AND ((exercise) OR (physical activity) OR (physical exercise)) AND (randomised controlled trial) AND ((therapy) OR (treatment))).

2.2. Eligibility criteria

We searched for randomised controlled trials focusing on exercise-based interventions for adults (aged ≥18 years) with depressive symptoms at study entry. Interventions included aerobic, anaerobic, or a combination of both activities in at least one study arm. Detailed information on activity type, intensity, duration, and frequency was required. Comparators included treatment as usual or any other active control group. Outcome measures of interest were quantitative data on psychosocial and occupational functioning, and/or quality of life. Additionally, we included depressive symptoms as a secondary outcome. Validated questionnaires were used to measure these outcomes. We excluded observational, qualitative, quasi-experimental, and single-case studies, as well as pilot or preliminary results, unpublished articles, and trials focusing solely on pharmacological treatment. We included original studies published in peer-reviewed journals in the following languages: English, Spanish, Catalan, French, Italian, Portuguese, and German.

2.3. Study selection and data extraction

Using the inclusion and exclusion criteria, two authors (A. G-E and N. A-O) independently screened titles and abstracts of potential studies. Relevant full-text articles were retrieved for further review and examined by the same authors. Discrepancies were resolved by consensus with a third researcher (M.C.H). Results were tracked using Mendeley Desktop reference management software (version 1.19.4, Elsevier) and imported into Rayyan (Ouzzani et al., 2016). For the selected studies, two reviewers (A. G-E and N. A-O) independently extracted relevant information, including sample characteristics, intervention details, comparator group, assessment instruments, and main findings.

2.4. Risk of bias

Two reviewers (A. G-E and N. A-O) independently assessed the risk of bias, with a third reviewer (J. M-S) resolving discrepancies. The Cochrane Collaboration's Risk of Bias Tool for randomised trials (Sterne et al., 2019) and the RoB2 Excel tool were used to evaluate methodological quality (see Figs. 2 and 3). The effect of the assignment to interventions was evaluated as the "intention-to-treat effect." Bias was categorised as "low" (−), "high" (+), or unclear (?) when details were insufficient.

3. Results

3.1. Results of the search

Out of 6024 records initially identified, 37 full articles were screened after removing duplicates. Among these, 22 articles were excluded due to reporting irrelevant outcomes (6 articles), not meeting eligibility criteria (4 articles), irrelevant study type (8 articles) or publication (3 articles), and 1 article with a duplicated sample. Ultimately, 15 studies were included in this review (Klein et al., 1984; Singh et al., 1997; Singh et al., 2005; Kerse et al., 2010; Callaghan et al., 2011; Mota-Pereira et al., 2011; Danielsson et al., 2014; Daley et al., 2015; Schuch et al., 2015; Huang et al., 2015; Pibernik-Okanović et al., 2015; Abrahão et al., 2016; Strid et al., 2016; Lok et al., 2017; De Groot et al., 2019). Fig. 1 shows the flowchart of the selection process.

3.2. Included studies

A total of 2064 participants were included in the studies, which were conducted in Australia (Singh et al., 2005), Brazil (Schuch et al., 2015; Abrahão et al., 2016), Croatia (Pibernik-Okanović et al., 2015), New Zealand (Kerse et al., 2010), Portugal (Mota-Pereira et al., 2011), Sweden (Danielsson et al., 2014; Strid et al., 2016), Taiwan (Huang et al., 2015), the United Kingdom (Callaghan et al., 2011; Daley et al., 2015), the USA (Klein et al., 1984; Singh et al., 1997; De Groot et al., 2019), and Turkey (Lok et al., 2017).

3.3. Design

All studies had a randomised controlled trial design. Among them, 46.7 % had two arms (Singh et al., 1997; Kerse et al., 2010; Callaghan et al., 2011; Mota-Pereira et al., 2011; Daley et al., 2015; Schuch et al., 2015; Lok et al., 2017), 46.7 % had three arms (Klein et al., 1984; Singh et al., 2005; Danielsson et al., 2014; Huang et al., 2015; Pibernik-Okanović et al., 2015; Abrahão et al., 2016; Strid et al., 2016), and 6.7 % had four arms (De Groot et al., 2019). The intervention designs varied, with the most common being exercise combined with treatment as usual versus treatment as usual alone (Singh et al., 2005; Daley et al., 2015; Schuch et al., 2015; Huang et al., 2015; Lok et al., 2017). The choice of 'active' comparator interventions also varied, with cognitive-behavioural therapy (CBT) and health/disease education being the most frequently selected (Singh et al., 1997; Huang et al., 2015; Pibernik-Okanović et al., 2015; Abrahão et al., 2016; Strid et al., 2016; De Groot et al., 2019). See Table 1 for details on the characteristics of the included studies.

3.4. Participants

Seven studies included participants from non-clinical settings (Klein et al., 1984; Singh et al., 1997; Singh et al., 2005; Danielsson et al., 2014; Schuch et al., 2015; Huang et al., 2015; De Groot et al., 2019), seven included participants from clinical settings (outpatients from mental health services, primary care, a diabetes clinic, and a rheumatology clinic) (Kerse et al., 2010; Callaghan et al., 2011; Mota-Pereira et al., 2011; Daley et al., 2015; Pibernik-Okanović et al., 2015; Abrahão et al., 2016; Strid et al., 2016), and one study included participants from a mixed setting (volunteers from a nursing home) (Lok et al., 2017).

All studies included participants with depressive symptoms, which were assessed using various instruments. The inclusion criteria varied across studies. For example, Klein et al. (1984) used Research Diagnostic Criteria (RDC) and the Symptom Checklist-90-Revised (SCL-90-R) for psychiatric outpatients. Callaghan et al. (2011) included participants receiving treatment for depression but did not employ symptom severity cut-points. Some studies relied on either DSM-IV, DSM-IV TR, or ICD-10 for Major Depressive Disorder (MDD) criteria (Mota-Pereira et al., 2011; Danielsson et al., 2014; Daley et al., 2015; De Groot et al., 2019) or risk of depression (Kerse et al., 2010). Other studies used instruments such as the Beck Depression Inventory (BDI) (Singh et al., 1997; Lok et al., 2017), the Geriatric Depression Scale (GDS) (Singh et al., 2005; Huang et al., 2015), the Patient Health Questionnaire (PHQ-9 and PHQ-2) (Pibernik-Okanović et al., 2015; Strid et al., 2016), and the Hamilton Scale for Depression (HAM-D) (Schuch et al., 2015), along with specific DSM-IV diagnostic criteria for MDD, minor depression, or dysthymia.

