

Dimensions of Physical Activity Are Important in Managing Anxiety in Older Adults: A Systematic Review and Meta-Analysis

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Physical activity (PA) is a known approach for managing anxiety symptoms in older adults. This systematic review and meta-analysis address the benefits of PA and its dimensions (frequency, session time, type, and intervention period) on anxiety symptoms in older adults aged 65 years and above. Searches covered eight databases reporting eight randomized controlled trials (RCTs) and five non-RCTs. Meta-analysis of RCTs (standardized mean difference = -0.41 ; 95% confidence interval $[-0.58, -0.24]$; $p < .00001$) and Fisher's method of combining p values for non-RCTs supported the effectiveness of PA for managing anxiety symptoms in older adults. Subgroup analysis revealed significant effects for all PA types, session times, frequency, and intervention periods compared with control groups, albeit with different magnitudes of effect. In conclusion, although some dimensions of PA contribute to its effectiveness for anxiety, PA intensity and mode required to maximize PA effects remain unclear.

Keywords: aging, intervention, intervention period, session time, PA frequency, PA type

Anxiety disorder is one of the most common wide-reaching mental health problems (Baxter et al., 2014). In 2019, the world-wide anxiety disorder incidence and prevalence was estimated to be 45.82 million and 301.39 million, respectively, and accounted for 28.68 million disability-adjusted life years lost (Yang et al., 2021). This is to say, substantial years of good health are lost to anxiety disorders. Though anxiety disorders are reported in all age groups, they are increasingly common in older adults affecting between 14% and 17% of the older adult population worldwide (Canuto et al., 2018; Kirmizioglu et al., 2009; Wolitzky-Taylor et al., 2010). Anxiety disorders in the aging population have become an increasing concern globally. This is not surprising, considering the aging population with an estimated increase in people aged over 60 years from 1 billion in 2020 to 1.4 billion by 2030 and 2.1 billion by 2050 worldwide (World Health Organisation, 2021).

Older adults are thought to be predisposed to diagnosed and undiagnosed anxiety problems as a result of reduced social support, increased prevalence of chronic disease, loss of independence, fear of death, and the loss of self-esteem associated with the process of aging (Alipour et al., 2009; Boyd, 2008). According to the Diagnostic and Statistical Manual of Mental Disorders, anxiety disorders are characterized by feelings of excessive and persistent worry, fear,

and apprehension, which can be further classified into generalized anxiety disorder, separation anxiety disorder, selective mutism, specific phobia, panic disorder, social phobia, and agoraphobia (American Psychiatric Association, 2013). These characteristics, though dependent on the type of anxiety, negatively impact on the well-being and quality of life of older adults (Olatunji et al., 2007; Vancampfort et al., 2017). The negative effects or symptoms of anxiety are usually a result of a disproportional reaction to the threat causing it. However, feelings of anxiety are not always negative, but can also be important in protecting one from danger in terms of the fight or flight response, making it essential for survival (Gutiérrez-García & Contreras, 2013).

Strategies to reduce the negative symptoms of anxiety have therefore been a valid subject of constant investigation. Pharmacotherapy and psychotherapy have traditionally been used to manage anxiety symptoms and disorders. However, such approaches although commonly used, do have disadvantages compared with lifestyle interventions such as physical activity (PA). PA has been defined as any bodily movement produced by skeletal muscles that involves energy expenditure (Caspersen et al., 1985; World Health Organization, 2020a) and typically occurs within four domains: occupational, household, leisure, and commuting activities (Strath et al., 2013). Exercise is a form of PA which is planned, structured, and repetitive leading to improvement in physical fitness, whereas sports is a form of PA that is competitive (Caspersen et al., 1985). Examples of PA especially for older adults include walking, yoga, resistance exercise, aerobic exercise, dance, and tai chi (Kazeminia et al., 2020). Compared with PA, pharmacotherapy and psychotherapy have been proven to be less efficient and more costly, leading to the emergence and adoption of PA as a means to reduce the negative impact of anxiety symptoms and/or disorders in older adults (Chisholm et al., 2016; Kandola et al., 2018; Olthuis et al., 2016). PA not only has positive effects on managing anxiety symptoms and/or disorders but also wider benefits such as stress relief, improved physical functioning, and social well-being, and fewer side effects than drug treatments (Heaney et al., 2010, 2011, 2014). As a result of the diverse benefits of PA, the World Health Organization (WHO) recommends that adults aged 65 years and


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above should engage in moderate-intensity (150–300 min) or vigorous-intensity (75–150 min) aerobic exercises weekly and at least 3 days of multicomponent exercise to achieve added benefits (World Health Organization, 2020b).

Several psychological mechanisms such as self-efficacy and distraction have been proposed to explain the effects of PA on anxiety symptoms and/or disorders (Anderson & Shivakumar, 2013). One proposed mechanism is that of anxiety sensitivity and exposure, such that when an individual is exposed to a feared anxiety-related sensation such as rapid heartbeat in the context of PA, it increases the tolerance for, and manages the psychological reaction to, similar sensations in the context of anxiety symptoms and/or disorders (Ströhle et al., 2009). PA exposure is thought to explain the negative correlation between anxiety-related sensations and exercise frequency (Broman-Fulks & Storey, 2008; Smits et al., 2008).

Numerous studies have been conducted in line with the anxiolytic effects of PA among the general population (Biddle & Asare, 2011; Dale et al., 2019; de Souza Moura et al., 2015; Herring et al., 2010; McDowell et al., 2019). In a systematic review of 10 studies, a narrative synthesis revealed a positive impact of PA combined with occupational therapy and lifestyle changes in a general population diagnosed with a variety of anxiety disorders (de Souza Moura et al., 2015). In this review, other interventions were combined with PA interventions, thus the results reported do not reflect the independent contribution of PA in reducing the impact of anxiety disorders (de Souza Moura et al., 2015). Likewise, a meta-analysis reported that PA interventions, motivational, and educational sessions to promote increased PA improved anxiety symptoms in healthy older adults with no known diagnosis of anxiety (Conn, 2010). Also, Conn (2010) revealed weekly and total dose (in minutes) of PA were not associated with reduced anxiety symptoms but moderate- to high-intensity PA significantly lowered anxiety symptoms. In contrast, Bartley et al. (2013) found no significant effects of PA on anxiety disorders in a meta-analysis of seven trials. The results from this study were deemed to have been affected by control conditions as a significant effect was seen when analysis was limited to studies with nonintervention controls (waitlist or placebo control conditions) but not when controls also received an intervention (such as nonaerobic activity). This review also focused on people diagnosed with an anxiety disorder and did not capture others who have anxiety symptoms but no formal diagnosis. Again, a recent systematic review in populations younger than 65 years with elevated anxiety symptoms or diagnosed anxiety found PA to be a useful treatment option for anxiety symptoms and disorders in comparison with placebo but no significant difference when compared with other forms of treatment such as cognitive behavior therapy and medication, regardless of the methodological limitations of the included studies (Stonerock et al., 2016). While there is a vast amount of literature on PA and its importance in managing anxiety symptoms and/or disorders, there is less emphasis on older adult populations. In addition, PA dimensions (frequency, intensity, time [session time, in minutes], type, and intervention period [in weeks]) in general populations have been addressed (Conn, 2010) but, again, there is a paucity of research on how relevant PA dimensions are in boosting the effectiveness of PA in older adults.

