Exercise and Psychological Stress in Older Adult Populations: A Systematic Review

by

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Abstract

Background: Exercise has been shown to have stress-reducing effects. Exercise is a non-invasive, relatively inexpensive activity, warranting further investigation as a protective influence against stress in older adults.

Methods: A systematic review was conducted, searching electronic databases PubMed, Web of Science, PsycInfo, and SportDiscus from inception to February 2021. Randomized controlled trials investigating exercise interventions for stress in adults aged 50+ were included in this review. Data on type, intensity, and duration of the intervention were also extracted.

Results: 854 studies were identified by the search strategy. Twelve randomized controlled trials met inclusion criteria. Trials involving low-intensity qigong and trials combining aerobic and anaerobic or aerobic and nutrition education showed the strongest evidence of stress reduction.

Discussion: Exercise may reduce stress in older adults. Suitable duration of program ranges from 3 months to 1 year. Light to moderate activity is recommended for best results, with qigong the most consistent and common exercise.

Keywords:

Stress management, Physical activity, Intervention, Older adults, exercise, systematic review

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List of Acronyms

BMI: Body Mass Index

BSI-18: Brief Symptom Inventory-18

CDC: Center for Disease Control and Prevention

COPD: Cardio Obstructive Pulmonary Disease

MHR: Max Heart Rate

HR: Heart rate

MMSE: Mini Mental State Examination

MVPA: Moderate to Vigorous Physical Activity

MWR: Max Weight Repetition

OA: Open Access

PRISMA-P: Preferred Reporting Items for Systematic Reviews and Meta-Analyses Protocols

PROSPERO: International Prospective Register of Systematic Reviews

RCT: Randomized controlled trials

ROB: Risk of bias

V02 Max: Maximum oxygen volume

Chapter 1.

Introduction

Psychological stress has been shown to have wide ranging negative effects on adult's overall health, including but not limited to cardiovascular issues, heart disease, as well as all-cause mortality (Russ et al., 2012; Nielsen et al., 2008). Some evidence shows that mental health (anxiety, depression, and stress) improves in a linear fashion from early adulthood into old age (Thomas et al., 2016). This may be due to older adults being able to regulate emotional reactions to stress better than their younger counterparts (Luong & Charles, 2014). Older adults ability to navigate stress is still important however, as stress and negative life events are associated with negative effects for physical as well as mental health in late-life (Charles et al. 2013; de Frias & Whyne 2015). As people age, there are specific challenges that may exacerbate stress levels. such as increased loneliness, bereavement, increased frailty, financial strain, and/or transitioning out of the workforce (Scott, Jackson, & Bergeman, 2011). Due to increasing longevity worldwide, a higher proportion of adults are reaching older ages and those challenges thus become more likely. The probability of older adults with sub-optimal health encountering stress as they age has also increased (Osmanovic-Thunström et al., 2015). To mitigate this possible increase in stress and its negative impact on older adults, protective and stress reducing mechanisms need to be thoroughly investigated. Exercise may help remedy this debilitating reaction to life's stressful events.

With the role of stress, the mechanisms involved and the predominantly negative responses post event, there needs to be an instrument through which stress can be reduced. A possible mechanism through which we can better alleviate stress both safely and cheaply, is through exercise (Gerber et al., 2016). Defined by the CDC (2017) as a subcategory of physical activity, exercise is planned, structured, repetitive, and purposive, in the sense that the improvement or maintenance of one or more components of physical fitness is the objective general or structured movement of the body that increases energy expenditure. In this paper, physical activity will be considered any general movement performed by the body's muscular skeletal system that results in energy expenditure, whereas exercise is to be considered the more structured predefined supervised program involving various forms of activity.

The level of physical activity one is able and willing to perform has been linked to both objective stress markers and decreases in subjective stress perception in the general adult population (Klaperski, et al, 2013; Lippke et al, 2015). What is less understood is if and how exercise influences the effects of stress in the older adult population and if so, what type, intensity, and duration is required for optimal stress reduction in this age group.

1.1. Aim

This systematic review attempts to articulate the best evidence for the ideal duration, intensity, and type of exercise as a means for stress reduction in the older adult population. This review will also investigate the feasibility of each intervention within the older adult segment of the population. In sum, this review aims to help to advise older adults, their loved ones, and possibly recreational aides (stakeholders) of the optimal exercise recommendations for improved mental health, specifically stress reduction, so that older adults may navigate through any stressful circumstances as efficiently as possible.

1.2. Theory/Models/Key Concepts

1.2.1. Transactional theory of stress and coping

Lazarus and Folkman's transactional theory of stress and coping (1984) helps place the current predicament of older adults in a wider net of understanding. It helps situate older adults and their ability to negotiate their interpretations and appraisal of this unique stressor. Lazarus and Folkman (1984) define stress as "…an imbalance between demands and an individual's available resources." Stress occurs when the burden of an event, for example aging-related health problems, is too much for the individual to negotiate given the person's resources. If the individual has an effective set of tools to cope with the stress, including but not limited to physical activity, the individual may be more effective at managing the stress or may not appraise the situation as stressful at the outset. It is not just the stress itself that may increase, but all the other comorbidities and influences derived from the initial stressor. The ramifications of this inability to properly manage and deal with stress (stress-induced cognitive interference) is that it can have a negative influence on working memory and attentional resources (Stawski et al., 2006).

1.2.2. Resilience Model

One way in which older adults may use exercise to help reduce the negative effects of psychological stress is through the fostering of psychological resilience. Resilience, conceptualized as the ability to bounce back from difficult circumstances or adversities, may be of importance moving forward because of our aging population. Cosco, et al. (2017) recommend that using an “asset-based approach”, by way of individual, environment and/or social resources, older adults may benefit from improved resilience at the individual and population level. These three levels of influence converge to help inform the theory of the life course model of multimorbidity resilience (Wister et al., 2016). Although social and environmental resources are of importance, they are mostly comprised of higher-level public policy or population level interventions and factor less into individual or micro level behavioral modification. Physical activity, though it can be affected by macro level policy change as well, is a factor in which the individual has the most control over. Exercise can be the catalyst through which stress-fighting individual resilience can be accumulated (Childs & de Wit, 2014; Resnick & Inguito, 2011). This increase in resilience may provide the resources or coping styles to combat stress more effectively (MacLeod et al., 2016). When older adults experience age related challenges, in this case stress, some in this population react better than expected considering the situation in which they find themselves. Through being more physically active, these individuals are better able to sustain health and further to effectively manage any such challenges that arise from the aging process with greater success (Harris, 2008; Wu et al., 2013; Rantanen et al., 2012). Physical activity was associated with increased resilience, fewer depressive symptoms, and fewer negative emotions overall (Zach et al., 2021).

The life course model of multimorbidity by Wister and colleagues (2007) stipulate several levels at which an individual can develop resilience. It can be at the individual, family, community, or societal level. Each of these levels provides potential resources for the individual to adjust either during disruption or reengagement with their personal resilience. It also adds the idea of non-linearity to the resilience equation detailed later in this paper with regards to the inverse relationship seen in some research on stress and physical activity. The model focuses on three important and relevant consequences that are imparted to the individual via resilience. These are the outcomes of wellness, recovery, and growth or development. If this model were to be applied to stress as one of the potential morbidities that is faced by older adults, and exercise as one of the protective influences that promotes resilience, it would look at how exercise provides improved wellness for older adults, for example, undergoing cancer treatment (Schwartz, de Heer, & Bea., 2017), and helps with recovery or aid in diffusion of stress in older adults (Ong et al., 2006). In the third outcome of resilience, it helps to promote growth through disruption of homeostasis, which is a central tenant of the hypothalamic-pituitary-adrenal axis model of stress reaction (Habib et al., 2001) which will be described later in this section.

1.2.3. Locus of control

The psychological concept of locus of control was first developed by Rotter in 1966. Since then, it has become an important element that constitutes personality psychology. Locus of control is one mechanism through which resilience is demonstrated (Georgescu et al., 2019). Those with a strong internal locus of control are better psychologically insured from specific stressors, forming a form of barrier or resilience upon those individuals (Buddelmeyer & Powdthavee, 2016). While certain positive assets help provide resilience to the aging population, physical activity provides the increase to perceived control over one's circumstances which may help activate those other additional resources (Carriedo et al., 2020). Older adults who are more equipped to negotiate stressful events may, in the future, realize the impact of personal agency and be able to place control more effectively over their lives on themselves which is a very important psychological development for older adults. With a more internal locus of control, older adults are more likely to exhibit positive affect during a stressful event, such as living with cancer (Brivio et al., 2021). The opposite belief has much more negative outcomes. Older adults who have an external locus of control, or put differently, the strong feeling of an inability to change or control their stressful situation – are significantly more likely to develop negative mental health outcomes as a result (Smallheer et al., 2018). In a recent review, Robinson and Lachman (2017) with the help of longitudinal studies, suggest that within the aging process, control beliefs have a significant effect on positive changes to health such as increases in physical activity but noting that it is not a unidirectional relationship. Rather, an older adult is constantly reappraising their control over their life and in doing so changing or sustaining their health at that moment. That also means that the less control one believes they have over their lives, the less positive choices they are willing to make to counter these changes. The authors suggestions are that interventions to change this outcome should be tailored to the individual with a personalized approach so that both the barriers to improved health and their goals for improved health can be met.

1.2.4. Physiological (HPA-Axis Model)

Stress is not only expressed in psychological terms but is something that has been investigated through its physiological manifestations. Shortly after encountering a stressor (physical, emotional, or psychological threat to homeostasis) the hypothalamic pituitary adrenal (HPA) axis begins to produce hormones, namely cortisol. Cortisol is then released into the bloodstream from the adrenal system (Habib et al., 2001). Other systems of the body affected include both the endocrine system and the cardiovascular system, by way of increasing the amount of cortisol secreted, producing elevated heart rate and an increase in blood pressure. Mental alertness and tension increase thereafter (Schneiderman et al., 2005). Stress affects both the nervous system and the immune system, by increasing the amount of circulating inflammatory markers, e.g., Interleukin-6 and Interleukin-1β, following a bout of acute stress (Steptoe et al., 2007).

The hypothalamic pituitary adrenal (HPA) axis is our primary stress system. It is very sensitive to both acute and chronic stress. Thus, it is of great importance when discussing resilience to stress. Psychological resilience may be the catalyst in warding off the effects of chronic stress on the HPA axis (Gaffey et al., 2016). By being resilient, older adults are better able to regulate their emotions (Fredrickson, 2003; Tugade et al., 2004) and thoughts and thus more able to negotiate the event.

1.2.5. Cross-Stressor Adaptation Theory

Another plausible theory for how exercise may influence psychological stress is through the cross-stressor adaptation theory. Exercise is thought to affect the human brain physiologically through a neurochemical reaction. Stress hormones such as adrenaline and cortisol as well as heart rate reactivity are reduced after performing physical activity (Mücke et al., 2018). This evidence points to the theory that exercise provides exposure to a physical stressor which itself triggers a stress response – enabling the individual to successfully deal with the perceived stress because it is less taxing on their system. This is summarized using the cross-stressor adaptation hypothesis (Sothmann et al., 1996). This theory posits that those who are more physically active will show both lower physiological as well as psychological responses to either physical stressors (physical activity) or other stressors (environmental or psychological). This response may mitigate any deleterious mental health effects that would otherwise affect them. What is most important regarding this theory is that the body and the systems within it all naturally want to be at homeostasis or put differently, they do not want to be at either extreme of the pendulum (too much threat or not enough threat). So, when the body is under a certain psychological pressure whether sudden or over a long period of time, the body has a response system to bring it back to level. Physical exercise can adjust the body into increasing that baseline level so that the stress that would have previously affected the individual is now much less concerning.

1.2.6. Psychobiological Framework

As of writing of this review, there is no consensus on the relative importance of physiological or psychological mechanisms through which stress can be alleviated through exercise. Rather, a psychobiological framework or model may make more sense than the two of them being separate. Peluso and Guerra de Andrade (2005), suggest combining them into this type of framework would create a more holistic and comprehensive understanding of the mechanisms. This would allow greater understanding of how effects from exercise varies according to environmental stimuli and the psychological and biological characteristics of each individual in question.

1.3. Intensity

The psychological mechanism through which exercise is theorized to reduce stress is through a type of protective barrier that shields the individual from negative affect (Childs & de Wit, 2014). This research shows that regular physical activity has a protective influence against the negative emotional consequences of stress. Studies, however, have not made clear, what intensity is necessary for this type of mood change to occur (Schnohr et al., 2005; Dunn et al., 2001). Both these studies present evidence that the largest positive mood effect comes from those who were sedentary prior to the intervention and increased to a light amount of exercise – two to four hours per week – providing evidence that intense physical activity is perhaps not necessary for desired psychological gains. However, in another recent study (Ge et al., 2020) on female adults, those who reported light and moderate intensity physical activity were more likely to report being stressed than those who reported vigorous physical activity. Other evidence points to more intense physical activity aggravating or invoking higher perceived stress (Paolucci et al., 2018). Intensity of the exercise is an important feature that needs to be better understood to ensure that a holistic understanding of the positive effects of physical activity are known.

1.4. Research Gaps

Reviews of trials involving the effect of exercise on older adults' mental health is not a new concept. However, previous systematic reviews related to older adults' mental health and exercise have primarily focused on depression (Forsman et al., 2011) and anxiety (Mochcovitch et al., 2016) or specific types of exercise (Tai Chi) (Wayne et al., 2014). Reviews that include stress as a primary outcome usually involve younger cohorts. Gerber and Pühse (2009) conducted a literature review that investigated the stress buffering effect of exercise and found that just over half of the studies reviewed showed evidence of this exercise-based stress buffer effect. They also showed evidence that exercising during times of heightened stress does not produce more stress. They do however remark that research with elderly is scarce and thus more research is necessary to make any concrete assertions, which provides more rationale for this review. The one article that did include older adults (Unger et al., 1997), showed a direct and stress-buffering protective effect from exercise. This is the first systematic review to my knowledge that includes psychological stress as the primary outcome of measurement following an exercise intervention within the older adult population.

Chapter 2.