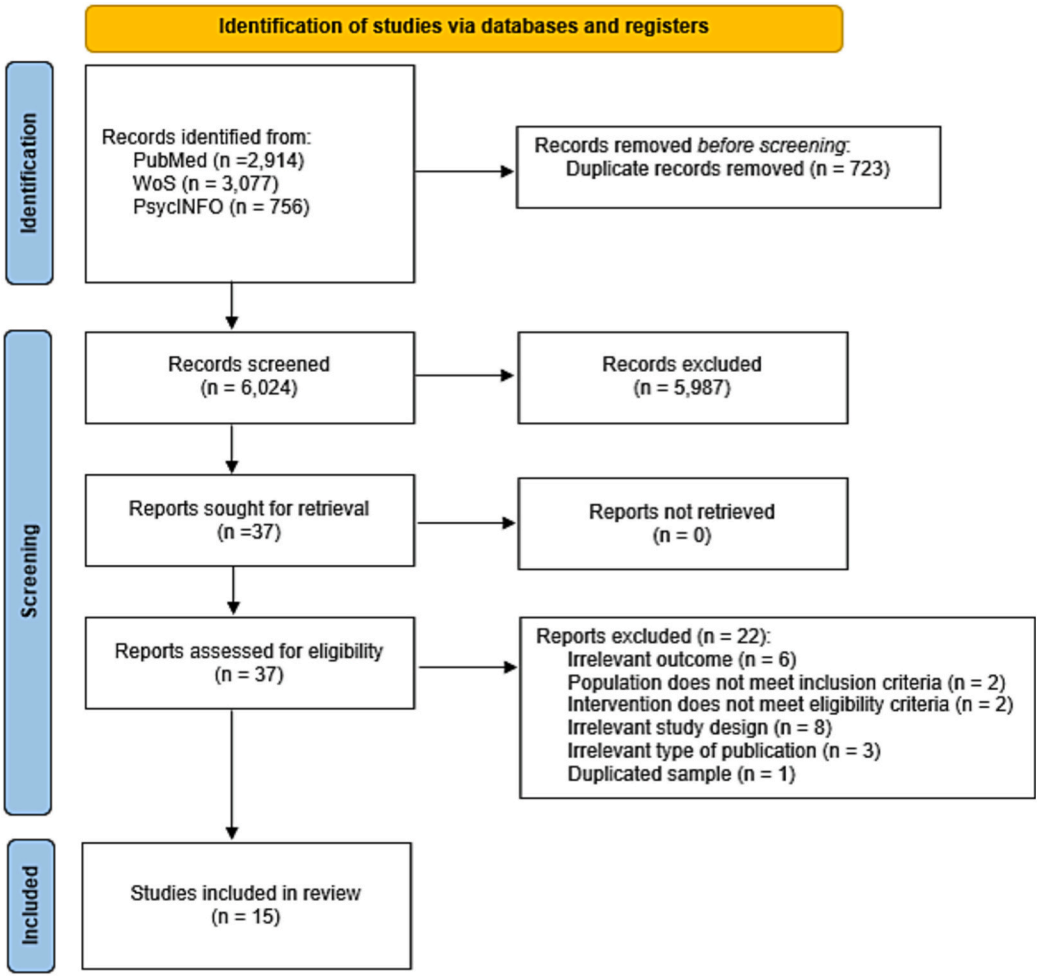

Fig. 1. Flow diagram describing the identification, selection, and the systematic review of the studies. The selection process followed the recommendations of the PRISMA.

Only one study did not employ screening measures for symptom severity or cut-off points (Abrahão et al., 2016).

The age of participants ranged from 30 to 81 years, with a majority being female (70.25 %) (see Table 2).

3.5. Interventions

The interventions lasted for an average of 11.6 weeks (2–26), with 3 sessions per week (2–5), each lasting between 30 and 90 min. One trial did not mention duration and only indicated that assessments were conducted at discharge (Schuch et al., 2015). Seven trials conducted group sessions (Singh et al., 1997; Singh et al., 2005; Callaghan et al., 2011; Huang et al., 2015; Pibernik-Okanović et al., 2015; Lok et al., 2017; De Groot et al., 2019), five conducted individual sessions (Klein et al., 1984; Kerse et al., 2010; Mota-Pereira et al., 2011; Daley et al., 2015; Schuch et al., 2015), two studies used a combination of group and individual consultations (Danielsson et al., 2014; Strid et al., 2016), and one trial did not specify the format (Abrahão et al., 2016).

The most common type of exercise was aerobic, which was provided in ten trials (Klein et al., 1984; Callaghan et al., 2011; Mota-Pereira et al., 2011; Danielsson et al., 2014; Daley et al., 2015; Schuch et al., 2015; Pibernik-Okanović et al., 2015; Strid et al., 2016; Lok et al., 2017; De Groot et al., 2019). Two trials focused on strength exercises (Singh et al., 1997; Singh et al., 2005), while two others offered a combination of aerobic and strength exercise (Kerse et al., 2010; Huang et al., 2015). In Abrahão et al. (2016), one group performed aerobic exercises, while another group completed strength exercises.

All trials considered participants' abilities, tolerance, or perceived exertion. However, the extent to which participants had control over the nature of the exercises varied. In six trials, the exercise modality and intensity were the same for all participants (Klein et al., 1984; Singh et al., 1997; Singh et al., 2005; Mota-Pereira et al., 2011; Huang et al., 2015; Lok et al., 2017). Four studies prescribed exercises based on personal preferences and individual conditions (Kerse et al., 2010; Callaghan et al., 2011; Daley et al., 2015; Schuch et al., 2015), and one study partially took them into account (Danielsson et al., 2014). In one trial, participants in the intervention group were randomised to different intensity levels, resulting in changes in exercise modalities (Strid et al., 2016).