Of those studies that have explored the benefits of PA in managing the negative effects of anxiety symptoms and/or disorders in older adults, very few have highlighted the role of PA dimensions (Kazeminia et al., 2020; Mochcovitch et al., 2016). The dimensions of PA are important in planning and assessing its effectiveness (Strath et al., 2013) as well as informing future PA interventions for

older adults. Among the few systematic reviews with an emphasis on older adults, regular and supervised exercise reduced anxiety symptoms in older adults with no diagnoses of anxiety disorders (Mochcovitch et al., 2016). Similarly, a recent systematic review stated sports significantly reduced anxiety symptoms in older people in a meta-analysis of 19 studies (Kazeminia et al., 2020). There are several limitations in current reviews investigating PA and its anxiety reducing effects in older adults. These systematic reviews carried out in populations of older adults have focused on the overall effectiveness of PA and not on the dimensions of PA that contribute to its effectiveness (Kazeminia et al., 2020; Mochcovitch et al., 2016). Also, the age range for older adults in studies included in reviews has been inconsistent and has included populations 50 years and older. According to the World Health Organization, older adults are considered as 65 years and above (WHO Study Group on Aging and Working Capacity & World Health Organization, 1993). In addition to this, reviews have not captured unpublished studies such as gray literature. Gray literature is described as relevant information produced by government, businesses, or academic bodies but not disseminated by commercial publishers (Paez, 2017). Gray literature can be in the form of theses, dissertations, conference papers, and reports which contribute to the pool of scientific knowledge and help to reduce publication bias (Paez, 2017). Last, anxiety symptoms such as fear and worry are seen as normal among the aged, thus mostly undiagnosed in older adults (Mochcovitch et al., 2016). This is to say, focusing solely on older adults diagnosed with an anxiety disorder was not a good representation of older adults living with the undiagnosed negative effects of anxiety symptoms.

Consequently, this sets the context for analyzing the scientific evidence including gray literature on the effects of PA on anxiety symptoms and/or disorders among older adults aged 65 years and older. The main aim of this systematic review and meta-analysis was to assess the impact of PA on anxiety in older adults aged 65 years and above with existing anxiety which includes, with or without, a formally diagnosed anxiety disorder. The secondary aim of this review was to understand the dimensions of PA best for maximizing the effect on anxiety symptoms and/or disorders and to inform the design of future PA interventions.

Methods

This systematic review and meta-analysis were conducted in line with the 27-item checklist PRISMA 2020 statement which guides reporting of a clear and accurate systematic review (Page et al., 2021). The protocol for this review was registered with PROSPERO, protocol number CRD42021253424 on May 6, 2021.

Eligibility Criteria

The inclusion criteria for studies were categorized into Population, Intervention, Comparator, and Outcome. All included studies met the following conditions under each Population, Intervention, Comparator, and Outcome category. The population was older adults aged 65 years and above of all genders and from different settings including community dwelling, outpatients, residential care homes, and supported housing or assisted living facilities. PA and/or exercise were the interventions considered. PA and/or exercise interventions were compared with control groups with no physical activity, no exercise, or groups receiving usual care. This review and meta-analysis focused on changes in levels or severity of anxiety symptoms following a PA intervention as the outcome. For the purpose of this review, anxiety is considered as the exaggerated

response to a threat that negatively affects well-being and presents itself as anxiety symptoms and/or a diagnosed form of anxiety disorder. In addition to the above criteria, designs of included studies were restricted to intervention studies including randomized controlled trials (RCTs), non-RCTs, feasibility, and pilot intervention studies. The inclusion of intervention studies only narrowed the scope of this review to best inform future intervention studies. Only studies reported in English were included.

Search Strategy

The search for relevant studies was conducted in the following electronic databases: PubMed, CINAHL, PsycINFO, Cochrane Central Register of Controlled Trials, Web of Science, and Clinical trials.gov. Gray literature was included hence searches were also made in Google Scholar and Open Grey. The reference lists of eligible studies were also searched manually to capture additional studies. Searches were carried out in May 2021 with no limit on the date range of included studies. A search strategy and search terms suitable for each database are included in the [Supplementary Material S1](#) (available online). Search alerts were created for electronic databases which give notifications of newly published studies, biweekly, through email. Search results from databases were imported into EndNote Reference Management (version X9) software. Two reviewers (Ofosu and de Nys) independently screened titles and abstracts using Rayyan software ([Ouzzani et al., 2016](#)). Subsequently, full texts of potentially eligible studies were screened by the reviewer (Ofosu) to further check for eligibility. All conflicts at different stages of screening were resolved by the two reviewers through discussions leading to a consensus, with availability of a third reviewer if necessary (Whittaker).

Risk of Bias Assessment for Included Studies

In this systematic review, risk of bias for the included studies was assessed. Risk of bias evaluates how authors of included studies carried out their respective studies, analyzed, and reported results. Similar to the screening process, two reviewers independently assessed the risk of bias of both RCTs and non-RCTs using Cochrane risk of bias assessment (RoB 2) tool ([Sterne et al., 2019](#)) and Joanna Briggs Institute (JBI) critical appraisal tool ([Tufanaru et al., 2017](#)), respectively. The Cochrane risk of bias assessment tool assessed risk of bias of RCTs under six domains: randomization process, deviations from intended interventions, missing outcome data, measurement of outcome, and selection of reported results ([Sterne et al., 2019](#)). The RoB 2 tool proposes a level of risk of bias for each domain, and each reviewer made a final informed judgment to accept or change the purported risk of bias assessment. Subsequently, an overall risk of bias assessment was made, based on the algorithm mapping responses and judgments under each domain. A “high” or “some concerns” risk of bias judgment implied a level of bias in trials consequently reducing the confidence in results ([Sterne et al., 2019](#)). A summary of the overall risk of bias of all included RCTs generated from the risk of bias visualization tool ([McGuinness & Higgins, 2020](#)) is shown in the [Supplementary Material S2](#) (available online). The JBI critical appraisal tool for nonrandomized experimental studies is a checklist of nine items that assess manipulation of variables, similarity in comparison groups, presence of control group, measurement of outcomes, and statistical analysis ([Tufanaru et al., 2017](#)). An overall appraisal was made based on reviewers’ independent response to all items to include, exclude, or seek further

information (see [Supplementary Material S3](#) [available online] for JBI critical appraisal summary).