Methods

Before conducting this systematic review and to better establish it in an agreed upon standard, a protocol was developed and published in an open access journal. This was done for several reasons. It provided an opportunity for planning and to provide documented methodologies in advance of the review. It also ensured that duplication of effort and time by other research teams would unlikely occur. It also ensured peer-reviewed guidelines were followed regarding inclusion, exclusion criteria or other decisions, while conducting the review and finally to reduce the possibility of selective reporting once the review was completed. To do this, I used the guidelines outlined and set out in the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) checklist (Moher et al., 2015). A detailed completion of the PRISMA-P checklist can be found in Appendix A. This systematic review is registered with PROSPERO at (https://www.crd.york.ac.uk/prospero/display_record.php?ID=CRD42020192546). More detail regarding the methods employed in this review can be found at Churchill, R., Riadi, I., Kervin, L., Teo, K., & Cosco, T. (2021). Deciphering the role of physical activity in stress management during a global pandemic in older adult populations: a systematic review protocol. Systematic reviews, 10(1), 1-4.

The protocol listed above was published in an open-access journal, *Systematic Reviews*. This provides another level of transparency and allows for more knowledge translation to occur as potential barriers are eliminated from contention. Open access (OA) journals reduce permission requirements (affiliation with university or other applicable institution and removes price barriers for readers so that anybody who is interested in this area of research may have access to it. It also provides more access for other researchers to build upon this work.

Inclusion and exclusion criteria for included studies are shown below in Table 1.

Table 1. Inclusion and Exclusion Criteria

Inclusion Criteria	Exclusion Criteria
Age ≥ 50	Self-reported exercise
Pre + post intervention stress score	Non-human
RCT trials	Severe cognitive impairment
Psychological report of stress	Protocols, reviews, editorials
Peer-reviewed articles	
Supervised and/or objective reporting of exercise	

2.1. Types of Studies

This systematic review examines randomized controlled trials that investigate psychological stress levels before and after an exercise intervention. The reason for only including randomized controlled trials was due to them offering the highest level of evidence (Guyatt et al., 2002). If the randomized controlled trials are of sound methodologies, then the systematic review in question will be able to make stronger inferences (Charrois, 2015). The studies included were all original, peer-reviewed and there was no limitation on what year the studies were published or a cut-off for recent articles. I did not limit studies based on language or country of origin so that all relevant articles would be included.

2.2. Types of Participants

Studies including older adults of any gender without severe cognitive impairment that may make certain exercises dangerous were included. Studies including participants without the ability to perform the exercise in question, were excluded. Included studies must include adults 50 years of age or older. This age cut off was used so that studies involving older adults in places with low life expectancy would potentially be included. In sub-Saharan Africa, older adults are considered over the age of 50 (Velkoff & Kowal, 2007; Shenkin et al., 2017). By opening the age cut off to 50, a more substantive catalogue of articles could potentially be included. If studies include multiple age group stratification, included studies must detail the relevant data of adults over the previously mentioned age stipulation (50+).

2.3. Types of Interventions

This review included both aerobic and anaerobic interventions as well as both individual and group-based exercise. No limitations were put on the type of exercise, so long as it was considered a form of exercise by the authors of the original paper. Of importance: All exercise interventions had to be supervised and/or objectively measured examples of exercise. In this case, the term supervised is defined as an exercise regimen that is overseen or moderated by either a health professional, coach, or a researcher, such that adherence and proper intensity can be observed. Any interventions with only self-reported exercise were excluded. This was decided to reduce the amount of bias with regards to self-reporting activity levels (Wells et al., 2016; Lee et al., 2011; Prince et al., 2008). Interventions ranged from low intensity to moderate to vigorous levels of intensity. It was of importance to transcribe the intensity that each participant or intervention occurred at during the respective exercises – either by heart rate, V02, or another metric.

2.4. Types of Comparators

The treatment in the comparator arm had to be less intensive than the treatment in the intervention arm, e.g., depending on the treatment arm, comparative arm(s) could be usual care, physical activity education, exercise program waitlist or non-physical activity/exercise interventions. No major restrictions were used as exclusion criteria in this review.

2.5. Types of Outcomes

The main outcome of interest is perceived psychological stress. Other terms that were accepted include “distress” as this is defined as either severe or chronic stress or both. Therefore, both acute stress (short term) and/or chronic stress (long term) were included. The stress score was assessed using various psychological stress questionnaires or assessment tools. While the Perceived Stress Scale or PSS is the most widely used psychological instrument for assessing perceived stress (Cohen et al., 1983), other scales that evaluate psychological stress were accepted. All included studies needed to have a baseline or pre-intervention score as well as a post intervention score at various time intervals during the trial for comparison of stress levels.

2.6. Search Methods

This systematic review searched four databases: PubMed, Web of Science, PsycInfo, and SPORTDiscus. These four databases were used due to precedent setting previous reviews on the role of exercise in combatting stress (Stults-Kolehmainen & Sinha, 2014; Mücke et al., 2018). Of note, while SPORTDiscus is not a common database to search for general reviews, it was used as it is considered the most preeminent database for sports, sports medicine, and kinesiology research, all relevant in this chosen area of research. Keywords were related to the following concepts: stress management, exercise, and older adults. To get the most effective search results from the previously mentioned databases, the following search terms were used: ("exercise") OR ("physical activity") AND ("stress") AND ("manag*") OR ("reduc*") OR ("prevent*") OR ("control*") AND ("older adults") OR ("elderly") OR ("seniors") OR ("geriatric") AND ("intervention"). Other inclusion criteria included only randomized control trials, only human studies, and the age of the participants had to be 50 years of age and older (Table 1). Aside from SPORTDiscus (all fields were searched), these search terms were examined using "title and/or abstract" searching to ensure specificity. The exact search string can be found in Appendix B as well as in Churchill et al., 2021.

All articles were imported into Endnote and duplicates were then removed. With the help of two independent collaborators, titles and abstracts were screened first, followed by full text screening to make sure that all inclusion and exclusion criteria were followed and met.

2.7. Data Extraction

All relevant data was then extracted into a Google Sheet document. Information for each article extracted included: Title, authors, year of publication, country of publication, population demographics, sample size, intervention type and dosage, control type and dosage, setting of delivery of intervention, type of analysis, outcomes (perceived stress), time between pre and post intervention, BMI, smoking rate, dropouts, and any adverse effects mentioned. An example of the output and data accrued in the spreadsheet can be found in Appendix C.

2.8. Effect size

Where applicable, the effect sizes for the psychological stress outcomes will be reported. Cohen's d (Cohen, 1988) - used to indicate the standardised difference between two means, will be described, where applicable, as either small (0.2), medium (0.5), or large (0.8). Pearson R (Freedman, Pisani & Purves, 2007) – which measures the strength and direction of linear relationships between pairs of continuous variables – will also, if applicable, be recorded and described in the Results section of this review.

2.9. Quality Assessment

To assess the quality of each trial included in this review, methods found in the Cochrane Risk of Bias Tool Version 2 (ROB-2) were used. This was done to evaluate the risk of bias in each of the randomized controlled trials included in this review. The ROB-2 tool was used specifically in this review as it has recently become the standard in assessing risk of bias of randomized controlled trials (Jørgensen et al., 2016). This tool evaluates the following: a) random sequence generation, (b) allocation concealment, (c) selective reporting, (d) incomplete outcome data, (e) performance bias (blinded participants and/or personnel), and (f) detection bias (blinded outcome assessment). Each randomized controlled trial was given a subjective grade of low, high, or unclear as per the ROB-2 (Sterne et al., 2019). Low, high, and unclear risks of bias are displayed in green, red, and yellow, respectively. A study was denoted as having an unclear risk of bias if not enough information was provided, or if the information presented was unclear, for at least one of the six categories provided. In addition to the assessment of bias, had there been a meta-analysis, the quality of the aggregated studies included within this review would have been assessed using the GRADE (Grading of Recommendations Assessment, Development and Evaluations) approach (Guyatt et al., 2011).

2.10. Meta Analysis

Meta-analyses would have been performed had there been at minimum three included studies sufficiently homogeneous in terms of study design, participants, interventions, and outcomes to support necessary summary measures. A random-effects meta-analysis would have been performed due to the likelihood of similar effect sizes. Heterogeneity would have been assessed using the I^2 statistic with values above 75% and $p < 0.05$ used to indicate high heterogeneity (Higgins et al., 2003). If there had been high heterogeneity, a meta-analysis would not have been initiated. Since a meta-analysis was not applicable, a narrative synthesis of the literature was conducted instead.

2.11. Narrative Synthesis

Due to the previously mentioned stipulation regarding the replacement of a meta-analysis with a narrative synthesis, it is best to describe in brief what was done. A narrative synthesis is a method used in systematic reviews to synthesize findings from multiple studies that uses primarily words and text to summarise and explain the findings of the review in question. A framework developed by Popay et al. (2006) for a narrative synthesis, suggests that systematic reviews without a meta-analysis usually consists of theory of why or why not an intervention works and for whom, developing a synthesis of findings from the included studies, exploring relationships in the data, and assessing the robustness of the synthesis.

2.12. GRADE Assessment

A GRADE Assessment (Grading of Recommendations, Assessment, Development and Evaluations) would have been conducted for pooled data had there been a meta-analysis conducted. Due to there not being enough homogeneity in the trials, due in large part to the low number of included trials and the subject matter, a GRADE Assessment was not conducted. GRADE assessments are not done on individual studies but rather it assesses the confidence/quality of evidence (very low, low, moderate, or high) of the grouped results. This quality reflects the authors confidence that the evaluations of the effects listed are accurate. This is done to provide clinical practice recommendations more effectively. GRADE provides a systematic way in which imprecision, inconsistency, indirectness of study results, and publication bias are involved in the reporting of the pooled results (Balshem et al., 2011).

Chapter 3.

Results

3.1. Included Studies

The search of databases yielded 854 articles. After screening the title and abstracts, 81 articles remained. Of these 81 studies, three articles were not available through the institutional library accessible to the reviewers. All attempts were made to contact the lead authors (via ResearchGate) to obtain access to the full texts of these three articles, but no response was received by the time the manuscript had been written. This left me with 78 articles, of which I excluded 33 due to age restrictions, 2 due to duplicate data but different authors, 11 due to self-reported levels of exercise, 7 due to not being an RCT, 10 being due to the lack of a measure of perceived stress, and 1 because it was a protocol paper. This left 12 articles in total to be reviewed. The sequence of this screening process can be seen below in the PRISMA flowchart in Figure 1.

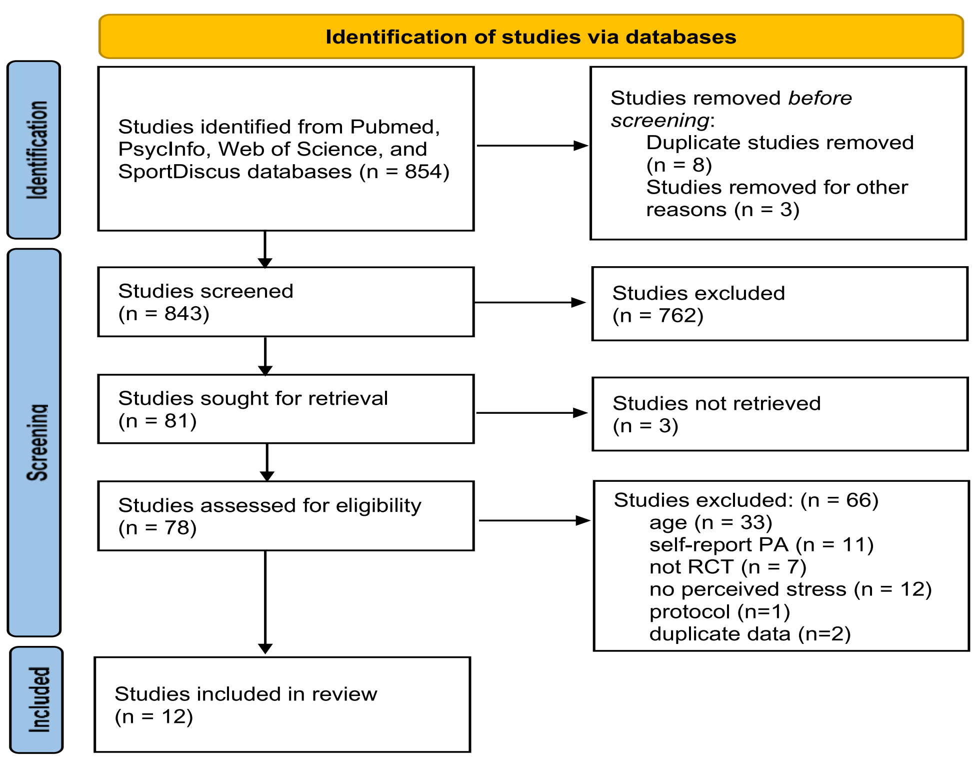

Figure 1. PRISMA flowchart: Screening process for study inclusion

3.2. Study Characteristics

Of the twelve included trials, the majority were from English-speaking Western Countries (USA-6, Canada-1, Australia-1) with the remaining coming from Finland (1), Iran (1), and China (2). All twelve articles however were published in the English language.

Table 2. Study Demographics

Author(s)	Year	Country	Population	Age	n	Dropout
Campo et al	2014	USA	prostate cancer survivors, sedentary	55+	29	11/27.5%
Cormie et al	2015	Australia	men with prostate cancer, 46% past smoker, 2 current smokers	stratified ≥70, ≤ 70, intervention mean 70	63	8/12.7%
Courneya et al	2017	Canada	post-menopausal women at risk for breast cancer, inactive, non-smoker, BMI 22-40, v02 < 34	50-74	400	14 / 3.5%
Ehlers et al	2017	USA	community-dwelling, read and write in English, right-handed, low active/inactive, MMSE >23, cog. status > 21	60-79	247	39/15.9%
Gothe et al	2016	USA	Low-active, healthy community dwelling	55-79	108	10 / 9.3%
Imayama et al	2011	USA	overweight/obese, post-menopausal women, BMI > 25, low active, no breast cancer, no hormone replacement past 3 months, non-smoking	50-75	439	57 / 13%
King et al	1993	USA	no cardiovascular disease/stroke, no medication hypertension/hyperlipidemia, women: no hormone replacement therapy 20% smokers	50-65	357	NA
Pourhabib et al	2018	Iran	heart failure	60-74	53	7 / 11.7%
Puterman et al	2018	USA	family caregivers of relatives with dementia, non-smokers	50-75	68	4 / 5.9%
Vaapio et al	2007	Finland	fallen once in past year, living at home	65+	513	61 / 10.3%
Xiao et al	2018	China	cardiovascular disease, 19.4% smoking	≤64, ≥65 (65%)	129	5 / 3.7%
Zhang et al	2016	China	chronic COPD	58-72	130	18 / 12.2%

3.3. Key Findings

Key Findings from all twelve articles are presented below and divided by exercise type or modality (Tables 3, 4, 5, 6, 7, and 8). The information included in the tables includes the following: type of exercise, length of trial, intensity ranking of activity, how the authors defined the intensity, duration of activity, and important findings related to stress. In addition to these high-level summaries below, following will be detailed narrative summaries of each distinctive type of exercise.