Most studies conducted supervised onsite exercise sessions (Klein et al., 1984; Singh et al., 1997; Singh et al., 2005; Callaghan et al., 2011; Danielsson et al., 2014; Huang et al., 2015; Pibernik-Okanović et al., 2015; Abrahão et al., 2016; Strid et al., 2016; Lok et al., 2017), while four studies included both partially supervised sessions and unsupervised home-based exercises (Kerse et al., 2010; Mota-Pereira et al., 2011; Daley et al., 2015; De Groot et al., 2019). Thirteen trials specified the professionals responsible for supervised exercise programs, including exercise therapists (Callaghan et al., 2011; Danielsson et al., 2014), a trained nurse (Kerse et al., 2010), a physical activity facilitator (Daley et al., 2015), fitness instructors (Mota-Pereira et al., 2011; Huang et al., 2015; Pibernik-Okanović et al., 2015; Strid et al., 2016; De Groot et al., 2019), researchers (Singh et al., 1997; Schuch et al., 2015; Lok et al., 2017), and mental health professionals (Klein et al., 1984).

Table 1
Characteristics of the included studies.

Study	Intervention				
	Type	Setting and format	Length and frequency	Intensity	Comparator
Klein et al. (1984) (Klein et al., 1984)	Aerobic	Home-based and individual	12 w, 2 times/w, 45′ sessions	Tailored	1. Meditation 2. Interpersonal and cognitive therapy
Singh et al. (1997) (Singh et al., 1997)	Strength	Onsite and group	10 w, 3 times/w, 50′ sessions	Vigorous	Health education
Singh et al. (2005) (Singh et al., 2005)	Strength + TAU	Onsite and group	8 w, 3 times/w, sessions of 65'sessions	Arm 1: Vigorous Arm 2: Light	TAU
Kerse et al. (2010) (Kerse et al., 2010)	Aerobic, balance and strength + TAU	Home-based and individual	24 w, 3 times/w, at least 30′ sessions	Tailored	Social visits + TAU
Callaghan et al. (2011) (Callaghan et al., 2011)	Aerobic + Psychosocial support + TAU	Onsite and group	4 w, 3 times/w	Tailored	Prescribed exercise + Psychosocial support + TAU
Mota-Pereira et al. (2011) (Mota-Pereira et al., 2011)	Aerobic + Usual pharmacotherapy + Accelerometer	Home-based and individual	12 w, 5 times/w, 30–45′ sessions	Moderate	Usual pharmacotherapy + Accelerometer
Danielsson et al. (2014) (Danielsson et al., 2014)	Aerobic + Usual pharmacotherapy	Onsite and mixed	10 w, 2 times/w, 50–60′ sessions	Moderate/ vigorous	1. Body awareness + Usual pharmacotherapy 2. Advice + Usual pharmacotherapy
Daley et al. (2015) (Daley et al., 2015)	Aerobic + TAU	Home-based and individual	6 m, 3–5 times/w, final goal of 30′ sessions	Moderate	TAU
Schuch et al. (2015) (Schuch et al., 2015)	Aerobic + TAU	Onsite and individual	2 w, 3 times/w	Tailored	TAU
Huang et al. (2015) (Huang et al., 2015)	Aerobic and strength + TAU	Onsite and group	12 w, 3 times/w, 50′ sessions	Moderate	1. CBT + TAU 2. TAU
Pibernik-Okanović et al. (2015) (Pibernik-Okanović et al., 2015)	Strength + flexibility	Onsite and group	6w, once/w, 90′ sessions	Light/medium	1.Psychoeducation + diabetes TAU 2. Diabetes education + TAU
Abrahão et al. (2016) (Abrahão et al., 2016)	Arm 1: Aerobic + TAU Arm 2: Strength + TAU	Onsite and not reported	12 w, 3 times/w, 50′ sessions	Moderate/ vigorous	Lupus education + TAU
Strid et al. (REGASSA study, 2015–2016)* (Strid et al., 2016)	Aerobic, strength, or flexibility + Usual pharmacotherapy	Offsite and individual	12 w, 3 h/w, 60′ sessions	Low, moderate, or high	1. Internet-based CBT + Usual pharmacotherapy 2. TAU
Lok et al. (2017) (Lok et al., 2017)	Aerobic + TAU	Onsite and group	10 w, 4 times/w, 40′ sessions	Not reported	TAU
de Groot et al. (2019) (De Groot et al., 2019)	Aerobic + Usual pharmacotherapy	Offsite and group	12 w, 6 monitored sessions, final goal of 150′/w	Moderate	1. CBT + Usual pharmacotherapy 2. CBT + Exercise + Usual pharmacotherapy 3. TAU

CBT Cognitive-behavioural therapy, *HRR* heart rate reserve, *1RM* one-repetition maximum, *TAU* treatment as usual, *W* week(s).

3.6. Outcomes

There was heterogeneity in the instruments used to assess outcomes.

3.6.1. Assessment of functioning and quality of life

For the assessment of functioning, six studies used the 36-Item Short Form Health Survey (SF-36) (Klein et al., 1984; Singh et al., 1997; Singh et al., 2005; Kerse et al., 2010; Huang et al., 2015; Abrahão et al., 2016; Lok et al., 2017), while four studies used its 12-Item version (SF-12) (Callaghan et al., 2011; Daley et al., 2015; Pibernik-Okanović et al., 2015; De Groot et al., 2019). Two studies used the Global Assessment of Function (GAF) (Mota-Pereira et al., 2011; Danielsson et al., 2014). Other assessments included the Social Adjustment Self-Report Questionnaire (SAS) (Klein et al., 1984) and the Outcome Questionnaire-45 (OQ-45) (Strid et al., 2016).

Four trials conducted additional assessments on quality of life using the Quality of Life in Depression Scale (QLDS) (Callaghan et al., 2011), the EQ-5D (Daley et al., 2015), the WHOQOL-BREF (Schuch et al., 2015), and the Diabetes Quality of Life measure (DQOL) (De Groot et al., 2019).

3.6.2. Assessment of depression

Depression measures varied across studies. The most commonly used tools were the BDI and BDI-II (Singh et al., 1997; Callaghan et al., 2011; Mota-Pereira et al., 2011; Abrahão et al., 2016; Lok et al., 2017; De Groot et al., 2019), followed by the HDRS (Klein et al., 1984; Singh et al., 1997; Singh et al., 2005; Mota-Pereira et al., 2011; Schuch et al., 2015). Four studies reported scores on the GDS (Singh et al., 1997; Singh et al., 2005; Kerse et al., 2010; Huang et al., 2015). Danielsson et al. (2014) and the authors of the REGASSA study (Hallgren et al., 2015) reported Montgomery-Åsberg Depression Rating Scale MADRS scores. Additional scales included the Edinburgh Postnatal Depression Scale (EPDS) (Daley et al., 2015) and the Centre for Epidemiological Studies Depression Scale (CES-D) (Pibernik-Okanović et al., 2015).