Data Extraction

For each study, extracted data where possible covered reported sociodemographics (age, country, gender, and settings), characteristics of participants (sample size and health status), intervention details in line with frequency, intensity, time session time/intervention period, and type principles ([Pescatello et al., 2014](#)); mode of PA delivery; setting; comparison group; and outcome (measure of anxiety). Data were independently extracted by one reviewer (Ofosu), and the second reviewer (de Nys) cross-checked extracted data sheet. There were no conflicts at the stage of data extraction. Change in anxiety reported as a continuous outcome led to the extraction of means/mean change, *SDs*, and *p* values. Postintervention anxiety scores ($M \pm SD$) were used in data synthesis. For studies that did not report mean and *SD*, other quantitative metrics such as medians, interquartile range, *SEs*, effect sizes, *t* or *p* values, and confidence intervals were used to compute *M* and *SDs* ([Luo et al., 2018](#); [Wan et al., 2014](#)). Also, the Review Manager (RevMan version 5.4.1) calculator was used to combine outcomes from two or more arms of PA intervention ([Review Manager \(RevMan\), 2020](#)).

Data Analysis

For included RCTs, data were analyzed using RevMan (version 5.4.1; [Review Manager \[RevMan\], 2020](#)). A random effects model was used in meta-analyses because studies differed indicating heterogeneity; therefore, an overall effect size cannot be assumed ([Borenstein et al., 2009](#); [Higgins et al., 2021](#)). Small, moderate, and large effect sizes were estimated for continuous outcomes using the standardized mean difference (SMD). The SMD approach was adopted since all studies measured the primary outcome—anxiety, using different psychometric scales, hence the need for the standardization ([Higgins et al., 2021](#)). In addition, anxiety was measured as a continuous outcome further informing the calculation of standardized mean differences for the eight RCTs in the meta-analysis ([Faraone, 2008](#)). The included non-RCTs included either none or minimal statistical information other than *p* values and effect direction which resulted in the choice of combining *p* values as an acceptable method of synthesis visually displayed as an albatross plot as opposed to SMDs ([Borenstein et al., 2009](#)). Furthermore, the included non-RCTs had methodological heterogeneity making meta-analysis inappropriate ([Achana et al., 2014](#); [Harrison et al., 2017](#)). *p* values were combined using the Fisher’s method ([Fishers, 1932](#)).

Investigation of Heterogeneity and Subgroup Analysis

Heterogeneity of studies was presented as a statistical test, generated in RevMan along with forest plots from meta-analysis. The I^2 statistic was the measure of heterogeneity given in percentages ranging from: not important (0%–40%), moderate (30%–60%), substantial (50%–90%) to considerable (75%–100%; [Deeks et al., 2021](#)). Subsequently, a subgroup analysis was conducted to address issues of heterogeneity. In this review, subgroups compared were categorized under PA frequency (number of sessions per week), time (session time in minutes), type, and intervention period (in weeks). These subgroups are a part of the dimensions of PA which are integral in understanding how PA is assessed for clinical and research applications as well as for determining

exercise prescription (Pescatello et al., 2014; Strath et al., 2013). Due to missing data for most studies on the measure of PA used, the intensity of PA as a subgroup comparison was not able to be assessed. Also, mode of PA as a subgroup was modified to PA type, as most PA interventions in included studies combined two or more types of PA or exercise in an intervention. In addition, PA frequency and time (session time) were analyzed in one subgroup analysis because there were not adequate studies under each group to qualify for a split subgroup analysis. Last, due to considerable heterogeneity between studies regarding the type of anxiety measured or anxiety measure used, and lack of detail regarding type of anxiety assessed in some studies, it was not possible to conduct a meaningful subgroup analysis to assess the impact of different anxiety types/measures.

Subgroups under each category were as follows: for frequency/session time—low (<60 min of PA, three times a week) or high (60 min of PA, three times a week); for type—single (one type of exercise) or mixed (multiple types of exercises) PA; and for intervention period—short (<12 weeks) or long (≥ 12 weeks). Subgroups were categorized based on the most common PA frequency, time (session duration), type, and intervention period extracted from included studies.

Publication Bias

There was the need to assess publication bias (the possibility of studies with statistically significant results being more likely to be published over studies with nonsignificant results) in this systematic review. Egger's test was used to assess publication bias (Egger et al., 1997). The presence of publication bias was addressed using the trim and fill analysis. The trim and fill analysis imputes potentially missing studies due to publication bias and provides a bias-adjusted overall effect estimate (Jin et al., 2014).

Results

Search Results

An initial 6,106 studies were retrieved, of which 1,541 duplicates were removed. Screening of titles and abstracts further excluded 4,299 studies, leaving 266 studies for full-text retrieval and screening. Following full-text screening, there were 13 included studies (see Figure 1 PRISMA diagram). Among these 13 studies, there were eight RCTs and five non-RCTs. The majority of studies excluded were due to wrong population (participants aged below 65 years), wrong intervention (no PA or exercise), wrong study design (longitudinal, cross-sectional, and observational studies), wrong outcome (no anxiety measure), wrong comparison (other forms/types of PA), and others (foreign language, wrong publication type—conference abstracts and wrong intervention period—acute single bout of PA or exercise). Full text of four studies was not retrieved due to the inaccessibility and nonresponse from corresponding authors following article requests.

Risk of Bias for Included Studies

Six out of the eight RCTs had an overall low risk of bias in design, conduct, and reporting of the studies, whereas the remaining two studies were rated with some concerns in deviations from intended intervention and randomization process, respectively, (see Supplementary Material S2 [available online] for Cochrane RoB

2 summary). The five non-RCTs were appraised and judged to be suitable to be included in this review, as there was no risk of bias (see Supplementary Material S3 [available online] for JBI critical appraisal summary). Generally, there was no detection of a high risk of bias in method and conduct in any included study.

Study Characteristics

Participants

A total of 719 older adults (age range 65–97 years) were included across all 13 studies. With the exception of one study (Cassilhas et al., 2010) which included only males, the majority of study participants were female (57.3%). Participants from nine studies were generally healthy with no known or diagnosed medical conditions, whereas participants from the remaining four studies were diagnosed with heart failure, dementia, and chronic obstructive pulmonary disease. Participants were recruited from the community, care homes, and clinics across the United Kingdom ($n = 3$), the United States ($n = 4$), Brazil ($n = 2$), Canada ($n = 1$), Denmark ($n = 1$), Iceland ($n = 1$), and Italy ($n = 1$). Two studies (Pedersen et al., 2016; Sigurðardóttir, 2014) showed up to 39% to 49% dropout due to less interest, lack of time, injuries, and pain both related and unrelated to the intervention. The remaining studies showed low to no dropout also as a result of participants' inability to make time, medication use, dislike of intervention, personal circumstances, hospitalization, death, and injuries unrelated to the intervention.