Table 3. Low Impact Exercise Interventions and Findings

Author(s)	Exercise	Trial Length	Intensity Rank	Intensity Defined	Duration	Findings	Analysis Used
Campo et al. 2014	Qigong	2x week: 3 months	moderate	BORG scale (perceived exertion): median = 4.3, range = 1.8-8.4	1 hour	Qigong associated with sig. decrease in distress vs. control (p<0.05)	Wilcoxon non-parametric tests
Xiao et al. 2018	Baduanjin (Fitness Qigong)	5x week: 4 months	Light	NA	24min	Qigong group sig. higher confidence to manage emotional distress (p=0.011)	Paired t-test
Zhang et al. 2016	Qigong Yijin Jing	7x week: 6 months	Light	Heart rate increase < 20 bpm, Breathing rate increase <5 times/min,	1 hour	Qigong group sig. more capable managing distress vs. control + self-management exercise groups (p<0.001); effect increases 1-3-6 months	Repeated-measures ANOVA
Gothe et al. 2016	Hatha Yoga	3x week: 2 months	Light	Beginner class → increase complexity over trial	1 hour	No group difference, both sig. decrease stress pre-post (p=0.001)	ANCOVA

Note: ANOVA = Analysis of Variance, ANCOVA = Analysis of Covariance

Table 4. Dancing Intervention and Findings

Author(s)	Exercise	Trial Length	Intensity Rank	Intensity Defined	Duration	Findings	Analysis Used
Ehlers et al. 2017	Dancing, walking, walking + nutrition	3xweek: 6 months	light/moderate	Dancing: increase in intensity, walking: 50-60%MHR →60-75%	1 hour	perceived stress decreased in control and intervention (p<0.02) not between exercise mode (p>0.29) or exercise vs. control (p>0.11)	One-way ANOVA

Note: ANOVA = Analysis of Variance

Table 5. Aerobic Choice Interventions and Findings

Author(s)	Exercise	Trial Length	Intensity Rank	Intensity Defined	Duration	Findings	Analysis Used
Courneya et al., 2017	Aerobic Choice	5x week: 1 year	Light/moderate	65-75% MHR	1 hour	Not significant ($p=0.69$)	Least-square mean change/group difference
Puterman et al., 2018	Aerobic Choice	3x week for first 9 weeks; 4/5x week 15 weeks: 6 months	moderate	40%HRR→increase to upper moderate by week 9	20min→30min	Aerobic exercise group sig. decrease in perceived stress ($p<0.05$)	Linear mixed models
King et al. 1993	Aerobic choice (walking/jogging)	3x week high intensity 5x week low intensity: 1 year	Moderate/hard	Low: 60-73% MHR High: 73-88% MHR after first 6 weeks	Low: 30min High: 1 hour	Sig. decrease for all conditions vs. control ($p<0.008$), home-based low intensity + high intensity sig. decrease vs. group high intensity + control ($p<0.003$)	ANCOVA

Note: ANCOVA = Analysis of Covariance

Table 6. Aerobic + Anaerobic Interventions and Findings

Author(s)	Exercise	Trial Length	Intensity Rank	Intensity Defined	Duration	Findings	Analysis Used
Cormie et al., 2015	Aerobic + Anaerobic (weights)	2x week: 3 months	Moderate//hard	Aerobic: 70-85% MHR Anaerobic: 6/12 MWR 1-4 sets (progressive and tailored)	1 hour	Sig. decrease in psychological distress for exercise group (p=0.045) vs. control	Chi-square, ANCOVA, t-tests
Pourhabib et al., 2018	Aerobic + Anaerobic (weights)	3x week: 3 months	light	Aerobic: slow walking Anaerobic: last 8 weeks: 500g dumbbells	1 hour: 30 min walk, 30 min dumbbells	Sig. decrease psychological stress for exercise group (p<0.001) vs. control	Independent t-test

Note: ANCOVA = Analysis of Covariance

Table 7. Aerobic + Diet Intervention and Findings

Author(s)	Exercise	Trial Length	Intensity Rank	Intensity Defined	Duration	Findings	Analysis Used
Imayama et al. 2011	Aerobic + diet	5x week: 1 year	Moderate/hard	Gradual increase to 70-85% MHR sustained for final 10 months	45 minutes	Aerobic exercise alone not significant, (p=0.23), add diet education sig. = (p=0.006)	t-Tests

Table 8. Anaerobic Intervention and Findings

Author(s)	Exercise	Trial Length	Intensity Rank	Intensity Defined	Duration	Findings	Analysis Used
Vaapio et al. 2007	Anaerobic (lower-leg muscles)	1 year	NA	Individualized and progressive over trial	40-50 minutes:30 minutes + warmup and cooldown	Sig. decrease stress for men (p=0.029) and 65-74 age group (p=0.037) vs. control	Logistic regression analyses with generalized estimation equations (GEE)

3.3.1. Low-impact low-intensity exercise: qigong, yoga, dancing

Nearly half (five of twelve) of the included studies chose to investigate the effect of low-impact, low intensity types of exercise such as qigong, yoga, or dance movements (Campo et al., 2014; Xiao et al., 2018; Zhang et al., 2016; Ehlers et al., 2017; Gothe et al., 2016). Three of those studies investigated the effects of qigong on distress (Campo et al. 2014; Xiao et al., 2018; Zhang et al., 2016). Qigong ("qi" = energy flow, "gong" = achievement or skill) is an ancient Chinese martial art that consists of slow-flowing movements while practicing deep breathing with a meditative focus to enhance 'Qi' or life energy to improve overall well-being (Rogers et al., 2009). All three studies that used qigong showed statistical associations for three separate populations including: prostate cancer survivors, patients with COPD, and patients with chronic cardiovascular disease. The qigong trials lasted three, four and six months, of which one study (Zhang et al., 2016) showed the ability to manage distress increased the longer the intervention took place (scores increased steadily from baseline to one month, three months, and even stronger at six-month follow-up). All three qigong interventions involved group participation. Although all three involve the practice of qigong, there are important differences between each type of qigong. Campo et al.'s intervention involved general qigong, described above, whilst Xiao et al.'s intervention involved Baduanjin qigong which is one of the most common forms of qigong (Wang & Zhang, 2015). It includes 8 slow movements and is much more static in movement while Zhang et al.'s intervention used Yijin Jing, which incorporates strength, force and flexibility, movement, and stillness, with the mind and body working as one. It involves movement of the extremities helping to promote circulation and organ function, as well (Ding et al., 2014).

One study examined the effects of dancing on perceived stress or situational stress (Ehlers et al., 2017). They also included a walking and a walking + nutrition condition. There were no group differences between control and the dancing condition, though all conditions had a significant decrease in stress, but none of them differed when compared to each other.

Yoga was the other type of intervention that is generally low impact and low intensity. Gothe and colleagues (2016) investigated the effect of hatha yoga on perceived stress but found no significance between the yoga and their static stretching control group. However, both the yoga group and the control group showed significant decreases in stress from baseline and after the 8-week program.

3.3.2. Aerobic Exercise

Three studies investigated the effect of aerobic exercise on perceived stress. Puterman and colleagues (2018) studied the effect of self-selected aerobic exercise on high-stress dementia caregivers. They compared their perceived stress after six months to that of a waitlist control group and only the exercise group had significant decrease in perceived stress. Courneya and colleagues (2017), also looked at self-selected aerobic exercise but compared moderate volume and high volume on perceived stress. They found no significant effect on perceived stress. The third study (King et al., 1993) looked at individual walking or jogging at either low intensity or high intensity or group supervised walking or jogging at high intensity. They found significant differences between all groups combined vs the no-exercise control as well as significant differences between the two individual groups compared to the group exercise and the no-exercise control.

3.3.3. Aerobic + Nutrition

One study (Imayama et al., 2011) looked at the effect of moderate to vigorous aerobic exercise with and without a nutritional education program and their effect on overweight or obese older women's perceived stress. Aerobic exercise alone did not significantly alter perceived stress post intervention, though in conjunction with the diet education program, it did in fact decrease perceived stress for this population.

3.3.4. Aerobic + Anaerobic

Two studies investigated the effect of not only aerobic exercise but added anaerobic fitness (weight training) as well. Cormie et al. (2015) were researching the effect of moderate to high intensity aerobic exercise (bike, treadmill, rowing) as well as maximum repetition on eight major muscle group machines. They found a significant decrease in psychological distress after the three-month intervention compared to the control. Another similar study (Pourhabib et al., 2018) looked at elderly with a history of heart failure. The participants participated in a protocol that included treadmill walking and resistance weights for the duration of a three-month trial. They also found a significant decrease in psychological stress compared to the health education control group.

3.3.5. Anaerobic

One group (Vaapio et al., 2007) looked solely at the role of weight training on elderly who had a history of falling in the past year. The exercises included were designed to improve lower leg muscle strength, balance, and coordination. They were performed sitting or standing depending on the participant. This program was conducted over a full year and in the assessment following their results showed that men in the active group had significant decreases in distress compared to the control group and that when sub divided into age groups, those in the 65-74 age group also showed significant decreases in distress compared to the same age group in the control condition.

3.3.6. Group Based Vs. Individual

Of the twelve included studies, eight included group-based exercise. Of those eight, six found associations between intervention and control. King et al. specifically investigated the role of group exercise compared to individual exercise and found that the two individual exercise groups had decreases in perceived stress.

Of the four studies that looked at individual exercise, two identified associations, one found an association if nutrition education was added to the exercise, and the other was insignificant.

3.3.7. Intensity

The intensity of each trial varied: one intervention did not have information concerning the intensity of the intervention. As for the other eleven interventions, five of them used maximum heart rate (MHR), one used heart rate recovery (HRR) – the decrease of heart rate after one minute of exercise cessation - and one used the BORG rating of perceived exertion (BRE). The other four did not define how they measured the intensity of their interventions. Four of the interventions were described as light intensity (either 60% MHR or an increase of less than 20 beats per minute (BPM), two were light/moderate (60% to 75% or 65% to 75% MHR), two were moderate (median of 4.3 on BORG scale and the other starting at 40% and then increasing and maintaining an upper moderate zone of MHR), two were moderate/hard (70% to 85% MHR), and one had moderate (60%-73%) and hard conditions (73% to 88% MHR).

3.3.8. Duration

Of importance when describing each trial is both the length of the trial and the length of each session of exercise. Studies included ranged in duration from two months to a full year. For each bout of exercise, seven of the included studies had one-hour interventions, one was 45 minutes, one was 40 to 50 minutes, one was 24 minutes, one was 35-40 minutes and increased to 65-70 minutes by the end of the trial, and one was 20 minutes and increased to 30 minutes by the end of the trial.

3.3.9. Comparators

The comparators used in this review included either an education control, a non-physical control, waitlist-control, stretching, minimum health guidelines, or usual care.

3.3.10. Health of Participants

Of the twelve trials that were reviewed, only four could be considered as healthy older adults. This is defined by the investigators as not having any physical disease or serious conditions. Of the other eight trials, inclusion criteria included: COPD, heart failure, history of falls, prostate cancer, high risk of breast cancer, cardiovascular disease, overweight or obese, and sedentary or inactive. The four that were healthy included family caregivers of patients with dementia, healthy non-smoking, but low-active older adults, and community dwelling adults with no history of cardiovascular disease or stroke. Another important demographic that influences exercise output is history of smoking. Of the twelve trials, only six (50%) had demographic information regarding number of smokers. Three trials involved populations of all non-smokers. Two trials involved roughly 20% smokers, while the other one involved nearly 50% with a history of smoking but only had 2 participants who were active smokers.

3.4. Dropout Rate

The dropout rate or the rate at which participants leave a research program after randomization occurs is important to note when referring to exercise programs for older adults. Of the twelve trials included one study (King et al., 1993) did not include dropout rates or causes. The highest dropout rate by way of percentage was Campo et al. (2014) at a rate of 27.5%, while the others ranged from a low of 3.5% to 15.9%. Of the eleven trials that included dropout rates, only three (Campo et al., 2014; Imayama et al., 2011; Vaapio et al., 2007) performed an attrition or dropout analysis in their results. Of those three, only Vaapio et al.'s (2007) trial found differences in the dropout group versus the retained group. They split it up by gender and found that for males, the dropout group was more likely to be living alone and have lower cognitive functioning by way of the MMSE. As for women, the dropout group was more likely to be older, and have lower cognitive, physical, and mental abilities. All the relevant information gathered regarding dropout rates are included below in table 9.

Table 9. Dropout Analysis

Author	Intervention Dropout	Reasons	Control Dropout	Control reasons	Attrition bias
Campo et al	4	Health reasons (2), bad timing, no reason given	7	Health reasons (2), bad timing, too busy, not interested (2), family reasons	No differences between dropout group and retained group
Cormie et al	1	Nauseous, Dizziness, fatigue (cancer therapy)	7	Desire to exercise (4), travel for assessment (2), time constraints	No dropout analysis performed
Courneya et al	5	Medical reasons (2), nonadherent (2), personal reasons	9	Medical reasons (2), nonadherent, personal reasons (5), relocation	No dropout analysis performed
Ehlers et al	Dance:12 Walk:6 Walk+:7	Reasons not given	14	Reasons not given	No dropout analysis performed

Author	Intervention Dropout	Reasons	Control Dropout	Control reasons	Attrition bias
Gothe et al	3	No longer interested, family emergency, time commitment	7	No longer interested (2), family emergency (2), time commitment, Health condition (sickness), travel	No dropout analysis performed
Imayama et al	Exercise:11 exercise + Diet: 9	Exercise: Medical (2), transportation (2), work/family, death, other (5) Exercise+diet: work/family (2), medical, relocation, other (5)	7	Dissatisfied with randomization (3), other reason (4)	No differences between dropout group and retained group
Pourhabib et al	5	Missed program sessions	2	No reason given	No dropout analysis performed
Puterman et al	3	Medical, relocation, caregiver burden/stress	1	Dissatisfied with randomization	No dropout analysis performed
Vaapio et al	31	Death (5), Health (14), relocation, financial, study dissatisfaction (2), no reason (9)	29	Death (4), Health (9), financial, low motivation, study dissatisfaction (4), no reason (10)	Among men: higher cog. Function in retained vs dropout, dropouts more likely to be living alone Among women: retained: younger, better cognitive, physical, and mental abilities

Author	Intervention Dropout	Reasons	Control Dropout	Control reasons	Attrition bias
Xiao et al	1	Loss of contact	4	Loss of contact (4)	No dropout analysis performed
Zhang et al	Qigong: 8 SME: 6	Qigong: Health (3), lost to follow-up (2), stopped exercise (3) SME: stopped exercise (4) health (2)	4	Loss of contact (4)	No dropout analysis performed

3.5. Risk of Bias

For the RCTs in this review, most of the domains were evaluated as having a low risk of bias (selective reporting, allocation sequence concealment, and selective outcome reporting). There were three studies that did not report or were unclear regarding their method of random sequence generation and three did not report or were unclear regarding allocation concealment. One did not use allocation concealment, presenting a high risk of bias in that category. Two of the trials were assigned high risk of bias in the performance bias category due to knowledge of the allocated interventions by participants during the study while three were unclear or did not mention blinding methods. As for detection bias, one study was assigned high risk of bias as they did not use blinding of the outcome assessment by research staff. Five of the trials were unclear or did not mention assessment blinding. As with the majority of RCTs, selective reporting was unclear in all studies.