3.6.3. Other outcomes

Twelve trials reported adherence to the exercise intervention, considering session attendance and/or completion of predefined goals. Klein et al. (1984) reported that 57 % of participants completed the intervention, without explicitly defining the term “completion”. Similarly, one study labelled all exercise group participants as completers, but adherence characteristics and rates were not provided (Lok et al., 2017). Singh et al. (1997) reported a median adherence of 93 %, while Callaghan et al. (2011) focused on attendance and found rates of 66 %. In one trial, adherence rates to exercise sessions were 95 %–100 % for high intensity and 99–100 % for low intensity (Singh et al., 2005).

One study reported a 91 % adherence rate, calculated through accelerometer data, defined as completing at least 50 % of the walks per week during the program (Mota-Pereira et al., 2011). Kerse et al. (2010) measured adherence by recording exercise units and frequency. During the first 6 months, one-third of participants completed the recommended units at least 3 times weekly, two-thirds completed them at least twice a week. At 12 months, 55 % completed the recommended training at least twice a week, 25 % exercised at least 3 times a week, and one-

Table 2
Sample characteristics.

Study	Sample				Depressive symptoms screening	Functioning and/or Quality of life assessment
	N	Type	Mean age	% female		
Klein et al. (1984) (Klein et al., 1984) USA	74	Volunteers from community	30.02	71.62	> 60th percentile SCL-90-R score for psychiatric outpatients + RDC	SF-36, SAS
Singh et al. (1997) (Singh et al., 1997) USA	32	Volunteers from community	71.3	60.71	DSM-IV criteria for MDD, minor depression, or dysthymia + BDI score > 12	SF-36
Singh et al. (2005) (Singh et al., 2005) Australia	60	Volunteers from community	69	55	DSM-IV criteria for MDD, minor depression or dysthymia + GDS score ≥ 14	SF-36
Kerse et al. (2010) (Kerse et al., 2010) New Zealand	193	Outpatients from primary healthcare service	81	59	DSM-IV or ICD-10 for MDD or risk of depression + 3-question depression screen	SF-36
Callaghan et al. (2011) (Callaghan et al., 2011) UK	38	Outpatients from mental health service	53.7	100	Under monitoring or treatment for depression. No symptom severity assessment	SF-12, QLDS
Mota-Pereira et al. (2011) (Mota-Pereira et al., 2011) Portugal	33	Outpatients from mental health service	47.52	57.57	DSM-IV criteria for MDD for >9–15 months	GAF
Danielsson et al. (2014) (Danielsson et al., 2014) Sweden	62	Volunteers from community	45.4	77.4	DSM-IV criteria for MDD evaluated with the MINI	GAF
Daley et al. (2015) (Daley et al., 2015) UK	94	Outpatients from primary healthcare service	30.5	100	ICD-10 criteria for MDD	SF-12, EQ-5D
Schuch et al. (2015) (Schuch et al., 2015) Brazil	50	Inpatients from a hospital unit	40.3	74	DSM-IV criteria for MDD evaluated with the MINI + HAM-D score ≥ 25	WHOQOL-BREF
Huang et al. (2015) (Huang et al., 2015) Taiwan	57	Volunteers from community	76.53	52.6	GDS-15 with scores ≥5	SF-36
Pibernik-Okanović et al. (2015) (Pibernik-Okanović et al., 2015) Croatia	209	Outpatients from Diabetes clinic	58.1	54	Subsyndromal depression according to PHQ-2 + subjective need of professional help	SF-12
Abrahão et al. (2016) (Abrahão et al., 2016) Brazil	63	Outpatients from Rheumatology clinic	42.9	96.8	No symptom severity assessment	SF-36
Strid et al. (REGASSA study, 2015–2016) * (Strid et al., 2016) Sweden	879	Outpatients from primary healthcare service	43	73	PHQ-9 score ≥ 10 + interview using the MINI	OQ-45
Lok et al. (2017) (Lok et al., 2017) Turkey	80	Nursing home	Not reported	45	BDI score ≥ 10	SF-36
de Groot et al. (2019) (De Groot et al., 2019) USA	140	Volunteers from community	56	77	DSM-IV TR criteria for MDD	SF-12, DQOL

BDI Beck Depression Inventory, *DSM-IV* Diagnostic and Statistical Manual of Mental Disorders 4th edition, *DSM-IV TR* Diagnostic and Statistical Manual of Mental Disorders 4th edition text revision, *GDS* Geriatric Depression Scale, *GDS-15* 15-item Geriatric Depression Scale, *HAM-D* Hamilton Depression Scale, *ICD-10* International Classification of Diseases-10, *MDD* Major depressive disorder, *MINI* Mini-International Neuropsychiatric Interview, *PHQ-2* Patient Health Questionnaire-2, *PHQ-9* Patient Health Questionnaire-9, *RDC* Research Diagnostic Criteria, *SCL-90-R* Symptom Checklist-90-Revised, *SF-36* 36-Item Short Form Health Survey, *SAS* Social Adjustment Self-Report Questionnaire, *SF-12* 12-Item Short Form Health Survey, *QLDS* Quality of Life in Depression Scale, *GAF* Global Assessment of Function, *EQ-5D* European Quality of Life 5 Dimensions, *WHOQOL-BREF* World Health Organization Quality of Life Brief Version, *OQ-45* Outcome Questionnaire-45, *DQOL* Diabetes Quality of Life.

third walked at least 3 times a week during the same period. Danielsson et al. (2014) defined adherence as attendance at >50 % of exercise sessions and not initiating another healthcare treatment, which was fulfilled by 85 % of participants.

In the REGASSA study (Strid et al., 2016; Hallgren et al., 2015), participants completed an average of one exercise session per week, resulting in a 33 % adherence rate. Schuch et al. (2015) reported that participants performed 90.72 % of exercise sessions overall.