Intervention Characteristics

Intervention characteristics are shown in Table 1. Studies adopted various types of PA or exercises including resistance or strength training, aerobic exercise, yoga, and dance. Eight out of 15 studies incorporated two or more types of PA in the interventions with the remaining five focusing solely on resistance or strength exercise (Cassilhas et al., 2010; Swales et al., 2022; Zanusso et al., 2012) or dance (Vaccaro et al., 2019; Wshah et al., 2019). The frequency varied widely across all studies with PA interventions carried out once or twice per week for a few studies ($n = 4$) and up to three to four times for all others. For intervention period and session time, a minimum period of 6 weeks and a maximum of 24 weeks were recorded with the shortest PA session time (Pedersen et al., 2016) lasting about 12 min and the longest (Vaccaro et al., 2019) for 120 min in a single session. All interventions, except one (Aguiñaga et al., 2018), were supervised in groups by researchers, care home staff, certified dance instructors, and professionals (physiotherapists, physiologists). That one study was neither supervised nor carried out in a group (Aguiñaga et al., 2018). Nine studies reported the setting of the PA intervention to be participants' homes, research centers, dance school facilities for older adults, and health centers. PA interventions for the RCTs were compared with no exercise, waitlist, social games, or a healthy aging video (see Table 1, for full details). On the contrary, non-RCTs were not compared with any other group except for one study (Sigurðardóttir, 2014) that had a "no exercise" control group. In addition, authors recorded adverse events unrelated to the intervention such as injury, illness, hospitalization, and death, with the exclusion of one study (Pedersen et al., 2016) where participants reported that trainings (resistance training and team sports) were intense resulting in minor injuries (muscle-tendon soreness) and feelings of pain during the intervention. At the occurrence of any minor injuries, participants were exempted from training until recovery (Pedersen et al., 2016).

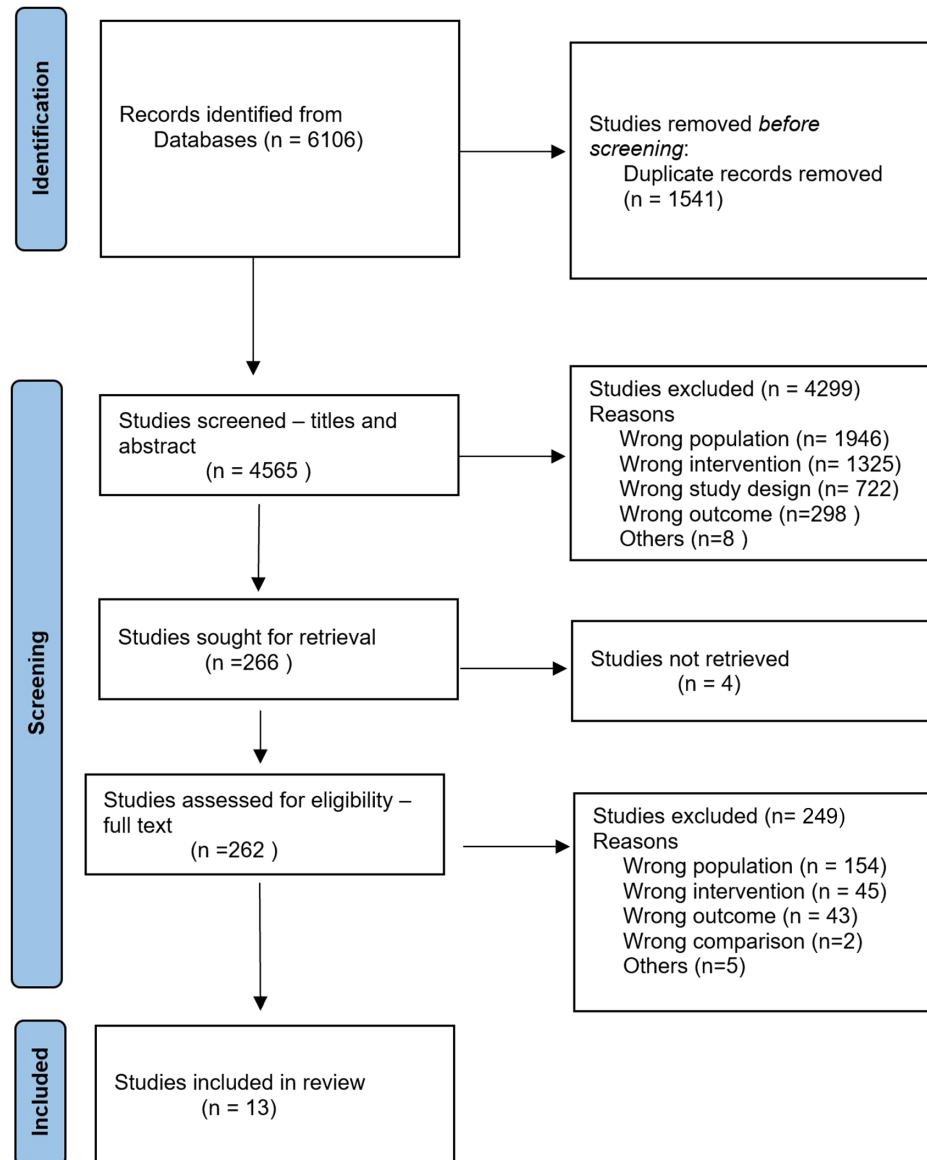


Figure 1 — PRISMA flow diagram of search and screening stages.

PA Measures

For most studies, PA itself was not measured; rather physical function and fitness were assessed. The few studies (Aguinaga et al., 2018; Pedersen et al., 2016; Witham et al., 2008; Wshah et al., 2019) in which PA was measured used both objective and self-reported measures such as Godin Leisure-Time Exercise Questionnaire (Godin & Shephard, 1985) and accelerometers.

Anxiety Measures

Anxiety was measured in all included studies using self-reported measures. The most common measure used was the Hospital Anxiety and Depression Scale (Zigmond & Snaith, 1983) reported in five studies in different languages (English and Danish). Second to this was the State Trait Anxiety Inventory (Spielberger & Gorsuch, 1983) used to assess anxiety in five studies. The remaining studies used either the Beck Anxiety Inventory (Brazilian-adapted version; Cunha, 2011), Generalized Anxiety Disorder Assessment (Spitzer et al., 2006), or Philadelphia Geriatric Center

Apparent Affect Rating scale (anxiety component; Lawton et al., 1996).

Analysis of Included Studies

Meta-analysis was carried out for the eight RCTs to assess the effect of PA on change in anxiety (Figure 2). There was a significant small negative effect that supported the effectiveness of PA in reducing anxiety in comparison with control conditions (SMD = -0.41; 95% confidence interval [CI] [-0.58, -0.24]; $p < .00001$). Low or no heterogeneity was recorded, $\chi^2(7) = 6.63$, $p = .47$; $I^2 = 0\%$.