Table 10. Risk of Bias in Included Studies

	random sequence generation	allocation concealment	selective reporting	incomplete data	performance bias	detection bias
Campo (2014)	+	-	?	+	-	+
Cormie (2015)	+	+	?	+	+	?
Courneya (2017)	+	+	?	+	-	+
Ehlers (2017)	+	+	?	+	?	?
Gothe (2016)	?	+	?	+	+	+
Imayama (2011)	+	+	?	+	?	+
King (1993)	+	+	?	+	+	+
Pourhabib (2018)	+	+	?	+	?	?
Puterman (2018)	+	?	?	+	+	+
Vaapio (2007)	+	+	?	+	+	?
Xiao (2018)	?	?	?	+	+	?
Zhang (2016)	?	?	?	+	+	-

Note: + = low risk, - = high risk, ? = unknown

3.6. Effect Sizes

Of the twelve studies included in this review, only three included effect sizes in their results. Two of them had small effects while one had a large effect. Campo et al. (2014) had an effect size or Cohen's d of -1.2 representing a large effect size. Gothe et al. (2016) had effect sizes ranging from 0.27 to 0.38 (though they did not specify for what variables), representing small effects, which they surmised as being due to normal and healthy subjects with high cognitive abilities. The final study to provide effect sizes was Ehlers et al. (2017) which provided an effect size of -0.2 for perceived stress which represents a small effect. Of the other nine studies that did not include effect sizes themselves, eight of them provided adequate information with Xiao et al. (2018) the lone trial with insufficient data provided, thus manual effect sizes were tabulated. Three of the included trials had large effects (Pourhabib et al., 2018; Vaapio et al., 2007; Zhang et al., 2016), one had a medium effect (Puterman et al., 2018) while the other four trials had small effect sizes (Cohen's d) ranging from 0.04 to 0.26.

3.7. Power Level

Statistical power is the probability of finding an effect, assuming that the effect is actually there. As mentioned previously, while the majority of the twelve included studies did not include effect sizes, only 8 of them commented on the statistical power level achieved or not achieved. Campo et al. (2014) used a power level of 0.80. Cormie et al. (2015) used a power level of 0.80, Courneya et al. (2017) used a power level of 0.8, Puterman et al. (2018) used a power level of 0.8. Imayama et al. (2011) estimated a power level of 0.999. Ehlers et al. (2017) and Vaapio et al. (2007) power levels were based on sample sizes from previous results from similar studies, thus sufficiently powered. Gothe et al. (2016), Xiao et al. (2018), Zhang et al. (2016), Pourhabib et al. (2018), and King et al. (1993) did not provide power levels in their studies. After manual calculations were performed, Pourhabib et al. (2018) had a power level of 0.998, Zhang et al. (2016) had a power level of 1.0, Gothe et al. (2016) were powered at 0.857, King et al. (1993) were underpowered. Xiao et al. (2018) did not provide statistics for the control group thus making it impossible to calculate power statistics.

3.8. Stress Scales Used

Various questionnaire formats were used including: The Perceived Stress Scale (PSS) was the most common psychometric tool used as it was included in six of the twelve studies. Within the PSS, there were both the PSS-10 (the 10-item format) and the PSS-14 (the fourteen-item format), and two studies did not supply information for which one they used. The BSI-18 (Global Severity Index) was used in two separate studies. Other less common measures of stress included the MHI Mental Health Inventory: psychological distress, the 15D HRQOL: distress, the SEMCD6: Confidence to manage emotional distress, and the Regulatory Emotion Self-Efficacy Questionnaire (RESE): perceived distress or despondency subscale.

Chapter 4.

Discussion

While older adult cohorts may experience lower levels of stress when compared to younger age groups, stress and its effects are still very important for older adults, their health, and overall quality of life (Charles *et al*. 2013; de Frias & Whyne 2015). Exercise may be one way in which this can be done. This systematic review provides some evidence that gentle exercise (low impact, low intensity) in the form of a qigong intervention (Campo et al., 2014; Xiao et al., 2018; Zhang et al., 2016) produced a decrease in perceived stress. Aerobic exercise (walking, jogging, or biking) in tandem with anaerobic exercise, such as weightlifting (Cormie et al., 2015; Pourhabib et al., 2018), was also beneficial in reducing stress. Aerobic training in tandem with nutrition or diet education (Imayama et al., 2011) showed promising associations as well. Finally, strength training for men and younger old (65-74 years of age) participants (Vaapio et al., 2007) provided some evidence for reductions or managing perceived stress. These results provide some consistency with regards to previous literature or systematic reviews on the role of specific exercise on stress management.

4.1. Integration with conceptual models

Lazarus and Folkman's transactional theory on stress and coping (1984), highlights the idea of three problem-focused coping strategies which include: taking control, information seeking, and evaluating the positives and negatives of taking a certain action. These coping mechanisms are used to change the meaning of the stressor and thus give less overall meaning to it, all the while attempting to divert focus to something or somewhere else (Folkman & Lazarus, 1988). For exercise or physical activity to take a proper foothold in this process, it must have beneficial properties. Some of the effects of exercise are more obvious than others. The first strategy of taking control, makes intuitive sense. Actively participating in an activity program helps to reinforce the idea that one has control over their own emotions, feelings, and overall temperament. As for information seeking, one study points to the idea that moderate physical activity helps improve cognitive flexibility as well as increased performance of working memory so that better understanding of the initial stressor and being able to define the most effective of possible actions to mitigate the stressor may be easier than if that person were to remain sedentary (Chang & Etnier, 2009). Even though this part of the model – problem focused coping - has some limitations, especially if the problem is outside the control of the individual in question (Rick, 2012). It could be argued however that even if a problem is outside the individual's control (family member diagnosed with cancer or serious illness) that individual still has the ability to change how they react psychologically or emotionally to that information and thus allow it to stress them psychologically or not.

Another important by-product of exercise as an effective stress management tool is the personal agency it gives older adults in actively dealing with stress. In a large sample of older adult cardiac outpatients, higher internal health locus of control was associated with higher levels of physical activity (Mercer et al., 2018). Other studies show evidence that having an internal locus of control was consistently associated with decreased levels of anxiety and increased problem-solving coping skills when compared to those with an external locus of control (Arslan et al., 2009). Realizing that older adults can actively reduce their own stress by shifting or keeping their locus of control internally by way of exercising can be an empowering realization. If older adults' stress is left unaddressed or untreated, it can have extremely negative effects now and into the future. Practicing physical activity or exercise may be beneficial and more effective than various pharmacotherapy options or remaining sedentary.

Physical exercise provides more than just agency. It is a very effective coping mechanism. it provides an active form of resilience for the older adult population that helps them negotiate the stress proactively rather than through rumination. Resilience and physical activity have been shown to be reciprocally linked. Engaging in physical activity is a characteristic of resilient people and resilience provides more of an impetus to becoming physically active (Bowling, & Iliffe, 2011). Whether it is qigong or combined aerobic and anaerobic exercises, engagement in physical activity as an older adult provides evidence of an association with high levels of resilient behavior (Resnick & Inguito, 2011; Childs & de Wit, 2014).

Several plausible physiological mechanisms may explain the results of this review. One of the most held theories on the physiological mechanism of stress reduction from exercise is the cross-stressor adaptation hypothesis (Sothmann et al., 1996). Exercise works as a type of practice for our body in dealing with stress. Exercise is a natural stressor that helps our sympathetic nervous system improve its detection of stress and ensures that it does not overreact to the next stressor it faces and turns off the heightened arousal when the stress is over. For each bout of exercise, in this case, qigong, yoga, jogging, cycling, etc., the act of exercise would help prepare them for the next time they are psychologically stressed. One caveat to this however is that the exercise must hit a certain threshold to properly stress the individual. Naturally, this threshold would be different for each person and each exercise. As Childs & de Wit (2014) suggest, it must "perturb homeostasis" by way of any physiological, emotional, or psychological stressor. For yoga which involves more stretching than other activities, it may not stress the body enough, while qigong involves more continuous flow and physical movements. Similarly, dancing may produce improved mood, but it may not have been physiologically stressful enough to engage the sympathetic nervous system. This would help explain why qigong was effective and yoga and dancing were not.

As noted in the introduction, the role of group exercise in older adult populations should not be overlooked regarding its importance. Older adults have a propensity to be motivated to be active with friends, a spouse, or a larger group. This review includes predominantly group interventions, and this makes intuitive sense considering how older adults often join health programs because of the social aspect. Also, it is much more resource friendly to utilize a group-based intervention so that the laboratory setting and personnel in question can monitor numerous participants at the same time rather than scheduling individualized interventions which would cost more financially and take up more time.

4.2. Making sense of the review findings

4.2.1. Mind-body exercise

The evidence provided in this review as it relates to mind-body exercises such as yoga and qigong provide relatively consistent results with previous reviews on younger and healthier populations. One systematic review, conducted by Chong et al. (2011) looked at yoga's effect on stress management. While the 8 trials included showed positive results, The authors did emphasize that there were methodological issues in almost all the 8 trials included – both short duration bouts of yoga, limited follow-up data, half of the trials did not have a control, and half did not have randomization, most had small sample sizes, etc. Also of note is that they only included trials involving healthy adults between the ages of 18 to 65. Another more substantive review done a year later by Li and Goldsmith (2012), looked at 35 yoga trials that were focused on yoga's effect in reducing anxiety and stress. The authors found the same methodological issues as the previous review. As for qigong, a review conducted by Wang et al. (2014) suggests qigong when practiced between one and three months is effective in reducing stress among healthy adults. The significant results with regards to the three studies on qigong, are likely due to the added meditation and breathing involved in that type of exercise that is not involved in the other types of exercise in this review. In a systematic review and meta-analysis (Ng & Tsang, 2009), that covered 26 trials from 1997-2006 and looking specifically at older adults with chronic conditions, they found that those in the qigong arm of the trial, that there were increases in white blood cells and leukocytes, increase in the rate of the heart's stroke volume, improved lung functioning as well as a lowering of total cholesterol, systolic and diastolic blood pressure, as well as depressive mood scores. It is suggested that the stress amelioration pathway is through a combination of the nervous, endocrine, and immune systems. Also, of note for why the yoga intervention did not have similar results could be explained by the more intense focus on physical positions, also called "asana" rather than qigong's focus on mind and breathing. This idea may support the varying effectiveness of the two programs and how they interact with stress reduction. Also, of importance to note, is that yoga has many iterations or types (Bikram and Ashtanga are two of the hardest to master) and while the version used in Gothe's trial was hatha yoga, the effect of other types off yoga on stress reduction may be different. As for qigong, one plausible reason for its stress-reducing effects may come down to the added elements of breath regulation, and structured body movements involved in the exercise. This produces long and deliberate diaphragmatic breathing. This affects both the autonomous nervous system and the endocrine system leading to regained homeostasis (Wang et al., 2014). Other researchers (Tsang & Fung, 2008) have investigated the psychobiological mechanisms through which qigong is believed to alleviate stress and come up with three routes. First, monoamine neurotransmitters in the brain, second, the previously mentioned HPA-Axis, and third, brain-derived neurotropic factors. Though inconsistent results from another systematic review (Wang et al. 2014) suggest the exact mechanism is unknown, it does provide a plausible theory.

4.2.2. Multifactorial Designs

The evidence for the combination of exercise and diet programs is less clear for younger cohorts under the age of 50. One large study (Kiernan et al., 2001) showed null results for both overweight women and men with regards to perceived stress reduction when adding exercise to a diet program. The belief is that the community dwelling overweight population had such low levels of baselines stress that the exercise program had little room to decrease any more. This stands in contrast to individuals who are overweight but are involved in clinical or hospital-based diet programs with much higher baselines stress scores (Wadden et al., 1997). Other suggestions for the lack of change in perceived stress were the degree of obesity in this study population, age range (25-49), and the type of exercise prescription (brisk walk or jogging at 60-80% MHR). Another study by Daubenmier et al. (2007) however, shows an interaction between reductions in dietary fat intake and an increase in exercise consumption in reducing or alleviating perceived stress. They believe that the interaction of exercise, diet, and stress management are all additive and interact in improving future psychosocial outcomes Although it is beyond the scope of this review due to the primary focus on exercise, the combination of interventions shows great promise in being effective in reducing stress among older adults.

As for combining aerobic and anaerobic exercise into one intervention rather than looking at their effects independently, there is not a lot of evidence either for or against this approach. As for systematic reviews on the general adult population, the most recent (Elkington et al., 2017) that looked at comparing aerobic, anaerobic, or combined trials and their effects on psychological wellbeing (of which distress is one of the factors) found only one trial that looked at combining both, one looked at comparing them, and only two that looked at solely anaerobic exercise. From the one combined trial (Maraki et al., 2005), their results were promising in that they observed a twenty percent increase in psychological wellbeing. There were two other recent trials from Italy, that examined the role of combined aerobic and anaerobic exercise programs on perceived stress in the workplace. In the first trial (Fischetti et al., 2019) police officers who were randomized to the combined exercise intervention had significant decreased levels of perceived stress after 8-weeks compared to the waitlist control group. Another very recent trial investigated perceived stress in the population of helping professions such as police officers, doctors, psychologists, and teachers (Greco, 2021). They were investigating the effect of an 8-week combined aerobic and anaerobic intervention on work-related burnout. They found that perceived stress decreased significantly in the combined exercise group while there were no changes in the waitlist control group. Though these are encouraging results, it is only three small trials and the Maraki et al. trial's methodology only included one bout of acute exercise rather than looking at the effects of a longer-term exercise program.