Huang et al. (2015) found a decrease in exercise uptake over time after the initial prescription. Initially, all participants completed 100 % of the recommended exercise logs. However, adherence rates decreased to 63 % and 47 % at 3 and 6 months after the intervention, respectively. In contrast, Daley et al. (2015) reported that subjects completed 69.4 % of the recommended training logs and showed increased levels of exercise throughout the intervention, ranging from 161.1 to 245 min weekly by the end.

3.7. Adverse events

Few studies (Singh et al., 1997; Singh et al., 2005; Kerse et al., 2010; Danielsson et al., 2014) reported self-reported adverse events, which included musculoskeletal symptoms as the most common issue. Visits to health professionals and minor physical illnesses were also reported.

3.8. Costs

Detailed information concerning costs was not reported by any study.

3.9. Timing of outcome measures

All trials conducted baseline and end-of-intervention measurements. Three trials included long-term follow-up assessments, ranging from 1 to 9 months (Klein et al., 1984; Mota-Pereira et al., 2011; Strid et al., 2016).

3.10. Risk of bias in included studies

The quality and risk of bias varied among the studies, with risk classified from low to high. Only three studies (Kerse et al., 2010; Danielsson et al., 2014; Schuch et al., 2015) met the low-risk criteria for all factors, and one study (De Groot et al., 2019) had an overall low risk. Eight studies had some concerns (Singh et al., 1997; Singh et al., 2005; Callaghan et al., 2011; Mota-Pereira et al., 2011; Daley et al., 2015; Huang et al., 2015; Pibernik-Okanović et al., 2015; Abrahão et al., 2016), and three studies were deemed high risk (Klein et al., 1984; Strid et al., 2016; Lok et al., 2017). In addition, more than half of the included studies had small sample sizes, limiting results robustness.

Among studies with an overall assessment of "some concerns" or "high" risk of bias, reasons included a lack of information regarding the randomisation process (Klein et al., 1984; Singh et al., 1997; Callaghan et al., 2011; Mota-Pereira et al., 2011; Huang et al., 2015) or allocation concealment (Pibernik-Okanović et al., 2015; Lok et al., 2017), treatment of missing data (Klein et al., 1984; Strid et al., 2016), unblinded or half-blinded assessments (Klein et al., 1984; Singh et al., 1997; Mota-Pereira et al., 2011; Daley et al., 2015; Lok et al., 2017), and the inability to identify or confirm the pre-specified analysis plan due to lack of published protocols or trials registry (Klein et al., 1984; Singh et al., 1997; Singh et al., 2005; Mota-Pereira et al., 2011; Huang et al., 2015; Abrahão et al., 2016) or inconsistencies in the reported results (Strid et al., 2016; Lok et al., 2017).

Figs. 2 and 3 depict the summary and graphical representation of the risk of bias.

3.11. Primary outcome measures

3.11.1. General functioning

Most studies reported the effects of interventions on functioning, except for Schuch et al. (2015) who primarily focused on assessing depression and quality of life. Due to the diverse assessment methods used, changes were observed in various aspects depending on the specific instruments and study objectives. The Short Form Health Survey (SF-36 and SF-12) was frequently used by different authors to measure functioning, although some reported it a measure of quality of life. Since this questionnaire specifically evaluates health-related limitations, we categorised it as a measure of functioning and included the results originally reported as quality of life outcomes.

Seven studies reported significant improvements in functioning after exercise interventions. Singh et al. (1997) observed improved functioning measures, specifically in the subscales of Vitality ($p = .002$), Bodily Pain ($p = .001$), Role Emotional ($p = .02$), and Social Functioning ($p = .008$) compared to the control group.

In a subsequent study, Singh et al. (2005) examined the impact of different intensity levels on functioning. Across all groups, functioning improved in most SF-36 subdomains (p values ranging from <0.0001 to <0.04). The high intensity intervention showed superior improvement compared to the low intensity and usual care groups, specifically on the Vitality subscale ($p = .048$).

The exercise intervention conducted by Mota-Pereira et al. (2011) led to improved functioning compared to baseline values. Furthermore, at 8- and 12-week follow-ups, the exercise group demonstrated higher functioning parameters than the control group ($p = .006$). However, it is worth noting that participants in the exercise group had lower functioning scores than the control group at baseline ($p = .003$).

Abrahão et al. (2016) found significant improvements in functioning after cardiovascular training and resistance training interventions. These improvements were observed in all SF-36 subscales (except for Vitality in the cardiovascular training group) and were not present in the control group. Participants in the cardiovascular training group achieved significantly higher scores in the Role Physical and Vitality subscales compared to the other groups. Additionally, they had significantly higher values in the Role Emotional subscale compared to the resistance training group.

Huang et al. (2015) found that only the exercise group showed improved functioning ($p < .001$), with significantly higher SF-36 scores immediately after the intervention compared to baseline. This effect was not observed in participants who received CBT or TAU.

Strid et al. (2016) reported positive changes in psychological functioning. The exercise group achieved larger improvements than the control group ($p < .001$), as did the active comparator group (iCBT). Effect sizes favoured exercise ($d = 0.20$) and iCBT (Cohen's $d = 0.35$) compared to the control group.

Lok et al. (2017) found that exercise had a positive effect on functioning. In the intervention group, the SF-36 scores of the 8 subscales (Physical Health, Physical Role, Bodily Pain, General Health Perception, Vitality, Mental Health, Emotional Role, and Social Function) improved ($p < .05$). However, no significant difference was observed in the control group after the exercise program period. The two component summary scores reflecting physical and mental health were not presented.