For non-RCTs, p values of all five studies were combined using the Fisher's approach (Fishers, 1932; see Supplementary Material S4 [available online] for summary of pooling p values). Associated with this analysis is an albatross plot (Figure 3) which shows that there was a significant negative association favoring the beneficial impact of PA on the change in anxiety symptoms (Fisher's method [left]: $9.36e-04 = -0.000936$), with the exception of one study with an

Table 1 Summary of Extracted Data and Study Characteristics

Studies	N	Age (M/R)	(%) F	Loc	Health status	Type of PA	Duration, pw	PA supervision	PA Delivery	Measure for PA	Setting	Control group	Measure of anxiety
Aguinaga et al. (2018)	307	70.62 (INT) 71.43 (CON)	76.87%	United States	Generally healthy	Flexibility, Toning, and balance	24 weeks/at least 15 min	Nonsupervised	I	Godin Leisure-Time Exercise Questionnaire	Home	Healthy aging DVD	HADS
Bonura and Pargman (2009)	42	83.14	92.86%	United States	Generally healthy	Chair yoga/ chair aerobic/ walking	6 weeks/ 30 min/3 times pw	Supervised for chair	G and I	NR	NR	Social games	STAI
Bonura and Tenenbaum (2014)	98	77.04	69.81%	United States	Generally healthy	Chair yoga/ chair exercise	6 weeks/ 45 min/1 times pw	Supervised—Yoga instructor	G	NR	Facility for older adults	Waitlist	STAI—State subscale
Cassilhas et al. (2010)	43	65–75	0%	Brazil	Generally healthy	High resistance exercise	24 weeks/ 60 min/3 times pw	Supervised—Principal researcher/highly specialized auxiliary professionals	G	NR	Psychobiology and Exercise Research Center	No high resistance training	STAI
Pedersen et al. (2016)	44	67–93	56.82%	Denmark	Generally healthy	Team sports and resistance exercise	12 weeks/ 12–20 min/ 3 times pw	Supervised—elderly center's staff	G	Triaxial accelerometer	Older adults center	No exercise	HADS—Danish version
Swales et al. (2022)	11	86.09	63.64%	United Kingdom	Frail	Resistance training—machine based	6 weeks/ 60 min/3 times pw	Supervised—researcher	G	NR	Care home	Waitlist	HADS
Vedovelli et al. (2017)	29	80–97	100%	Brazil	Generally healthy	Resistance/ strengthening/ walking	12 weeks/ 60 min/3 times pw	Supervised—Physiotherapist/ assistants	G	NR	Residential home courtyard	No exercise	Brazilian Adapted Beck Anxiety Inventory
Zanuso et al. (2012)	20	74.3 (INT) 67.1 (CON)	50%	United Kingdom	Generally healthy	Strength and resistance exercise	12 weeks/ 60 min/3 times pw	Supervised—exercise professional	G	NR	NR	waitlist	STAI—Trait subscale
Edwards et al. (2008)	36	84.6	86.10%	United States	Moderate to severe dementia	Moderate-intensity chair based exercise	12 weeks/ 30 min/3 times pw	Supervised—Exercise physiologists and 2 research assistants	G	NR	Nursing homes	NR	Philadelphia Geriatric Center Apparent Affect Rating scale—Anxiety component
Sigurðardóttir (2014)	27	77.85	62.96%	Iceland	Generally healthy	Low-intensity aerobic/fitness-tance/strength training	12 weeks/ 40 min/2 times pw	Supervised	G	NR	NR	No exercise	Generalized Anxiety Disorder Assessment
Vaccaro et al. (2019)	25	71.2	68%	Italy	Generally healthy	Dance	24 weeks/ 120 min/4 times pw	Supervised—Two senior dance certified instructors	G	NR	Dance school	NR	STAI

(continued)

Table 1 (continued)

Studies	N	Age (M/R)	Age (%) F	Loc	Health status	Type of PA	Duration, pw	PA supervision	PA Delivery	Measure for PA	Setting	Control group	Measure of anxiety
Witham et al. (2008)	17	81.6	29.41%	United Kingdom	Heart failure with left ventricular systolic dysfunction	Aerobic/endurance/resistance/daily functional task	12 weeks/90 min/2 times pw	Supervised	G	Accelerometer	Outpatient—Medicine for the elderly clinics/local heart failure clinic	NR	HADS
Wshah et al. (2019)	20	73.4	70%	Canada	Chronic Obstructive pulmonary disease	Dance	8 weeks/60 min/2 times pw	Supervised—Professional dance instructors	G	Fitbit Charge two Physical Activity Tracker	West Park Health Care Center	NR	HADS

Note. RCTs = randomized controlled trials; non-RCTs = nonrandomized controlled trials; Loc = location; R = age range; INT = intervention group; CON = control group; HADS = Hospital Anxiety and Depression Scale; STAI = State-Trait Anxiety Inventory; NR = not reported; PW = per week; G = group; I = individual; PA = physical activity.

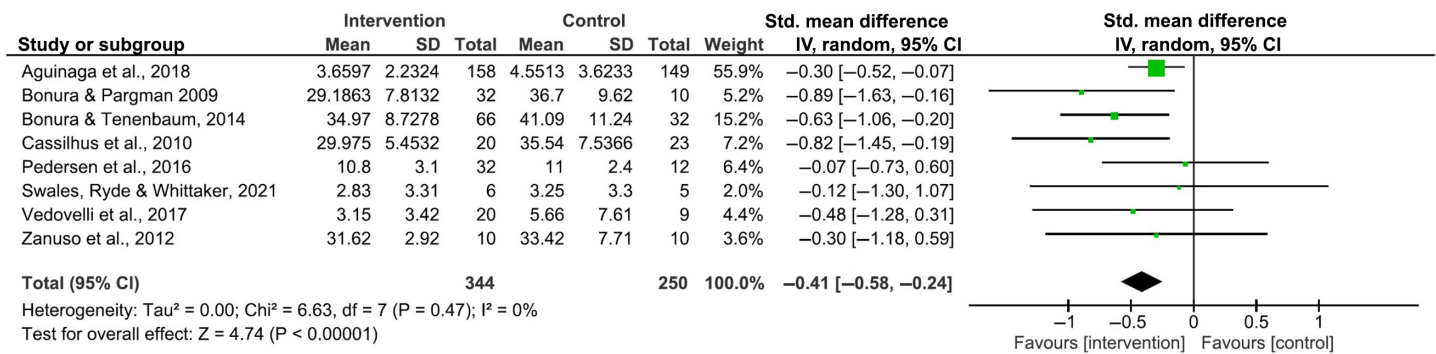


Figure 2 — Forest plot of the effect of PA on change in anxiety. PA = physical activity; CI= confidence interval.