As for previous evidence concerning the use of anaerobic or strength training independent of other exercise types, the evidence is equivocal. In a review by Elkington et al. (2017), they found only two trials that investigated the use of resistance exercise alone in combatting psychological distress. Of note, their review was only highlighting acute exercise (single dose) on psychological variables (pre workout and post workout), thus limiting long term effects of any one type of exercise. One trial found no significant change between 5 minutes pre-exercise and immediately after. The other trial (Comstock et al., 2013) looked at psychological distress at baseline and immediately after and 24 hours after strength training. They found that strength training actually increased psychological stress for both people with lean body mass (1.6-fold increase immediately and 1.8-fold increase at 24 hours) and those with obese body mass was even worse (3.4/3.5-fold increase immediately). This small amount of evidence runs counter to the one study reviewed in this research. Reasons for that may be age or obesity level, but more likely the amount of weight used, the repetitions, and the fact that they only did it once rather than have their bodies adjust and test stress levels at the end of a few months or in the case of Vaapio's trial, one year. One final possible reason for Vaapio et al.'s (2007) results were the fact that the exercise was just one part of a multi-faceted fall-prevention program also consisting of a geriatric assessment and risk analysis, educational lectures, and monthly psychosocial activities (singing, quizzes, and reading poems).

4.2.3. Trial Duration

The trials included in this review ranged in duration from two months to one year. The three trials that included qigong ran for 3 months (Campo et al. 2014), 4 months (Xiao et al., 2018), and 6 months (Zhang et al., 2016). The trial that ran for 6 months showed an increased effect the longer the trial was conducted, providing some evidence that trial duration is important in reducing stress. Meanwhile, the trial involving yoga

(Gothe et al., 2016) only ran for two months and while they showed an association between yoga and stress reduction, there were no differences between groups. Perhaps, had this trial run longer, the contrasting effects would have been stronger. For the two multicomponent trials involving aerobic and anaerobic interventions (Cormie et al., 2015; Pourhabib et al., 2018), both used a three-month trial, and both had positive results, providing evidence that for this type of combined exercise, three months is adequate. For both the aerobic and diet combined trial (Imayama et al.2011), and the anaerobic trial (Vaapio et al., 2007), both lasted for one year and had positive results, however it is unknown if trials lasting less time would invoke the same type of results. For aerobic choice trials, the results were less clear. Two of the trials lasted for a full year, of which one had positive results while the other did not. The third (Puterman et al., 2018), had a 6-month trial and they did have effective results for stress reduction. Finally, the dance trial (Ehlers et al., 2017) lasted for six months but did not find between group differences for dance or for the other intervention arms of the trial.

4.2.4. Exercise Duration

As for the actual duration of each exercise regimen, most trials in this review used a one-hour intervention with mixed results: four of the seven had significant results while three did not. The other five trials which included less than an hour for the exercise condition, two trials used roughly a forty-five-minute bout, and both had positive results (Imayama et al., 2011; Vaapio et al., 2007). The two trials that used rather short duration exercise – twenty to thirty minutes - both showed positive associations (Puterman et al., 2017; Xiao et al., 2017). The final study (Pourhabib et al., 2018) started out with 35-40 minutes and increased to 65-70 minutes produced positive associations as well. To better understand the optimal length or duration of a bout of exercise, it is necessary to investigate the literature in this area. Bhui & Fletcher (2000) suggest that the daily duration of exercise is important but only for between-gender differences (men had reduced amounts of stress-related clinical issues the longer the exercise was endured – minimum 92 minutes a day compared to 0-44 minutes – while women had no significant differences in amount of stress in relation to duration of physical activity. As for trial length, there was a review conducted on exercise and stress (Sharon-David & Tenenbaum, 2017). They also found that there was considerable variability in duration and no one length of time seemed to be more or less effective. Two reviews specifically looked at exercise trial length in older adult populations. Theou et al. (2011) found that while there was not enough evidence to declare one type of activity as superior, that multicomponent trials lasting for five months or longer and three times per week, were the most instrumental in producing positive health outcomes. The other review (Chase, 2013) found no difference in dosage, whether it was twelve weeks or a full year.

4.2.5. Inverse Stress-PA relationship

There may be a very important confounding effect on the relationship between physical activity or exercise and psychological stress, notably an inverse relationship model. While most research is devoted to the mitigating effect of physical activity on stress, this model looks at how stress affects our ability or inability to perform exercise when at our most stressed levels. In a systematic review of the literature this phenomenon was observed by Stults-Kolehmainen & Sinha, (2014). Stress turned out to be one of the most pertinent barriers in why people did not perform physical exercise. This was the case in both acute stress as well as chronic stress situations (caregivers of older adults or parents of children with cancer diagnosis). Interestingly, these results – an inverse association - were even more common in studies involving older adults, specifically those over the age of 50. This review also showed that those who were habitually active prior to the stressful event were more likely to turn to physical activity to combat stress, while those at the beginning of their exercise regimen or who were less active prior to the stress were more likely to abstain from exercise during stressful times of their lives. Evidence exists that points to inactive older adults as having increased levels of stress. More time spent exercising at any intensity predicts lower stress levels (McHugh & Lawlor, 2012).

4.3. Limitations

4.3.1. Generalizability

As shown in this review, most of the published randomized controlled trials evaluating the effect of exercise on perceived stress have been conducted on older adults with health concerns including cardiovascular disease, heart disease, cancer treatment, obesity, COPD, and others. What this means is that older adults with conditions such as those listed may have stress that does not generalize to the average older adult who is relatively healthy. Also, with regards to the population studied, aside from two studies from China, one from Iran, and one from Finland, the other eight studies were conducted on English speaking western-centric populations. Therefore, any broad ranging conclusions may be biased in the sense that it is not applicable to minority populations or countries that are often understudied.

With regards to the inclusion criteria using an age restriction (50 years of age or older), this may have ultimately limited the breadth of the review. There is not a perfect cut-off with respect to defining older adults. However, in using 50+, the review was able to include many more trials whereas had I used 65+ which many consider as defining of old age, there would only have been two trials involved. Another point of contention with regards to age is the issue regarding age limits at all. Especially when considering the marked differences between the physical abilities of someone at 50 versus somebody at 65 or 80. While this was done to cast a wider net of eligible studies especially considering the lower potential for exercise trials involving participants over 65, there are some limitations that result from this. In a study conducted by Tuna et al. (2009), they discovered that young elderly, those aged 65 to 69 had considerably better functional fitness as well as aerobic endurance when compared to those who were 70 years of age or older. Another aspect of age is that those who are 50-65 are usually still involved in the workforce and thus have different stressors (day to day work stress, preparing for retirement stress, child rearing, etc.) than those who are over the age of 65 (health stress, becoming a grandparent and possibly taking over some child rearing responsibilities, etc.)

4.3.2. Self-report exercise

An important element to this review is concerning the inclusion of objectively measured and/or supervised exercise interventions. Any trials that use self-reported exercise interventions should be properly scrutinized given the disparity between perceived physical fitness and health when compared to objective measurements (Wells et al., 2016). Self-report physical activity has been shown to be commonly overestimated (Lee et al., 2011; Prince et al., 2008). When attempting to understand which types were overestimated and by how much, it has been shown that both moderate and vigorous activity were overestimated by 42 and 39 minutes a day respectively while sedentary time was underestimated by more than 2 hours (Schaller et al., 2016). This is substantial when considering many of these trials consisted of sixty-minute bouts of exercise. While using only objectively measured exercise trials was done to reduce the effect of a positivity bias surrounding self-report physical activity, it did reduce or eliminate the potential for possible effective interventions that used self-report exercise due to resource constraints or other causes, to be included in the review.

4.3.3. Exercise Intensity

Due to the nature of this review – consisting of primarily populations of older adults with health concerns, only one of the trials included a group who endured a hard intensity intervention, while two involved moderate to hard intensities. This is most likely due to concerns from participants as well as researchers regarding safe levels of activity. Because of this limitation, it is difficult to make a proper comparison regarding which intensity is best for optimal stress management effects to occur. Also of note, exclusion criteria consisted of studies involving participants who had severe cognitive impairment that would make exercise potentially dangerous. Although no studies were excluded for this reason, the criteria itself is a limitation of this review.

4.3.4. Psychometric (stress) scales

Included in this review were six different stress scales. The most common as mentioned previously was the perceived stress scale (PSS). It is the most commonly used most likely because of its high validity and reliability though of relevance, most psychometric reviews of the PSS were done with college students or workers (Lee, 2012) so validity inferences made with older adults may be subject to more scrutiny. Also, as it relates to the PSS, there are three formats that can or have been used. The mini 4-item questionnaire, the 10-item format, or the 14-item format. Each has varying levels of reliability and validity with the 4-item the worst (Lee, 2012). Though 2 studies did not explain which format they used, none of the trials involving the PSS confirmed using the 4-item questionnaire. In a study looking at the re-test reliability and internal consistency in the older adult cohort, it scored adequately well (Jiang et al., 2017).

Two of the studies included did not involve the amount of stress someone is perceiving but rather the individual's confidence in negotiating stress (Xiao et al., 2018; Zhang et al., 2016). Xiao et al. (2018) used the SEMCD-6 (a 6 item Likert scale that measures self-efficacy to manage chronic disease). While the whole scale was used in their study, they broke it down into the 6 items of which only the item: confidence to manage emotional distress was used for this review. The complete scale itself has been shown to have high reliability (Lorig et al., 2001) as well as statistically significant test-retest reliability (Lorig et al., 1996). Zhang et al. (2016) used The Regulatory Emotional Self-Efficacy (RESE) scale. It was developed to assess perceived self-efficacy in managing negative emotion – in this case distress – as well as expressing positive affect (Caprara & Gerbino, 2001). The negative emotion refers to despondency or distress (DES) as well as anger. The negative emotion is defined as the abilities in containing and suppressing emotions (in this case distress). The authors Caprara et al. (2008), suggest that both scales as well as the construct defined are useful across diverse countries and societies, although caution should be met with regards to mean values of the three constructs as they do not necessarily mean the same thing due to both cultural and language assumptions across the various countries studied.

The second most common scale used was the Brief Symptom Inventory-18 (BSI-18) which both Campo et al. (2014) and Cormie et al. (2015) used to measure distress. It is a shorter version of the multidimensional versions of the Symptom-Checklist 90-R. It involves 3 scales of 6 items as well as a Global Severity Index which was used to calculate distress in these two studies. Franke and colleagues (2017) confirm that it is a short and reliable instrument in measuring psychological distress in the general population. As for the older population (60-95), Petrowski and colleagues (2018), suggest that the item and scale properties were appropriate as was the reliability.

Another of the scales used to assess stress was the Mental Health Inventory (MHI): psychological distress score used by Pourhabib et al. (2018). It was designed as a consumer self-report tool to measure general psychological distress and wellbeing. It has been shown to have excellent internal validity as well as cross-cultural relevance (Al Mutair et al., 2018). In the aforementioned study, internal consistency was acceptable and test-retest reliability was stable.

The final stress measurement scale used was the 15D: HRQOL in Vaapio et al.'s (2007) study, which involves 15 measurements of health of which one is psychological distress. It is a generic, standardized, self-administered measure of health-related quality of life. It has been shown to be highly reliable and sensitive to change and valid for inferring years of quality life (Sintonen, 2015). Of note is that it is generalizable but only to Western-type societies. So, while it was used in a Finnish based study which can be considered typical of western values, it may not generalize to countries in Asia or other parts of the world. As for older populations, it has been shown to be valid, feasible, and a sensitive tool with those who have been diagnosed with Parkinson's (Haapaniemi et al., 2004) and very responsive for older adults with a history of fractures (Rohde et al., 2012).

4.3.5. Outside influence

Another limitation of these trials is the effect of any extra exercise or stress management techniques used outside of the trial. Although some of the studies' collaborators recommended to control subjects not to be active or to start another exercise program, there is little way in which to enforce such a claim. Intervention groups may also benefit from additional exercise when away from the trial and the researchers. Being in an active research trial may increase how active they are outside of it and thus effect their levels of stress.

4.3.6. Active control

Two studies involved in this review included control groups that involved more activity than a waitlist group. Ehlers et al. (2017) the group that investigated the role of dancing in ameliorating perceived stress, included a stretching, balance, and strengthening control group. While they considered it a control group, they did use yoga mats and resistance bands and their stretching and balancing exercises gained complexity throughout the trial. For this reason, it may be why both control and exercise conditions both had reduced stress and why there were no differences between the groups. Courneya et al. (2017) compared recommended weekly activity guidelines (150 minutes of MVPA per week) with another group who did twice as much (300 minutes of MVPA). They also did not discover an association between dose and stress which may support the idea that any amount of exercise is beneficial but that doubling the dose of exercise is not required to reduce stress. Perhaps if they had a non-active control group, such as a wait-list control group, this hypothesis could have been confirmed.

4.3.7. Exercise Supervision

Also, of note with regards to limitations is that even though every effort was made to exclude exercise trials that used self-report exercise and to only include supervised exercise, there was one study (King et al., 1993) that compared group-based supervised exercise with home based, self-reported exercise. Even though they attempted to confirm exercise adherence levels by having roughly half of the home-based exercise group wear a heart rate and body movement monitor for three consecutive days at baseline, six months, and 1 year follow up, conclusions made concerning the notion that exercise at home was more effective than the group-based exercise in a studio may be biased and not wholly accurate. While previous research suggests that supervised exercise leads to both improvements in adherence and intensity (Velthuis et al., 2010) levels Another factor that relates to supervised exercise that could limit stress reduction is the notion that those who are supervised may encounter increased levels of stress either due to body image issues, performance anxiety, or fear of falling and/or getting injured while being observed, all factors that could potentially affect the reduction of stress. While home-based exercise may show increased reductions in stress compared to in a laboratory or exercise facility setting (King et al., 1993) due to over reporting of exercise at home, it may also be due to lower levels of expectations or anxiety at home and thus a more calming setting to exercise in.

4.3.8. Bias

With any exercise research there is the possibility that the trials self-selected for participants that wanted to be involved in an exercise trial and secondly, that results may be skewed based on this. Cormie et al. (2015) had close to 30% of its participants as consistently active, Courneya et al. (2017) had over one-third of the participants as having a baseline physical activity rate over 10 MET hours per week (recommended is 7.5), Gothe et al.'s (2016) study included nearly one third of participants who had participated in yoga previously, and in Xiao et al. (2018), over 60% of the participants were current or previously manual-labor workers. If at baseline, the participants were already quite active, then the exercise used would not be novel or hard enough to necessarily stress the system for the benefits to occur as outlined in the cross-stressor hypothesis. Puterman et al.'s (2018) study attempted to mitigate this issue by having their inclusion criteria stricter in that participants were only included if they had not engaged in moderate to vigorous physical activity over the past six months at recommended levels (150 minutes moderate or 75 minutes vigorous per week). This removed the likelihood of this confounding variable, and the overall findings would likely be stronger if all studies accounted for this selection bias.