Seven studies reported mixed results, with improvements observed in some areas but not all, following exercise interventions. Klein et al. (1984) compared exercise, meditation, and group therapy and found a reduction in social and leisure impairment among exercise ($p < .01$) and

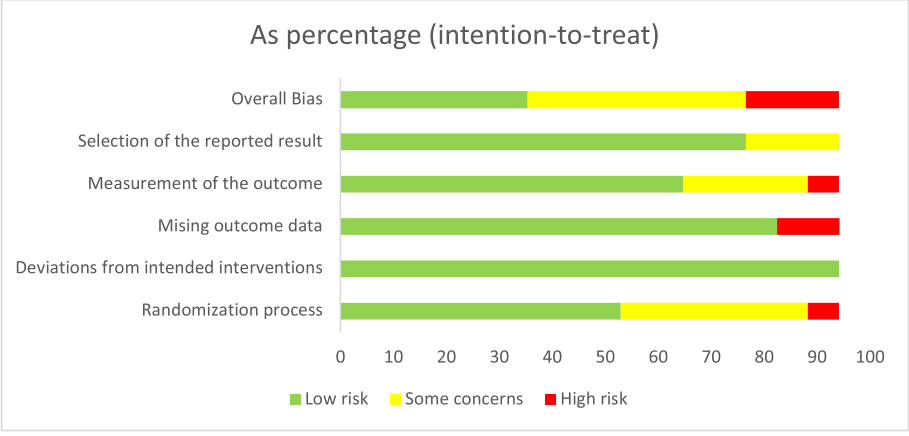

Fig. 2. Risk of bias graph for included studies displaying each domain presented as percentages.

Fig. 3. Tabular representation of risk of bias in individual studies.

meditation ($p < .05$) subjects after the intervention. However, significant improvement in overall social functioning was only observed among participants in the meditation group ($p < .01$).

Kerse et al. (2010) compared changes between groups at baseline and six months after the intervention but did not find a differential effect.

Danielsson et al. (2014) compared functioning among participants receiving aerobic exercise intervention, basic body awareness therapy (BBAT), or advice on physical activity. However, no differences were observed between the groups in global functional capacity.

In Daley et al.'s study (2015) the exercise-based intervention did not result in significant differences in the SF-12 total score, any of its domains, or in the component analyses at the 6-month follow-up: Physical Component ($p = .50$) and Mental Component summaries ($p = .11$).

Pibernik-Okanović et al. (2015) observed a significant improvement in diabetes-related distress and the mental health component score of the SF-12 for all patients at the 12-month follow-up ($F = 16.87$, $p < .001$, $\eta 2 = 0.09$; $F = 18.13$, $p < .001$, $\eta 2 = 0.09$). However, the Physical Component score did not change after any of the interventions ($p = .711$) and self-reported exercise increased in all groups ($F = 5.14$, $p = .008$, $\eta 2 = 0.03$). No significant differences were found between groups in any of the assessed domains after the 12-month follow-up.

De Groot et al. (2019) found partial evidence supporting a positive effect of exercise on functioning. The Physical Component score of the SF-12 was significantly higher at post-intervention in the exercise group ($p = .047$) and the exercise + CBT group ($p = .001$) compared to the TAU group. Patients who received only CBT did not differ in their health-related quality of life from the usual care group (Physical Component score: $p = .147$, Mental Component score: $p = .069$). However, there were no significant differences in the Mental Component score of the SF-12 for any of the groups compared to the usual care group (CBT group $p = .069$, CBT + exercise group $p = .270$, exercise group $p = .109$).

In a study by Callaghan et al. (2011), the change in functioning (mean SF-12 score) did not differ between the exercise intervention group with prescribed intensity and the group with preferred intensity ($p = .08$). However, participants who chose their intensity level had significantly increased General Health Questionnaire scores ($p = .001$). As both groups received an exercise intervention and no within-group statistical tests were conducted, it is unclear whether exercise led to an improvement in functioning or not.

Klein et al. (1984) observed effects on functioning at 9-month follow-up, specifically in the meditation group ($p < .01$). The improvement in social impairment seen post-treatment did not persist in the follow-up assessment. Treatment differences were more evident during follow-up, indicating that the effects of exercise and meditation treatments may be more enduring and general.

Kerse et al. (2010) found a significant decline in functional status for all patients ($p < .003$) over time. Nevertheless, both groups showed improvement in mental health ($p < .001$), and there were no changes in physical health for all participants ($p = .761$). No significant differences were observed between the groups ($p = .068$).

Daley et al. (2015) found no significant improvements in SF-12 domain scales, including Physical Component ($p = .77$) and Mental Component summary scores ($p = .64$), when comparing exercise and TAU at 12-month follow-up.

In the study by Huang et al. (2015), functioning did not significantly change from baseline at 3- and 6-months post-intervention for participants in the exercise, CBT, and TAU groups.

Strid et al. (2016) reported larger proportions of participants in the exercise and active comparator groups achieving recovery (OQ-45 score < 64) compared to the control condition ($p = .014$ and $p < .001$, respectively) at 12-month post-intervention, but no significant differences were found between the exercise and active comparator groups.

3.11.2. *Quality of life*

Callaghan et al. (2011) found significant improvements in the group that exercised in their preferred intensity measured with the Quality of Life in Depression Scale (QLDS) ($p = .0325$) compared with the pre-described intensity group after the interventions.

Daley et al. (2015) did not report significant differences between the exercise and TAU groups at 6- and 12-month follow-ups ($p = .12$ and $p = .22$ respectively), as measured with the EQ-5D instrument.

Schuch et al. (2015) assessed quality of life with the WHOQOL-BREF and described improvements in the physical and psychological domains of quality of life for exercise participants. In the physical domain, the difference between groups was greater at the second week assessment ($p = .002$) than at discharge ($p = .001$); conversely, this difference for the psychological domain was smaller at the second week ($p = .025$) than at discharge ($p = .01$).

De Groot et al. (2019) found significantly higher scores in the Diabetes Quality of Life Measure (DQOL) for both the exercise ($p = .001$) and exercise + CBT groups ($p < .001$) compared to TAU. There was no significant difference between the CBT-only group and TAU ($p = .061$).

3.12. Secondary outcome measure

3.12.1. Depressive symptoms

Most studies effectively reduced depressive symptoms. Post-treatment assessments showed that 9 out of 14 studies observed a reduction in depressive symptoms after exercise interventions. Singh et al. (1997) found that 59 % of the exercise group had a clinically meaningful response (50 % reduction in HRSD score) compared to 26 % of controls ($p = .067$). Depressive symptoms significantly decreased after the intervention in the exercise group, with a 2–3 times greater improvement compared to controls. Intensity of training was identified as an independent predictor of depression score reduction ($p = .0002$).

In a subsequent study, Singh et al. (2005) observed that over 60 % of participants in the high-intensity exercise group achieved a clinically meaningful response, compared to nearly 30 % in the low-intensity and over 20 % in the control group ($p = .03$). Higher intensity exercise led to the greatest improvement ($p < .006$), indicating that high-intensity training was the most effective treatment.