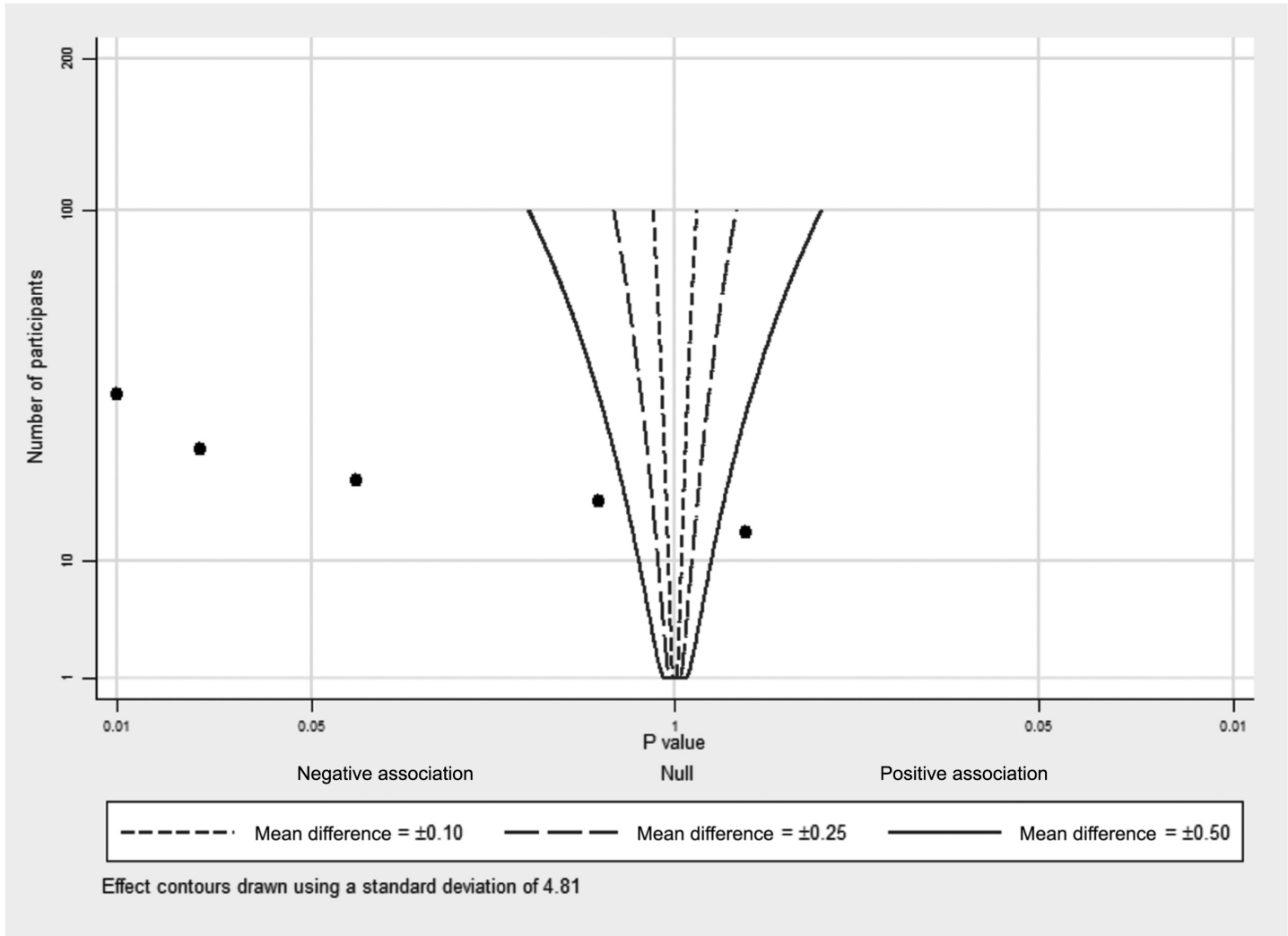


Figure 3 — An albatross plot of the effects of PA on anxiety with contours from mean differences. The above albatross plot is a scatter plot of the sample size of the five non-RCTs plotted against the p values reported for each study with the contours representing the mean difference effects. Each point represents a study with the smallest sample studies at the bottom and the largest at the top. PA = physical activity; RCT= randomized controlled trial.

insignificant positive association between PA and anxiety (Fisher’s method [right]: $9.74e-01=0.974$). Studies represented by points seen to the left of the albatross plot visually displays negative effects from the studies and to the right are the positive effects. In this review, it is clear studies generally conveyed negative effects as

majority of the studies (four out of five) are seen to the left of the plot implying a reduction in anxiety symptoms, and this plot confirms the results from the Fisher’s approach. Also, p values for strong negative results from studies are near zero, and p values for strong positive results are near 1, as seen in the plot. However, there is heterogeneity

of effect sizes as the points are scattered across the contours and not clustered around an effect size contour.

Subgroup Analysis

All subgroups (PA session times and frequencies, type, and intervention periods) were in comparison with control groups including no exercise (Cassilhas et al., 2010; Pedersen et al., 2016; Vedovelli et al., 2017), waitlist (Swales et al., 2022; Bonura & Tenenbaum, 2014; Zanusso et al., 2012), healthy aging DVD (Aguiñaga et al., 2018), and social games (Bonura & Pargman, 2009).

From the subgroup analysis, PA session times and frequencies lasting less than 60 min, three times a week had a significant small negative effect (SMD = -0.42; 95% CI [-0.70, -0.15]; $p = .003$) and low to moderate heterogeneity, $\chi^2(3) = 4.53$, $p = .21$; $I^2 = 34\%$. There was a significant moderate negative effect (SMD = -0.54; 95% CI [-0.95, -0.14]; $p = .009$) and no significant heterogeneity, $\chi^2(3) = 1.58$, $p = .66$; $I^2 = 0\%$, in the subgroup where the PA session lasted 60 min, with a frequency of three times a week. Therefore, both 60 min, three times a week of PA and PA for less than 60 min three times a week are effective when compared with the control groups even though there were variations in effect magnitude. Again, no differences, $\chi^2(1) = 0.23$, $p = .63$; $I^2 = 0\%$, were revealed for impact on anxiety between the subgroups of PA time (session time) and frequency (see [Supplementary Material S5](#) [available online] for forest plot).

There was a significant small negative effect of mixed PA type (SMD = -0.41; 95% CI [-0.62, -0.19]; $p = .0002$) with low heterogeneity, $\chi^2(4) = 4.60$, $p = .33$; $I^2 = 13\%$, compared with the control groups. A significant moderate negative effect (SMD = -0.56; 95% CI [-1.03, -0.09]; $p = .02$) was seen for one PA type with no heterogeneity, $\chi^2(2) = 1.55$, $p = .46$; $I^2 = 0\%$. This is to say both mixed and one PA type in comparison with the control groups were effective in reducing anxiety although the effect was larger for one type. There were no significant subgroup differences between mixed and one PA type, $\chi^2(1) = 0.35$, $p = .55$; $I^2 = 0\%$, (see [Supplementary Material S6](#) [available online] for forest plot), both relating to reduced anxiety.