Due to the methodology of systematic reviews, this review is only as strong as the studies included and the databases searched. With regards to exercise interventions there is a risk of a publication bias. There is a chance that only trials involving positive stress-reducing results will be published. This risk is especially important with systematic reviews with a low number of included studies (Ioannidis, 2005). Although this review included some trials with negative results for decreases in psychological stress, the trials were usually using stress as a secondary outcome of interest. As for the choice of databases, even though the four chosen were in line with previous reviews in the same area of research, there is no way for certain to know that all relevant articles were caught by the databases chosen. There may have been other more comprehensive databases, thus limiting the potential final conclusions made in this review.

4.3.9. Motivation

As it relates to the search strategy, while randomized controlled trials are the gold standard for research of this nature, it does leave a gap in the understanding of the motivational piece in the exercise conversation. In real-world scenarios, especially in North America, older adults make up a larger proportion of the sedentary population (Prince et al., 2020; Diaz et al., 2016). While it is important to know the ideal type, duration, and intensity of exercise to reduce stress, if the older adult is not part of a trial, or actively pursuing research participation, then they may not choose to do any physical activity or exercise on their own reducing any positive impact of this review.

4.3.10. Effect Size

Even though nine of the twelve studies included in this review did not include effect sizes, after calculating them manually, most of the effect sizes turned out to be small. This does not necessarily mean that the difference is inconsequential but rather small effects are common in psychological research and may still be of importance when compared to other stress reduction techniques. Even small changes in someone's perceived stress may have indirect effects on both their ability to be resilient and perhaps how they deal with future stressors in their lives. For clinically important outcomes such as stress, be it acute or chronic, it is important for future studies to discuss effect sizes and the purpose it serves in stress and exercise research.

4.3.11. Meta-Analysis

Meta-analyses provide the highest level of scientific rigour; however, a meta-analysis was not feasible for this current review as there was too much methodological heterogeneity among the randomized controlled trials included in this systematic review. Although there were three qigong trials, they each used different scales to define stress, their trials ran for different lengths of time, and they used different forms of the actual qigong program.

Chapter 5.

Future Directions / Conclusions

To our knowledge, this was the first review that synthesized information on the effectiveness of exercise interventions in reducing psychological perceived stress in adults aged 50 years and older. Knowing the best type, intensity, and duration of exercise in combatting psychological stress may increase efficiency and effectiveness among health practitioners and/or family caregivers as well as older adults themselves as it relates to the timely treatment of stress. It would help direct recreational aides to better help navigate best practices and to help motivate their client in choosing qigong or a combined aerobic and anaerobic program.

Even though all the studies included a randomized control trial and objectively measured exercise as part of their methodologies, in real world settings, the aspect of motivation to exercise remains an issue for older adults' exercise adherence. It is not simply good enough to state that qigong or aerobic exercise with nutrition education or aerobic and weight training are the most beneficial type of exercise and that the longer the activity the better for reducing stress among older adults. While knowledge is always the first step towards progress of understanding, if the activity or exercise uptake is not sufficient, in other words, knowledge without action, the possible stress reduction and the improvements in quality of life will likely not occur.

One of the major takeaways of this review is that the methods of activity that are most effective at reducing stress are in fact affordable and can be done either within the confines of older adults' homes or in their neighborhood. This is of increasing importance, because frequently, affordability and lack of time are considered two of the most cited barriers for why people remain sedentary or inactive (Reichert et al., 2007).

Exercise interventions are advantageous in that they are easily accessible, can be performed with very little setup, and that most populations can participate in some fashion. Once these interventions are developed, adequately tested, and tailored to individual needs of older adults, these interventions can become a primary mechanism for stress management. Mounting evidence shows that exercise is effective in reducing stress and its associated symptoms (heightened cortisol and increased heart rate) both independently and when compared to other techniques such as mindfulness (Pinniger et al., 2012). Those who exercise regularly have an advantage over those who do not.

While older adults have unique needs and may cope with stress differently than younger populations, it is important to develop a better understanding of what causes them stress and in turn, how to better alleviate that stress, in this case, through exercise. This is not to say that younger populations cannot benefit through exercise, but rather they were not part of the scope of this review.

For future research in this area, a better understanding of motivation and adherence would help provide additional management skills for a type of stress reduction toolbox for older adults with regards to any stressors that may occur in their lives. The results of this review provide evidence to the role of specific types of exercise in adding to stress management guidelines. Findings may also provide care aides, hospital staff, and/or family members or caregivers with evidence on how best to help older adults. Ultimately, this systematic review should provide evidence for non-pharmacological, effective, exercise treatments that aim to limit the potentially debilitating role of stress in the older adult population.

References

Al Mutair, A., Al Mohaini, M., Fernandez, R., Moxham, L., Lapkin, S., & Ham-Baloyi, W. T. (2018). Psychometric testing of the mental health inventory in an Arabian context: Cross-cultural validation study. *Nursing open*, *5*(3), 376-383.

Arslan, C., Dilmaç, B., & Hamarta, E. (2009). Coping with stress and trait anxiety in terms of locus of control: A study with Turkish university students. *Social Behavior and Personality: an international journal*, *37*(6), 791-800.

Balshem, H., Helfand, M., Schünemann, H. J., Oxman, A. D., Kunz, R., Brozek, J., Vist, G. E., Falck-Ytter, Y., Meerpohl, J., Norris, S., & Guyatt, G. H. (2011). GRADE guidelines: 3. Rating the quality of evidence. *Journal of clinical epidemiology*, *64*(4), 401–406.

Bhui, K., & Fletcher, A. (2000). Common mood and anxiety states: gender differences in the protective effect of physical activity. Social psychiatry and psychiatric epidemiology, 35(1), 28–35.

Bowling, A., & Iliffe, S. (2011). Psychological approach to successful ageing predicts future quality of life in older adults. Health and quality of life outcomes, 9, 13.

Brivio, E., Guiddi, P., Scotto, L., Giudice, A. V., Pettini, G., Busacchio, D., Dider, F., Mazzocco, K., & Pravettoni, G. (2021). Patients living with breast cancer during the coronavirus pandemic: the role of family resilience, coping flexibility, and locus of control on affective responses. *Frontiers in Psychology*, *11*, 3711.

Buddelmeyer, H., & Powdthavee, N. (2016). Can having internal locus of control insure against negative shocks? Psychological evidence from panel data. Journal of economic behavior & organization, 122, 88-109.

Campo, R. A., Agarwal, N., LaStayo, P. C., O'Connor, K., Pappas, L., Boucher, K. M., Gardner, J., Smith, S., Light, K. C., & Kinney, A. Y. (2014). Levels of fatigue and distress in senior prostate cancer survivors enrolled in a 12-week randomized controlled trial of qigong. *Journal of cancer survivorship : research and practice*, *8*(1), 60–69.

Caprara, G. V., Di Giunta, L., Eisenberg, N., Gerbino, M., Pastorelli, C., & Tramontano, C. (2008). Assessing regulatory emotional self-efficacy in three countries. Psychological assessment, 20(3), 227–237.

Caprara, G. V., & Gerbino, M. (2001). Affective perceived self-efficacy: The capacity to regulate negative affect and to express positive affect. Self-efficacy assessment, 35-50.

Carriedo, A., Cecchini, J. A., Fernández-Río, J., & Méndez-Giménez, A. (2020). Resilience and physical activity in people under home isolation due to COVID-19: A preliminary evaluation. Mental health and physical activity, 19, 100361.

Centers for Disease Control and Prevention. Glossary of terms. https://www.cdc.gov/nchs/nhis/physical_activity/pa_glossary.htm. 2017

Chang, Y. K., & Etnier, J. L. (2009). Exploring the dose-response relationship between resistance exercise intensity and cognitive function. *Journal of Sport and Exercise Psychology*, *31*(5), 640-656.

Charles, S. T., Piazza, J. R., Mogle, J., Sliwinski, M. J., & Almeida, D. M. (2013). The wear and tear of daily stressors on mental health. Psychological science, 24(5), 733-741.

Charrois T. L. (2015). Systematic reviews: what do you need to know to get started? The Canadian journal of hospital pharmacy, 68(2), 144–148.

Chase J. A. (2013). Physical activity interventions among older adults: a literature review. Research and theory for nursing practice, 27(1), 53–80.

Childs, E., & de Wit, H. (2014). Regular exercise is associated with emotional resilience to acute stress in healthy adults. *Frontiers in physiology*, *5*, 161.

Chong, C. S., Tsunaka, M., Tsang, H. W., Chan, E. P., & Cheung, W. M. (2011). Effects of yoga on stress management in healthy adults: A systematic review. *Alternative therapies in health and medicine*, *17*(1), 32–38.

Cohen, J. (1988). Statistical Power Analysis for the Behavioral Sciences (2nd ed.). Hillsdale, NJ: Lawrence Erlbaum Associates, Publishers.

Cohen, S., Kamarck, T., and Mermelstein, R. (1983). A global measure of perceived stress. *Journal of Health and Social Behavior*, 24, 386-396.

Cormie, P., Galvão, D. A., Spry, N., Joseph, D., Chee, R., Taaffe, D. R., Chambers, S. K., & Newton, R. U. (2015). Can supervised exercise prevent treatment toxicity in patients with prostate cancer initiating androgen-deprivation therapy: a randomised controlled trial. *BJU international*, *115*(2), 256–266.

Cosco, T., Howse, K., & Brayne, C. (2017). Healthy ageing, resilience, and wellbeing. Epidemiology and Psychiatric Sciences, 26(6), 579-583.

Courneya, K. S., McNeil, J., O'Reilly, R., Morielli, A. R., & Friedenreich, C. M. (2017). Dose-Response Effects of Aerobic Exercise on Quality of Life in Postmenopausal Women: Results from the Breast Cancer and Exercise Trial in Alberta (BETA). *Annals of behavioral medicine : a publication of the Society of Behavioral Medicine*, *51*(3), 356–364.

Daubenmier, J. J., Weidner, G., Sumner, M. D., Mendell, N., Merritt-Worden, T., Studley, J., & Ornish, D. (2007). The contribution of changes in diet, exercise, and stress management to changes in coronary risk in women and men in the multisite cardiac lifestyle intervention program. Annals of behavioral medicine: a publication of the Society of Behavioral Medicine, 33(1), 57–68.

de Frias, C. M., & Whyne, E. (2015). Stress on health-related quality of life in older adults: the protective nature of mindfulness. Aging & mental health, 19(3), 201-206.

Diaz, K. M., Howard, V. J., Hutto, B., Colabianchi, N., Vena, J. E., Blair, S. N., & Hooker, S. P. (2016). Patterns of sedentary behavior in US middle-age and older adults: the REGARDS study. *Medicine and science in sports and exercise*, *48*(3), 430.

Ding, M., Zhang, W., Li, K., & Chen, X. (2014). Effectiveness of t'ai chi and qigong on chronic obstructive pulmonary disease: a systematic review and meta-analysis. *The Journal of Alternative and Complementary Medicine*, *20*(2), 79-86.

Ehlers, D. K., Daugherty, A. M., Burzynska, A. Z., Fanning, J., Awick, E. A., Chaddock-Heyman, L., Kramer, A. F., & McAuley, E. (2017). Regional Brain Volumes Moderate, but Do Not Mediate, the Effects of Group-Based Exercise Training on Reductions in Loneliness in Older Adults. *Frontiers in aging neuroscience*, *9*, 110.

Elkington, T. J., Cassar, S., Nelson, A. R., & Levinger, I. (2017). Psychological responses to acute aerobic, resistance, or combined exercise in healthy and overweight individuals: a systematic review. *Clinical Medicine Insights: Cardiology*, *11*, 1179546817701725.

Fischetti, F., Cataldi, S., Latino, F., & Greco, G. (2019). Effectiveness of multilateral training didactic method on physical and mental wellbeing in law enforcement. Journal of Human Sport and Exercise, 14(4proc), S906- S915

Folkman, S.; Lazarus, R.S. (1988). "Coping as a mediator of emotion". Journal of Personality and Social Psychology. 54 (3): 466–75.

Forsman, A. K., Schierenbeck, I., & Wahlbeck, K. (2011). Psychosocial Interventions for the Prevention of Depression in Older Adults: Systematic Review and Meta-Analysis. *Journal of Aging and Health*, *23*(3), 387–416.

Franke, G. H., Jaeger, S., Glaesmer, H., Barkmann, C., Petrowski, K., & Braehler, E. (2017). Psychometric analysis of the brief symptom inventory 18 (BSI-18) in a representative German sample. BMC medical research methodology, 17(1), 1-7.

Fredrickson, B. L., Tugade, M. M., Waugh, C. E., & Larkin, G. R. (2003). What good are positive emotions in crisis? A prospective study of resilience and emotions following the terrorist attacks on the United States on September 11th, 2001. *Journal of personality and social psychology*, *84*(2), 365.

Freedman, D., Pisani, R., & Purves, R. (2007). Statistics (international student edition). Pisani, R. Purves, 4th Edn. WW Norton & Company, New York.

Gaffey, A. E., Bergeman, C. S., Clark, L. A., & Wirth, M. M. (2016). Aging and the HPA axis: Stress and resilience in older adults. *Neuroscience & Biobehavioral Reviews*, *68*, 928-945.

Ge, Y., Xin, S., Luan, D., Zou, Z., Bai, X., Liu, M., & Gao, Q. (2020). Independent and combined associations between screen time and physical activity and perceived stress among college students. *Addictive behaviors*, *103*, 106224.

Georgescu, D., Duiu, A., Cheivan, T., Mazilu, T., Rotariu, A., Toma, D., & Barangă, A. (2019). The relationship between locus of control, personal behavior, self-efficacy, and resilience. Romanian Journal of Cognitive Behavioral Therapy and Hypnosis, 6(1-2), 1-12.

Gerber, M., Holsboer-Trachsler, E., Pühse, U., & Brand, S. (2016). Exercise is medicine for patients with major depressive disorders: but only if the “pill” is taken!. *Neuropsychiatric Disease and Treatment*, *12*, 1977.

Gerber, M., & Pühse, U. (2009). Do exercise and fitness protect against stress-induced health complaints? A review of the literature. Scandinavian journal of public health, 37(8), 801-819.