After a 6-month follow-up, Kerse et al. (2010) reported a decrease in depression scores for all participants compared to baseline ($p < .001$). However, the exercise intervention did not significantly reduce depressive symptoms more than social visits ($p = .916$).

One trial (Mota-Pereira et al., 2011) reported an improvement in all depression parameters for the exercise group compared to baseline ($p < .05$). A post-treatment comparison between the exercise and control groups showed significantly lower scores in HDRS ($p = .014$), BDI ($p = .016$), and CGI-S ($p = .033$) for the exercise group. However, participants in the exercise group had greater depression severity than the control group at baseline ($p < .05$).

Callaghan et al. (2011) found that participants in the exercise of preferred intensity group had lower depression scores ($p = .006$) compared to the exercise 'as usual' group.

Danielsson et al. (2014) observed improvements in symptom scores for the exercise group ($p = .038$). Additionally, the exercise group showed a significant improvement compared to the advice group ($p = .048$), and self-rated depression outcomes favoured exercise ($p = .036$).

Daley et al. (2015) found that the exercise-based intervention resulted in lower depression scores compared to TAU, but the difference between the groups was not significant ($p = .053$) until adjusted for baseline EPDS score and demographic variables ($p = .03$). The intervention led to a higher proportion of recovered participants (46.5 % vs. 23.8 %) when defined as a ≥ 4 points reduction and < 13 score in EPDS.

Huang et al. (2015) observed a reduction in depressive symptoms for all groups post-treatment, with 57.9 % of subjects in the exercise group, 61.1 % in the CBT group, and 30.0 % in the control group showing no longer depressive symptoms. However, the exercise group did not show significant superiority over the control or CBT group.

Pibernik-Okanović et al. (2015) reported a significant reduction in depressive symptoms post-treatment across all intervention groups (exercise, psychoeducation, and diabetes education), but no significant differences were found between the groups.

Schuch et al. (2015) found significantly lower depression scores in the exercise group compared to usual care after the intervention ($p = .005$). However, there were no significant differences in remission ($p = .248$) or response rates ($p = .114$) between the groups at post-treatment.

In the REGASSA study (Strid et al., 2016), both the exercise and active comparator groups showed larger improvements in depressive symptoms compared to controls ($p < .001$), with clinically significant improvements in all three treatment groups from baseline to post-treatment. The treatment effect of exercise and iCBT was similar. Stratified analysis by age favoured exercise and iCBT ($p < .001$), except among younger participants (aged 18–34 years) where the group differences were not statistically significant ($p = .40$).

Lok et al. (2017) found that the exercise group showed a significant decrease in BDI scores after the intervention compared to controls ($p = .005$).

De Groot et al. (2019) reported a significant reduction in BDI-II depression scores after all three interventions compared to usual care (exercise group: $p = .021$, CBT + exercise group: $p < .001$, CBT: $p = .011$). Post-treatment, remission rates varied from 72 % in the exercise group, 71 % in the CBT + exercise group, 66 % in the CBT group, and 32 % in the usual care group. Participants in the intervention groups also reported greater improvement in negative automatic thoughts compared to the TAU group (exercise $p = .006$, exercise + CBT $p = .010$, CBT $p = .018$).

In contrast, Abrahão et al. (2016) found no positive influence on depression for either the cardiovascular or resistance training intervention. BDI scores did not change over time and did not significantly differ between the exercise and control groups after the intervention.

In the long-term follow-up assessment, Daley et al. (2015) found no significant differences in depression scores between participants who received the 6-month exercise intervention and those treated as usual.

Huang et al. (2015) reported decreased depression scores in the exercise group compared to baseline at post-treatment ($p = .003$), 3-month ($p = .012$), and 6-month follow-up ($p = .037$). Both the CBT and exercise groups had fewer participants with depressive symptoms than the control group at the 6-month follow-up. While the decrease in GDS scores immediately after treatment was non-significant between the exercise and CBT groups, the effect of exercise lasted longer as the CBT group did not show significantly decreased symptoms at 3 or 6-month follow-up.

After a 12-month follow-up, Kerse et al. (2010) found no differences between groups regarding depressive symptoms ($p = .269$). However, the number of participants with GDS-15 scores suggesting depression (>4) decreased from 29 % to 18 % ($p = .015$).

4. Discussion

In this systematic review, we found that the success of exercise-based interventions on functioning in people with transdiagnostic depressive symptoms when compared with any other active control group or TAU depends on factors such as baseline functional status, intervention intensity, supervision during exercise, and delivery method (15 trials, 2064 participants). Some trials demonstrated the expected beneficial effects of exercise on functioning (7/15) (Singh et al., 1997; Singh et al., 2005; Mota-Pereira et al., 2011; Huang et al., 2015; Abrahão et al., 2016; Strid et al., 2016; Lok et al., 2017).

Recently, there has been a surge in reviews examining the effects of exercise interventions on depressive symptoms. Over 80 reviews in the past five years have evaluated different forms of exercise in randomised clinical trials for their effectiveness in treating depressive symptoms. However, most of these reviews primarily focused on standard clinical measures, with only a few assessing functioning parameters as primary outcomes. In fact, <5 % of the clinical trials measure and report functional outcomes (McKnight and Kashdan, 2009).

Long-term studies on the impact of exercise-based interventions on functioning were limited in this review. None of the included trials assessed outcomes beyond 9 months after the interventions. Only five trials examined long-term follow-up changes (Klein et al., 1984; Kerse et al., 2010; Daley et al., 2015; Huang et al., 2015; Strid et al., 2016), indicating that the benefits may be relatively short-lived. Among these trials, no significant differences were found between exercise and comparator groups. However, one trial indicated that both exercise (various modalities and intensities) and iCBT were more effective than TAU in reducing psychological functioning impairment during long-term follow-up (Strid et al., 2016).

Most studies support the benefits of adjunctive exercise interventions on illness outcomes, despite variations in intervention format, duration,

settings, comparison groups, and participant conditions. The interventions that showed the most significant improvement in functioning lasted 8–12 weeks, with frequencies ranging from 3 h to four days per week. Though it is challenging to establish a generic prescription due to the unclear dose-response relationship between activity and depression, even minimal physical activity below major public health recommendations build up on its benefits (Pearce et al., 2022). Similar to this study, other research has also noted substantial heterogeneity in prescriptions (Xie et al., 2021), making it difficult to determine the "ideal treatment" dose.