Long and short PA intervention periods (long ≥ 12 weeks and short < 12 weeks) were compared with their respective control groups in a subgroup analysis (see [Supplementary Material S7](#) [available online] for forest plot). The subgroup analysis of long and short intervention period showed a significant small negative effect (SMD = -0.34; 95% CI [-0.53, -0.15]; $p = .0005$) for long intervention period and a significant moderate negative effect (SMD = -0.65; 95% CI [-1.00, -0.29]; $p = .0004$) for the short intervention period subgroup. There was no heterogeneity within individual subgroups of PA intervention period, long intervention: $\chi^2(4) = 3.19$, $p = .53$; $I^2 = 0\%$; and short intervention: $\chi^2(2) = 1.20$, $p = .55$; $I^2 = 0\%$; however, moderate to substantial heterogeneity was shown, $\chi^2(1) = 2.25$, $p = .13$; $I^2 = 55.5\%$, across both the long and short PA intervention periods. This means there were slight differences in the overall magnitude of impact of short PA intervention periods and long intervention periods each, compared with controls on anxiety, but both durations were effective, albeit, with heterogeneity across studies.

Publication Bias

The regression-based Egger test (Egger et al., 1997) was insignificant ($p = .07$), even though the standard funnel plot showed slight asymmetry (see [Supplementary Material S8](#) [available online]) suggesting a possible presence of publication bias among other reasons for funnel plot asymmetry (Sterne et al., 2011). A follow-

up trim and fill analysis (-0.93, 95% CI [-3.2, 1.36], $p = .426$; $I^2 = 68.2\%$, was conducted and the estimates were adjusted in the direction of the Egger's test (intercept = -0.29) which supported the possibility of publication bias as three additional studies were imputed (see [Supplementary Material S8](#) [available online]). However, this finding should be interpreted with caution as the Egger's test and funnel plots are more appropriate when the review involves 10 or more RCTs (Sterne et al., 2011).

Discussion

This systematic review and meta-analysis sought to explore the effectiveness of PA at reducing anxiety symptoms in older adults and the role PA dimensions (frequency, session time, type, and intervention period) play in PA effectiveness. PA was found to be effective in reducing anxiety in older adults, with small to moderate effect sizes. In addition to the overall effectiveness of PA, further analysis revealed dimensions of PA such as intervention frequency and session time, type, and intervention period influenced the effectiveness of PA in managing anxiety, such that all PA types, session times, frequency, and intervention periods were effective when compared with the control groups but showed moderate differences in effect magnitude. This implies that older adults aged 65 years and above with anxiety, whether formally diagnosed or undiagnosed can manage their anxiety levels by engaging in PA. They might take into consideration how long they exercise what type of PA they engage in and how frequently they exercise, as effects may be stronger for just one type of PA, shorter duration interventions, and PA sessions lasting 60 min, three times a week.

The above findings are not surprising as included studies with the exception of one by Sigurðardóttir (2014) found a significant negative association between PA and anxiety in older adults and these findings are reflected in the results of this review. This potentially supports the anxiety exposure and sensitivity mechanism which is that engaging in frequent exercise helps to manage anxiety-related sensations because bodily responses while exercising are likened to reactions when one is feeling anxious (Broman-Fulks & Storey, 2008; Smits et al., 2008). Thus, frequent exercise compared with none would increase such sensations and might be expected to make people less likely to catastrophize or respond in other negative ways to similar physical sensations associated with anxiety. However, other mechanisms may be responsible for this effect.

Like the present review, recent reviews such as Kazemian et al. (2020) and Mochcovitch et al. (2016) who looked at effects of PA on anxiety in older adults, but failed to explore the dimensions of PA, support the anxiety-reducing effects of PA. Several factors could account for the effectiveness of PA. As mentioned by Mochcovitch et al. (2016), regular and supervised PA increases the effectiveness of PA, and this can be seen in this present review as 93% of included studies were supervised by either health professionals or researchers. The presence of supervision may have served as a source of motivation to participants and increased PA adherence which can improve the effectiveness of PA. Also, the extensive knowledge trained supervisors have in PA may have contributed to the delivery of PA instructions during the intervention which could have improved the effects of PA on anxiety. This assumption is consistent with several other studies (Bonura & Pargman, 2009; Conn, 2010; Fennell, 2016; Kasim et al., 2020; Ntoumanis et al., 2017). In contrast, other studies suggest unsupervised PA is as effective as supervised PA (Aguiñaga et al., 2018; Atalay & Cavlak, 2012). However, there were not sufficient

unsupervised interventions in this review to be able to compare this in a subgroup meta-analysis.

In addition to this, group-based PA might have contributed to the benefits of PA on anxiety. A good number ($n=12$) of PA interventions reviewed in this study adopted a group-based mode of delivery. This is in line with findings from Burke et al. (2006) who concluded that, as the presence, contact and/or social support from others such as health professionals, researchers, and other participants increases during a PA intervention, so do the beneficial effects of PA. Other studies have also reported similar findings (Burke et al., 2006; Kahn et al., 2002; Komatsu et al., 2017; Smith et al., 2018). However, as stated before there were insufficient RCTs not conducted in a group to meta-analyze and compare this in the present review.

Further analysis revealed moderate effects for PA intervention periods that lasted <12 weeks, with those lasting longer than 12 weeks reporting a small effect both compared with control groups. This suggests PA intervention periods lasting less than 12 weeks or 12 weeks and more both reduce anxiety in older adults but vary in magnitude of effectiveness. It is uncertain what accounts for this finding, but it may be a result of better PA adherence over a shorter period as opposed to a longer period where enthusiasm might decrease with time. This finding may, however, be limited by the poor representation of studies with PA interventions less than 12 weeks included in the subgroup analysis and the moderate to substantial heterogeneity recorded between the subgroups. PA interventions of 12 weeks or more are widely recommended to be preferred and acceptable intervention time for managing anxiety in older adults and nine out of the 13 included studies supports this assertion. Notwithstanding this, acute, single bout, and short PA interventions have elicited similar positive effects in reducing anxiety in older adults (Bonura & Tenenbaum, 2014; Youngstedt, 2010). In agreement with this finding is a recent systematic review revealing PA intervention periods between 3 and 12 weeks significantly reduced anxiety as compared with no exercise (Herring et al., 2010). Notwithstanding this, efforts should be made to promote long-term engagement in PA and adherence strategies as anxiety is only managed or reduced after PA.