Gothe, N. P., Keswani, R. K., & McAuley, E. (2016). Yoga practice improves executive function by attenuating stress levels. *Biological psychology*, *121*(Pt A), 109–116.

Greco, G. (2021). Effects of combined exercise training on work-related burnout symptoms and psychological stress in the helping professionals. Journal of Human Sport and Exercise, 16(2), 424- 434.

Guyatt, G., Oxman, A. D., Akl, E. A., Kunz, R., Vist, G., Brozek, J., Norris, S., Falck-Ytter, Y., Glasziou, P., deBeer, H., Jaeschke, R., Rind, D., Meerpohl, J., Dahm, P., Holger, J., & Schünemann, H. J. (2011). GRADE guidelines: 1. Introduction—GRADE evidence profiles and summary of findings tables. *Journal of clinical epidemiology*, *64*(4), 383-394.

Guyatt, G., Rennie, D., Meade, M., & Cook, D. (Eds.). (2002). Users' guides to the medical literature: a manual for evidence-based clinical practice (Vol. 706). Chicago: AMA press.

Haapaniemi, T. H., Sotaniemi, K. A., Sintonen, H., & Taimela, E. (2004). The generic 15D instrument is valid and feasible for measuring health related quality of life in Parkinson's disease. Journal of neurology, neurosurgery, and psychiatry, 75(7), 976–983.

Habib, K. E., Gold, P. W., & Chrousos, G. P. (2001). Neuroendocrinology of stress. *Endocrinology and Metabolism Clinics*, *30*(3), 695-728.

Harris, P. B. (2008). Another wrinkle in the debate about successful aging: The undervalued concept of resilience and the lived experience of dementia. The International Journal of Aging and Human Development, 67(1), 43-61.

Imayama, I., Alfano, C. M., Kong, A., Foster-Schubert, K. E., Bain, C. E., Xiao, L., Duggan, C., Wang, C. Y., Campbell, K. L., Blackburn, G. L., & McTiernan, A. (2011). Dietary weight loss and exercise interventions effects on quality of life in overweight/obese postmenopausal women: a randomized controlled trial. *The international journal of behavioral nutrition and physical activity*, *8*, 118.

Ioannidis, J. P. (2005). Why most published research findings are false. *PLoS medicine*, *2*(8), e124.

Jiang, J. M., Seng, E. K., Zimmerman, M. E., Sliwinski, M., Kim, M., & Lipton, R. B. (2017). Evaluation of the Reliability, Validity, and Predictive Validity of the Subscales of the Perceived Stress Scale in Older Adults. Journal of Alzheimer's disease: JAD, 59(3), 987–996.

Jørgensen, L., Paludan-Müller, A. S., Laursen, D. R., Savović, J., Boutron, I., Sterne, J. A., Higgins, J. P., & Hróbjartsson, A. (2016). Evaluation of the Cochrane tool for assessing risk of bias in randomized clinical trials: overview of published comments and analysis of user practice in Cochrane and non-Cochrane reviews. *Systematic reviews*, *5*, 80.

Kiernan, M., King, A. C., Stefanick, M. L., & Killen, J. D. (2001). Men gain additional psychological benefits by adding exercise to a weight-loss program. *Obesity research*, *9*(12), 770-777.

King, A. C., Taylor, C. B., & Haskell, W. L. (1993). Effects of differing intensities and formats of 12 months of exercise training on psychological outcomes in older adults. *Health psychology : official journal of the Division of Health Psychology, American Psychological Association*, *12*(4), 292–300.

Klaperski, S., von Dawans, B., Heinrichs, M., & Fuchs, R. (2013). Does the level of physical exercise affect physiological and psychological responses to psychosocial stress in women? *Psychology of Sport and Exercise*, 14, 266–274.

Lazarus, R. S., & Folkman, S. (1984). *Stress, appraisal, and coping*. Springer publishing company.

Lee, E. H. (2012). Review of the psychometric evidence of the perceived stress scale. *Asian nursing research*, *6*(4), 121-127.

Lee, P. H., Macfarlane, D. J., Lam, T. H., & Stewart, S. M. (2011). Validity of the international physical activity questionnaire short form (IPAQ-SF): A systematic review. *International Journal of Behavioral Nutrition and Physical Activity*, *8*(1), 1-11.

Li, A. W., & Goldsmith, C. A. (2012). The effects of yoga on anxiety and stress. *Alternative medicine review : a journal of clinical therapeutic*, *17*(1), 21–35.

Lippke, S., Wienert, J., Kuhlmann, T., Fink, S., & Hambrecht, R. (2015). Perceived stress, physical activity, and motivation: Findings from an internet study. *Target*, 5, 8.

Lorig, K. R., Sobel, D. S., Ritter, P. L., Laurent, D., & Hobbs, M. (2001). Effect of a self-management program on patients with chronic disease*. Effective clinical practice*: *ECP*, 4(6), 256-262.

Lorig, K., Stewart, A., Ritter, P., Gonzalez, V., Lynch, J., & Laurent, D. (1996). Outcome measures for health education and other health care interventions. Sage.

Luong, G., & Charles, S. T. (2014). Age differences in affective and cardiovascular responses to a negative social interaction: the role of goals, appraisals, and emotion regulation. Developmental Psychology, 50(7), 1919.

MacLeod, S., Musich, S., Hawkins, K., Alsgaard, K., & Wicker, E. R. (2016). The impact of resilience among older adults. Geriatric Nursing, 37(4), 266-272.

Maraki, M., Tsofliou, F., Pitsiladis, Y. P., Malkova, D., Mutrie, N., & Higgins, S. (2005). Acute effects of a single exercise class on appetite, energy intake and mood. Is there a time of day effect?. *Appetite*, *45*(3), 272-278.

Mercer, D. A., Ditto, B., Lavoie, K. L., Campbell, T., Arsenault, A., & Bacon, S. L. (2018). Health locus of control is associated with physical activity and other health behaviors in cardiac patients. *Journal of cardiopulmonary rehabilitation and prevention*, *38*(6), 394-399.

Mochcovitch, M. D., Deslandes, A. C., Freire, R. C., Garcia, R. F., & Nardi, A. E. (2016). The effects of regular physical activity on anxiety symptoms in healthy older adults: a systematic review. *Brazilian Journal of Psychiatry*, *38*(3), 255-261.

Moher, D., Shamseer, L., Clarke, M., Ghersi, D., Liberati, A., Petticrew, M., Shekelle, P., & Stewart, L. A. (2015). Preferred reporting items for systematic review and meta-analysis protocols (PRISMA-P) 2015 statement. *Systematic reviews*, *4*(1), 1-9.

Mücke, M., Ludyga, S., Colledge, F., & Gerber, M. (2018). Influence of regular physical activity and fitness on stress reactivity as measured with the trier social stress test protocol: A systematic review. *Sports Medicine*, *48*(11), 2607-2622.

Ng, B. H., & Tsang, H. W. (2009). Psychophysiological outcomes of health qigong for chronic conditions: a systematic review. Psychophysiology, 46(2), 257-269.

Nielsen, N. R., Kristensen, T. S., Schnohr, P., & Grønbæk, M. (2008). Perceived stress and cause-specific mortality among men and women: results from a prospective cohort study. American journal of epidemiology, 168(5), 481-491.

Ong, A. D., Bergeman, C. S., Bisconti, T. L., & Wallace, K. A. (2006). Psychological resilience, positive emotions, and successful adaptation to stress in later life. Journal of Personality and Social Psychology, 91(4), 730–749.

Osmanovic-Thunström, A., Mossello, E., Åkerstedt, T., Fratiglioni, L., & Wang, H. X. (2015). Do levels of perceived stress increase with increasing age after age 65? A population-based study. *Age and ageing*, *44*(5), 828-834.

Paolucci, E. M., Loukov, D., Bowdish, D. M., & Heisz, J. J. (2018). Exercise reduces depression and inflammation but intensity matters. *Biological psychology*, *133*, 79-84.

Peluso, M. A., & Guerra de Andrade, L. H. (2005). Physical activity and mental health: the association between exercise and mood. Clinics (Sao Paulo, Brazil), 60(1), 61–70.

Petrowski, K., Schmalbach, B., Jagla, M., Franke, G. H., & Brähler, E. (2018). Norm values and psychometric properties of the brief symptom inventory-18 regarding individuals between the ages of 60 and 95. BMC medical research methodology, 18(1), 1-11.

Pinniger, R., Brown, R. F., Thorsteinsson, E. B., & McKinley, P. (2012). Argentine tango dance compared to mindfulness meditation and a waiting-list control: A randomised trial for treating depression. *Complementary Therapies in Medicine*, *20*(6), 377-384.

Popay, J., Roberts, H., Sowden, A., Petticrew, M., Arai, L., Rodgers, M., Britten, N., Roen, K., & Duffy, S. (2006). Guidance on the conduct of narrative synthesis in systematic reviews. A product from the ESRC methods programme Version, 1, b92.

Pourhabib, A., Fotokian, Z., Nasiri, M., & Abrotan, S. (2018). Effects of a group-based aerobic and resistance exercise program on physiological-psychological adaptation in elderly with heart failure. *Journal of Clinical Gerontology and Geriatrics*, *9*(2), 59-66.

Prince, S. A., Adamo, K. B., Hamel, M. E., Hardt, J., Gorber, S. C., & Tremblay, M. (2008). A comparison of direct versus self-report measures for assessing physical activity in adults: a systematic review. *International journal of behavioral nutrition and physical activity*, *5*(1), 1-24.

Prince, S. A., Melvin, A., Roberts, K. C., Butler, G. P., & Thompson, W. (2020). Sedentary behaviour surveillance in Canada: trends, challenges and lessons learned. *International Journal of Behavioral Nutrition and Physical Activity*, *17*(1), 1-21.

Puterman, E., Weiss, J., Lin, J., Schilf, S., Slusher, A. L., Johansen, K. L., & Epel, E. S. (2018). Aerobic exercise lengthens telomeres and reduces stress in family caregivers: A randomized controlled trial - Curt Richter Award Paper 2018. *Psychoneuroendocrinology*, *98*, 245–252.

Rantanen, T., Masaki, K., He, Q., Ross, G. W., Willcox, B. J., & White, L. (2012). Midlife muscle strength and human longevity up to age 100 years: a 44-year prospective study among a decedent cohort. Age, 34(3), 563-570.

Reichert, F. F., Barros, A. J., Domingues, M. R., & Hallal, P. C. (2007). The role of perceived personal barriers to engagement in leisure-time physical activity. American journal of public health, 97(3), 515-519.

Resnick, B. A., & Inguito, P. L. (2011). The Resilience Scale: Psychometric properties and clinical applicability in older adults. Archives of psychiatric nursing, 25(1), 11-20.

Rick, H. (2012). Stress, Health & Well-Being: Thriving in the 21st Century. Wadsworth, Cengage Learning, 540.

Robinson, S. A., & Lachman, M. E. (2017). Perceived control and aging: A mini-review and directions for future research. Gerontology, 63(5), 435-442.

Rogers, C. E., Larkey, L. K., & Keller, C. (2009). A review of clinical trials of tai chi and qigong in older adults. *Western journal of nursing research*, *31*(2), 245-279.

Rohde, G., Moum, T., & Haugeberg, G. (2012). Comparing 15D and SF-6D performance in fragility wrist and hip fracture patients in a two-year follow-up case-control study. Value in Health, 15(8), 1100-1107.

Rotter, J. B. (1966). Generalized expectancies for internal versus external control of reinforcement. Psychological Monographs. 80, 1–28.

Russ, T. C., Stamatakis, E., Hamer, M., Starr, J. M., Kivimäki, M., & Batty, G. D. (2012). Association between psychological distress and mortality: individual participant pooled analysis of 10 prospective cohort studies. BMJ, 345.

Schaller, A., Rudolf, K., Dejonghe, L., Grieben, C., & Froboese, I. (2016). Influencing factors on the overestimation of self-reported physical activity: a cross-sectional analysis of low back pain patients and healthy controls. *BioMed research international*, *2016*.

Schwartz, A., de Heer, H. D., & Bea, J. W. (2017). Initiating exercise interventions to promote wellness in cancer patients and survivors. *Oncology (Williston Park, NY)*, *31*(10), 711.

Schneiderman, N., Ironson, G., & Siegel, S. D. (2005). Stress and health: Psychological, behavioral, and biological determinants. Annual Review of Clinical Psychology, 1, 607–628.

Scott, S. B., Jackson, B. R., & Bergeman, C. S. (2011). What contributes to perceived stress in later life? A recursive partitioning approach. Psychology and aging, 26(4), 830.

Sharon-David, H., & Tenenbaum, G. (2017). The effectiveness of exercise interventions on coping with stress: research synthesis. Studies in Sport Humanities, 22(22), 19-29.

Shenkin, S. D., Harrison, J. K., Wilkinson, T., Dodds, R. M., & Ioannidis, J. (2017). Systematic reviews: guidance relevant for studies of older people. Age and ageing, 46(5), 722–728.

Sintonen H. (2001). The 15D instrument of health-related quality of life: properties and applications. Annals of medicine, 33(5), 328–336.

Smallheer, B. A., Vollman, M., & Dietrich, M. S. (2018). Learned helplessness and depressive symptoms following myocardial infarction. *Clinical nursing research*, *27*(5), 597-616.

Sothmann, M. S., Buckworth, J., Claytor, R. P., Cox, R. H., White-Welkley, J. E., & Dishman, R. K. (1996). Exercise training and the cross-stressor adaptation hypothesis. *Exercise and sport sciences reviews*, *24*(1), 267-288.

Stawski, R. S., Sliwinski, M. J., & Smyth, J. M. (2006). Stress-related cognitive interference predicts cognitive function in old age. *Psychology and aging*, *21*(3), 535.

Steptoe, A., Hamer, M., & Chida, Y. (2007). The effects of acute psychological stress on circulating inflammatory factors in humans: A review and meta-analysis. Brain, Behavior, and Immunity, 21(7), 901–912

Sterne, J., Savović, J., Page, M. J., Elbers, R. G., Blencowe, N. S., Boutron, I., Cates, C. J., Cheng, H. Y., Corbett, M. S., Eldridge, S. M., Emberson, J. R., Hernán, M. A., Hopewell, S., Hróbjartsson, A., Junqueira, D. R., Jüni, P., Kirkham, J. J., Lasserson, T., Li, T., McAleenan, A., … Higgins, J. (2019). RoB 2: a revised tool for assessing risk of bias in randomised trials. BMJ (Clinical research ed.), 366, l4898.