The ideal dose of physical activity remains uncertain due to high variability among studies. Recent data (Pearce et al., 2022; Hallgren et al., 2016) suggest that even small amounts of physical activity can benefit mental health, with the greatest impact observed when transitioning from inactivity to any level of activity. Additionally, a cohort study revealed that reducing time spent in moderate and vigorous physical activity negatively affects cognitive scores, implying that every minute of exercise provides benefits (Mitchell et al., 1978). While moderate exercise can be recommended with the principle of "the more, the better," it is important to consider a values-based approach to behavioural activation, encouraging individuals to engage in meaningful behaviours that promote long-term adherence to both physical and mental activities.

Adherence to exercise-based interventions is a major challenge. Tailoring exercise prescriptions to individual needs, abilities, limitations, and preferences is crucial (Knapen et al., 2015). Mental health benefits have been observed even below public health recommendations (Pearce et al., 2022). Delivery of interventions by qualified professionals, such as physiotherapists or physiatrists, enhances benefits and adherence (Stubbs et al., 2016). Inclusion of specialists enables adaptation of interventions to individual preferences, goals, and abilities, increasing adherence and maintenance of exercise (Firth et al., 2019). Multidisciplinary teams can provide clearer advice and training. Personalisation can be achieved by offering participants options for activity selection and recommending exercise plans based on their abilities and limitations, as suggested in the IDEA ongoing trial (García-Estela et al., 2021).

Functional assessment tools often overlap with indicators of quality of life, creating confusion and ambiguity in their conceptualisation. Both terms are frequently blended or interchanged with one another. The term "quality of life" is subjective and multidimensional, influenced by personal, social, and cultural factors (World Health Organization, 1996). Overall functioning encompasses physiological functions, activities, participation, and environmental factors. Some measurement tools provide dual outcomes, which is acceptable when outcomes belong to different domains. However, overlapping outcomes in quality of life and functioning domains can be problematic. This review identified studies (Singh et al., 1997; Singh et al., 2005; Kerse et al., 2010; Callaghan et al., 2011; Huang et al., 2015; Pibernik-Okanović et al., 2015; Abrahão et al., 2016) that reported quality of life outcomes using overall functioning measures, highlighting the conceptualisation gap.

4.1. Strengths and limitations

This review assesses exercise-based treatments for transdiagnostic depressive symptoms, focusing on improving functional outcomes/quality of life as the primary outcome. The included studies encompassed a range of symptom severities, including minor and major depression as well as subclinical symptomatology (Singh et al., 2005; Pibernik-Okanović et al., 2015). Although the sample heterogeneity might appear inconsistent, it enhances external validity as comorbid depressive symptoms are prevalent in a plethora of diseases.

Functional outcomes are crucial for assessing treatment response and understanding the impact of depressive symptoms. However, this review highlights that general functional outcomes are rarely used as primary measures in the treatment of depressive symptoms, with only two trials including them as such (Kerse et al., 2010; Abrahão et al., 2016). In most studies, functional outcomes are designated as secondary measures, potentially indicating inadequate statistical power to determine their effect size.

One limitation of this review is that it did not include trials of exercise-based interventions specifically targeting depressive symptoms in bipolar disorder. The available evidence does not differentiate between the impact of each polarity of bipolar disorder on functioning, which hinders a comprehensive understanding of the effect of exercise-based treatments on functioning outcomes. Additionally, there was an underrepresentation of studies focusing on somatic diseases compared to psychiatric illnesses. Overcoming these limitations is important for addressing functioning concerns in bipolar depression and expanding research on exercise interventions in somatic diseases.

Also, the selected studies in this review included adult and older adult populations, excluding children and youth due to not meeting the search criteria.

Unfortunately, the included articles did not systematically report side effects of exercise-based prescriptions using treatment-related side effects inventories. Therefore, there is a lack of evidence-based information on potential long-term problems associated with exercise in treating depressive symptoms. Future exercise-controlled trials should prioritise the estimation of side effects to address this gap.

Finally, a significant number (7/15) of the trials included in this review were not registered at their inception or retrospectively. This lack of transparency and incomplete reporting of the evidence raises concerns regarding bias and the authors' perception of physical exercise as a valid treatment for depressive symptoms. It is important to address this issue and ensure unbiased reporting in future studies.

5. Conclusions

Including exercise as a routine add-on treatment for individuals with transdiagnostic depressive symptoms, including subthreshold cases, can improve functioning/quality of life and symptom severity. Given the extensive evidence supporting the physical health benefits of exercise, it should be considered standard clinical practice to recommend exercise. To enhance effectiveness and adherence, two strategies should be considered: 1) evaluate individuals' abilities, limitations, and needs to create personalised exercise prescriptions with the help of qualified professionals, and 2) consider individuals' preferences and explore meaningful activities when designing exercise-based treatment plans. Even small doses of physical activity can have mental health benefits, particularly for those who have not previously engaged in exercise. However, the functional consequences of exercise-based treatments for depressive symptoms are often understudied, and existing RCTs have important methodological limitations. It is crucial for both researchers and healthcare professionals to expand their focus to include the functional outcomes of exercise interventions. Lastly, the development of exercise-based treatments that specifically target improvements in functional impairment is warranted.

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CRediT authorship contribution statement

Aitana García-Estela: Conceptualization, Data curation, Formal analysis, Methodology, Writing – original draft, Writing – review & editing. **Natalia Angarita-Osorio:** Data curation, Formal analysis, Methodology, Resources, Writing – original draft, Writing – review & editing. **Marlene Charlotte Holzhausen:** Data curation, Methodology. **Javier Mora-Salgueiro:** Formal analysis. **Víctor Pérez:** Supervision, Validation. **Esther Duarte:** Resources, Validation. **Guy Faulkner:** Supervision, Validation, Visualization. **Francesc Colom:** Conceptualization, Supervision, Validation, Writing – original draft, Writing – review & editing.

Declaration of competing interest

None.

Availability of data and material

The data are available from the corresponding author upon reasonable request (e.g., wanting to reproduce the review, data validation, or addressing limitations).

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Appendix. Supplementary data

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