Another key finding of this review was the moderate effect of engaging in one type of PA, whereas there was a small effect for partaking in multiple types of exercise; however, both were effective when compared with the control groups. This implies engaging in either one single type or multiple types of PA reduce anxiety symptoms in older adults. It is worth noting that studies categorized under one type of PA largely were resistance training. Anxiety has been related to changes in cortisol and disruption in the hypothalamic-pituitary-adrenal axis (Chrousos, 2009; Vreeburg et al., 2010). Similarly, resistance training has also been associated with reducing cortisol levels, which can result in improved anxiety symptoms (Agha-alinejad et al., 2013; Strickland & Smith, 2014). Even though there is a paucity in studies drawing a direct connection between anxiety, cortisol levels, and resistance training, evidence supporting the anxiolytic effects of resistance training are robust (Cassilhas et al., 2010; Kucharski et al., 2019; Pedersen et al., 2016; Swales et al., 2022). For engaging in multiple modes of PA, despite the small effect reported in the current review, authors have encouraged the combination of different exercises in PA interventions to improve anxiety due to the benefit to other important outcomes such as physical function (Rezola-Pardo et al., 2020; Rogers et al., 2018).

Furthermore, there appear to be limited differences on anxiety with the frequency and session time of PA. From this review, PA

lasting 60 min three times a week is effective in reducing anxiety as is shorter PA sessions and a fewer number of sessions, but to a greater extent. This finding corresponds with the WHO guidelines on PA and sedentary behavior. The World Health Organization (2020b), recommends that older adults aged 65 and above should do at least 150–300 min of moderate-intensity aerobic PA or 75–150 min of vigorous-intensity aerobic PA weekly, plus 3 days of strength and balance activities to achieve health benefits across a range of outcomes. The WHO recommendations have been accepted worldwide as the benchmark. In addition, there is strong evidence that supports the benefits of more frequent exercise in managing anxiety symptoms and disorders (Cassilhas et al., 2010; Vedovelli et al., 2017; Zanusso et al., 2012). Notwithstanding this, engaging in less than 60 min of PA three times weekly (below WHO guidelines) has also been shown to be effective in reducing anxiety symptoms. Similar to this finding, Petruzzello et al. (1991) reported that at least 21 min of exercise elicited reductions in trait anxiety. In the same way, a report from the United States Department of Health and Human Services supports the efficiency of at least 10 min of exercise (Physical Activity Guidelines Advisory Committee, 2018). In association with findings on PA frequency, less emphasis has been placed on this dimension (Yang, 2019). Appropriate PA frequency and session time may, however, be dependent on the mode of PA (aerobic, resistance, strengthening, or balance and stability training) and the capabilities of older adults as the WHO and U.K. chief medical officer's physical activity guidelines and recommendations are in reference to aerobic and strength/resistance exercise (Department of Health and Social Care, 2019; World Health Organization, 2020b). It is worth noting that the lowest combined PA session time and frequency in the present review was 12 to 20 min, three times a week (Pedersen et al., 2016), which showed a significant effect for lower intensities in relation to relatively frequent PA, albeit not meeting WHO guidelines, thus PA frequency should be explored extensively along with PA intensity.

Strengths, Limitations, and Recommendations

The present review is the first where authors have highlighted the dimensions of PA and the extent to which they affect the effectiveness of PA on anxiety in older adults aged 65 years and above. Other studies have either recruited general populations, older adults below 65 years or have not compared the effectiveness of different PA dimensions (Herring et al., 2010; Mochcovitch et al., 2016). Furthermore, the possibility of ascertainment bias may have been reduced due to the inclusion of gray literature in this review (Sigurðardóttir, 2014). In the same way, there was low to no overall risk of bias for included studies implying results convey actual treatment effects (Higgins et al., 2011). Another strength is the use of a standard procedure to assess the risk of bias in RCTs. This review made use of the Cochrane risk of bias tool which is clear and concise with theoretical and empirical supporting evidence (Jørgensen et al., 2016). Additionally, the inclusion of RCTs reduces the probability of results being affected by confounding variables and biases that arise from placebo effect (Shrier et al., 2007).

There are, however, several limitations; one is that in most included studies the authors did not report how PA was measured or how intense the PA was. For this reason, subgroup analysis was not possible for PA intensity. Therefore, there is the need for future studies that explore the ideal PA intensity that maximizes effects on anxiety in older adults and to clearly report how PA was measured. A limitation of the studies included in this review is the high

dropout rates reported which may have limited findings of certain studies (Pedersen et al., 2016; Sigurðardóttir, 2014). Based on this, it would be worth exploring the association between PA adherence and its effectiveness in treating anxiety in older adults. Also, the method of analysis (combining *p* values) adopted for the non-RCTs has its own shortcomings as this does not reveal the magnitude of the effect. However, this method of analysis was appropriate because studies did not include any more statistical data other than *p* values. In addition, findings from non-RCTs that showed a significant negative association may have been as a result of an effect in only one study, therefore results should be interpreted carefully (McKenzie & Brennan, 2021). Another limitation was that searches were filtered to include studies in English language, which may have led to a possibility of ascertainment bias. This could not have been avoided as translation of studies was not feasible. Furthermore, participants in the included studies were generally healthy with no clinically diagnosed anxiety disorder or known anxiety symptoms except for in one study (Aguíñaga et al., 2018) where a subsample of participants with high baseline anxiety scores (≥ 8 on Hospital Anxiety and Depression subscale) were analyzed separately. The majority of generally healthy participants may have contributed to the small to moderate effects of PA observed. It is possible that larger effects may be seen in older adults diagnosed with anxiety disorders or high anxiety symptoms as reported in Aguiñaga et al., (2018), and this would be worth exploring in future studies. Last, findings from the Egger's test and funnel plot for assessing the presence of publication bias should be interpreted with caution as it is recommended that these analyses should be carried out for reviews with 10 or more included studies (Sterne et al., 2011).

Conclusion

This systematic review and meta-analysis presented the impact of PA on reducing anxiety symptoms in older adults aged 65 years and above. It highlights more beneficial levels of dimensions (frequency, session time, type, and intervention period) of PA interventions in achieving greater improvements in anxiety. In view of this, authors of future studies can make use of more appropriate PA frequencies, session times, types, and intervention periods in designing interventions. Incorporating these aspects and more have also been recommended for the accurate reporting of PA and exercise interventions (Hoffmann et al., 2014; Pescatello et al., 2014). Authors may want to consider engaging older adults in one or multiple types of PA over an intervention period of 6–24 weeks or up to 12 weeks lasting up to 60 min, three times a week or less as these are effective to achieve reduced anxiety symptoms. It is worth bearing in mind that effects were largest for one type of PA (which was typically resistance training), durations of up to 12 weeks and sessions lasting 60 min, three times a week.

Consequently, this review adds to the broad existing evidence on PA and anxiety which can inform health care policies for older adults. However, there is still inadequate evidence on the ideal intensity and mode of PA to increase the anxiolytic effects of PA in older adults. Further investigation into how frequently older adults should engage in different modes of PA is also recommended, as this, to date, remains undetermined.

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