Stults-Kolehmainen, M. A., & Sinha, R. (2014). The effects of stress on physical activity and exercise. *Sports medicine*, *44*(1), 81-121.

Theou, O., Stathokostas, L., Roland, K. P., Jakobi, J. M., Patterson, C., Vandervoort, A. A., & Jones, G. R. (2011). The effectiveness of exercise interventions for the management of frailty: a systematic review. Journal of aging research, 2011, 569194.

Thomas, M. L., Kaufmann, C. N., Palmer, B. W., Depp, C. A., Martin, A. S., Glorioso, D. K., ... & Jeste, D. V. (2016). Paradoxical trend for improvement in mental health with aging: a community-based study of 1,546 adults aged 21-100 years. The Journal of clinical psychiatry, 77(8), 0-0.

Tsang, H. W., & Fung, K. M. (2008). A review on neurobiological and psychological mechanisms underlying the anti-depressive effect of qigong exercise. Journal of health psychology, 13(7), 857-863.

Tugade, M. M., Fredrickson, B. L., & Feldman Barrett, L. (2004). Psychological resilience and positive emotional granularity: Examining the benefits of positive emotions on coping and health. *Journal of personality*, *72*(6), 1161-1190.

Tuna, H. D., Edeer, A. O., Malkoc, M., & Aksakoglu, G. (2009). Effect of age and physical activity level on functional fitness in older adults. *European Review of Aging and Physical Activity*, *6*(2), 99-106.

Unger, J. B., Johnson, C. A., & Marks, G. (1997). Functional decline in the elderly: evidence for direct and stress-buffering protective effects of social interactions and physical activity. Annals of Behavioral Medicine, 19(2), 152-160.

Vaapio, S., Salminen, M., Vahlberg, T., Sjösten, N., Isoaho, R., Aarnio, P., & Kivelä, S. L. (2007). Effects of risk-based multifactorial fall prevention on health-related quality of life among the community-dwelling aged: a randomized controlled trial. Health and Quality of Life Outcomes, 5(1), 1-8.

Velkoff, V. A., & Kowal, P. R. (2007). Population aging in Sub-Saharan Africa: demographic dimensions 2006 (Vol. 7, No. 1). US Department of Commerce, Economics and Statistics Administration, US Census Bureau.

Velthuis, M. J., Agasi-Idenburg, S. C., Aufdemkampe, G., & Wittink, H. M. (2010). The effect of physical exercise on cancer-related fatigue during cancer treatment: a meta-analysis of randomised controlled trials. Clinical oncology, 22(3), 208-221.

Wadden, T. A., Vogt, R. A., Andersen, R. E., Bartlett, S. J., Foster, G. D., Kuehnel, R. H., Wilk, J., Weinstock, R., Buckenmeyer, P., Berkowitz, R. I., & Steen, S. N. (1997). Exercise in the treatment of obesity: effects of four interventions on body composition, resting energy expenditure, appetite, and mood. Journal of consulting and clinical psychology, 65(2), 269–277.

Wang, C. W., Chan, C. H., Ho, R. T., Chan, J. S., Ng, S. M., & Chan, C. L. (2014). Managing stress and anxiety through qigong exercise in healthy adults: a systematic review and meta-analysis of randomized controlled trials. *BMC complementary and alternative medicine*, *14*(1), 1-9.

Wang, C. Y., & Zhang, H. (2015). Influence of Baduanjin combined with routine treatment on blood glucose level in type 2 diabetic patients. *China Medicine and Pharmacy*, *5*(22), 49-52.

Wayne, P. M., Walsh, J. N., Taylor-Piliae, R. E., Wells, R. E., Papp, K. V., Donovan, N. J., & Yeh, G. Y. (2014). Effect of Tai Chi on cognitive performance in older adults: Systematic review and meta-analysis. *Journal of the American Geriatrics Society*, *62*(1), 25-39.

Wells, E. K., Avery, M. L., Eschbach, L. C., & Bunn, J. (2016). A Comparison of Perceived Physical Fitness and Objective Measurements. *Sport Journal*.

Wister AV, Coatta KL, Schuurman N, Lear SA, Rosin M, MacKey D (2016). A Lifecourse model of multimorbidity resilience: theoretical and research developments. International Journal on Aging and Human Development 82, 290–313.

Wu, G., Feder, A., Cohen, H., Kim, J. J., Calderon, S., Charney, D. S., & Mathé, A. A. (2013). Understanding resilience. Frontiers in behavioral neuroscience, 7, 10.

Xiao, X., Wang, J., Gu, Y., Cai, Y., & Ma, L. (2018). Effect of community-based practice of Baduanjin on self-efficacy of adults with cardiovascular diseases. *PloS one*, *13*(7), e0200246.

Zach, S., Zeev, A., Ophir, M., & Eilat-Adar, S. (2021). Physical activity, resilience, emotions, moods, and weight control of older adults during the COVID-19 global crisis. *European Review of Aging and Physical Activity*, *18*(1), 1-8.

Zhang, M., Xv, G., Luo, C., Meng, D., & Ji, Y. (2016). Qigong Yi Jinjing Promotes Pulmonary Function, Physical Activity, Quality of Life and Emotion Regulation Self-Efficacy in Patients with Chronic Obstructive Pulmonary Disease: A Pilot Study. *Journal of alternative and complementary medicine (New York, N.Y.)*, *22*(10), 810–817.

Appendix A.

Prisma-P Checklist

Section and Topic	Item	Checklist item	Location where item is reported
TITLE			
Title	1	Identify the report as a systematic review.	i
ABSTRACT			
Abstract	2	See the PRISMA 2020 for Abstracts checklist.	iii
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of existing knowledge.	1-7
Objectives	4	Provide an explicit statement of the objective(s) or question(s) the review addresses.	2
METHODS			
Eligibility criteria	5	Specify the inclusion and exclusion criteria for the review and how studies were grouped for the syntheses.	9
Information sources	6	Specify all databases, registers, websites, organisations, reference lists and other sources searched or consulted to identify studies. Specify the date when each source was last searched or consulted.	11
Search strategy	7	Present the full search strategies for all databases, registers, and websites, including any filters and limits used.	11

Section and Topic	Item	Checklist item	Location where item is reported
Selection process	8	Specify the methods used to decide whether a study met the inclusion criteria of the review, including how many reviewers screened each record and each report retrieved, whether they worked independently, and if applicable, details of automation tools used in the process.	11
Data collection process	9	Specify the methods used to collect data from reports, including how many reviewers collected data from each report, whether they worked independently, any processes for obtaining or confirming data from study investigators, and if applicable, details of automation tools used in the process.	11
Data items	10a	List and define all outcomes for which data were sought. Specify whether all results that were compatible with each outcome domain in each study were sought (e.g., for all measures, time points, analyses), and if not, the methods used to decide which results to collect.	10
	10b	List and define all other variables for which data were sought (e.g., participant and intervention characteristics, funding sources). Describe any assumptions made about any missing or unclear information.	10
Study risk of bias assessment	11	Specify the methods used to assess risk of bias in the included studies, including details of the tool(s) used, how many reviewers assessed each study and whether they worked independently, and if applicable, details of automation tools used in the process.	12
Effect measures	12	Specify for each outcome the effect measure(s) (e.g., risk ratio, mean difference) used in the synthesis or presentation of results.	12

Section and Topic	Item	Checklist item	Location where item is reported
Synthesis methods	13a	Describe the processes used to decide which studies were eligible for each synthesis (e.g., tabulating the study intervention characteristics and comparing against the planned groups for each synthesis (item #5)).	13
	13b	Describe any methods required to prepare the data for presentation or synthesis, such as handling of missing summary statistics, or data conversions.	13
	13c	Describe any methods used to tabulate or visually display results of individual studies and syntheses.	13
	13d	Describe any methods used to synthesize results and provide a rationale for the choice(s). If meta-analysis was performed, describe the model(s), method(s) to identify the presence and extent of statistical heterogeneity, and software package(s) used.	13
	13e	Describe any methods used to explore possible causes of heterogeneity among study results (e.g., subgroup analysis, meta-regression).	13
	13f	Describe any sensitivity analyses conducted to assess robustness of the synthesized results.	NA
Reporting bias assessment	14	Describe any methods used to assess risk of bias due to missing results in a synthesis (arising from reporting biases).	13
Certainty assessment	15	Describe any methods used to assess certainty (or confidence) in the body of evidence for a-n outcome.	13-14
RESULTS			
Study selection	16a	Describe the results of the search and selection process, from the number of records identified in the search to the number of studies included in the review, ideally using a flow diagram.	15

Section and Topic	Item	Checklist item	Location where item is reported
	16b	Cite studies that might appear to meet the inclusion criteria, but which were excluded, and explain why they were excluded.	15
Study characteristics	17	Cite each included study and present its characteristics.	16-17
Risk of bias in studies	18	Present assessments of risk of bias for each included study.	28-29
Results of individual studies	19	For all outcomes, present, for each study: (a) summary statistics for each group (where appropriate) and (b) an effect estimate and its precision (e.g., confidence/credible interval), ideally using structured tables or plots.	(a) 18-21 (b) 29-30
Results of syntheses	20a	For each synthesis, briefly summarise the characteristics and risk of bias among contributing studies.	22-24
	20b	Present results of all statistical syntheses conducted. If meta-analysis was done, present for each the summary estimate and its precision (e.g., confidence/credible interval) and measures of statistical heterogeneity. If comparing groups, describe the direction of the effect.	22-24
	20c	Present results of all investigations of possible causes of heterogeneity among study results.	22-24
	20d	Present results of all sensitivity analyses conducted to assess the robustness of the synthesized results.	NA
Reporting biases	21	Present assessments of risk of bias due to missing results (arising from reporting biases) for each synthesis assessed.	28-29
Certainty of evidence	22	Present assessments of certainty (or confidence) in the body of evidence for each outcome assessed.	NA
DISCUSSION			
Discussion	23a	Provide a general interpretation of the results in the context of other evidence.	31-38

Section and Topic	Item	Checklist item	Location where item is reported
	23b	Discuss any limitations of the evidence included in the review.	38-43
	23c	Discuss any limitations of the review processes used.	49, 44
	23d	Discuss implications of the results for practice, policy, and future research.	46-47
OTHER INFORMATION			
Registration and protocol	24a	Provide registration information for the review, including register name and registration number, or state that the review was not registered.	8
	24b	Indicate where the review protocol can be accessed, or state that a protocol was not prepared.	8
	24c	Describe and explain any amendments to information provided at registration or in the protocol.	NA
Support	25	Describe sources of financial or non-financial support for the review, and the role of the funders or sponsors in the review.	NA
Competing interests	26	Declare any competing interests of review authors.	NA
Availability of data, code, and other materials	27	Report which of the following are publicly available and where they can be found: template data collection forms; data extracted from included studies; data used for all analyses; analytic code; any other materials used in the review.	NA

Appendix B.

Database Search Queries

PubMed (title/abstract)

("physical activity"[Title/Abstract] OR "exercise"[Title/Abstract]) AND "stress"[Title/Abstract] AND "manag*"[Title/Abstract]) OR "reduc*"[Title/Abstract] OR "prevent*"[Title/Abstract] OR "control*"[Title/Abstract]) AND "older adults"[Title/Abstract]) OR "elderly"[Title/Abstract] OR "seniors"[Title/Abstract] OR "geriatric"[Title/Abstract]) AND "intervention"[Title/Abstract]) NOT "qualitative"[Title/Abstract]) NOT "interview"[Title/Abstract]) NOT "animal"[Title/Abstract]

PsycInfo (abstract)

(Physical activity or exercise) AND stress AND (manag* or reduc* or prevent* or control*) AND (older adults or elderly or seniors or geriatrics) AND intervention NOT qualitative NOT interview NOT animal

Web of Science (abstract)

AB= (exercise or physical activity or aerobic or anaerobic) AND AB= (stress* or distress) AND ALL= (manage* or reduc* or intervention or control* or prevent*) NOT AB= (qualitative or interview or review or animal or mouse or rat) AND AB= (older adults or elder* or senior* or geriatric*)

SPORTDiscus (All Fields)

TX (exercise or physical activity or fitness or aerobic training or strength training or cardiovascular training) AND TX (prevent or reduce or minimize or decrease) AND TX (stress or stress management or stress reduction or distress) NOT TX (qualitative or review or interview or animals) AND TX (older adults or elderly or geriatric or geriatrics or aging or senior or seniors or older people or aged 50+)

Appendix C.

Data Extraction Spreadsheet Example

Author(s) and Year	country	Population Inclusion	dropout	n_total	Age
Campo et al (2014)	USA	senior prostate cancer survivors, sedentary	11: health, timing, family, interest	29	55+
Cormie et al (2015)	Australia	men with prostate cancer	8: cancer side effects, wanted to exercise (control), time, travel	63	stratified ≥70, ≤ 70, intervention mean 70
Courneya et al (2017)	Canada	post-menopausal women at risk for breast cancer, inactive, nonsmoker, BMI 22-40, v02 < 34	14: medical, personal, relocation	400	50-74
Ehlers et al (2017)	USA	community-dwelling, able to read and write in English, right-handed, low active/inactive, over 23 on MMSE, over 21 on cognitive status questionnaire	1	247	60-79

control type	intervention type	intervention size	duration_PA	intensity_PA	P LEVEL
stretching	qigong	group	1 hour:2x week: 12 weeks	Borg: median=4.3, range=1.8–8.4) (progressive sessions)	p=0.002
usual care	aerobic (jogging, cycling, rowing), resistance	group (8-10)	1 hour:2x week: 3 months	aerobic (mod/high=70-85% MHR), 6/12 max weight rep (progressive	p=0.045
minimum public health guideline	aerobic choice	individual	1 hour/5x week: 1 year	65-75% MHR	p=0.69
strengthening/Stretching/Stability	dance, walking	group	1 hour:3x week: 24 weeks	Walking: increase 50%/60% MHR, 60%/75% MHR (6 weeks) Dancing: dancing increase intensity	p < 0.02 (mode of exercise no effect), p ≥ 0.29)

stress measure	type of analysis	mean_control_base	SD_control_baseline	mean_int_baseline	SD_int_baseline	mean_con_post	SD_con	mean_int_post	SD_int_post
PSS	T-Tests	3.71	2.64	3.43	2.75	3.89	2.75	3.35	2.84
Global Severity Index	chi-square,	5.2	9.7	3.8	4.9	7.3	9.4	3.9	4.5
PSS	least-square mean change/group diff.	17.1	7.3	17.	7.1	17.1	7.7	17.4	8.1
PSS-14	ANCOVA	13.95	7.2	12.11	6.4	12.18	6.4	10.67	5.6