



AUSactive



Brief Literature Review of the Effects of Exercise on Mental Illness

Prof. Elisabeth Wilson-Evered and Ms. Christina Maxwell

Revision based on feedback from:

Mr. Chris Alexander
Mr. Barrie Elvish

AUSactive

Dr Sarah Dash
Dr Bojana Klepac Pogrmilovic

Victoria University

What did we find?



Exercise appears to be helpful for anxiety and depression in different age groups.



Engaging in regular exercise can help to reduce the risk of having a mental illness.



Not getting enough exercise can increase mental illness.



People who have severe mental illness can improve their health by engaging in exercise.



Group-based exercise programs can be particularly beneficial for elderly people with depression.



Children and adolescents report less symptoms of mental illness and greater self-esteem from physical activity.



Exercise programs should be tailored to the individual and their mental health needs.



Much of the research recommended exercise programs that are supervised by a professional to maximise the benefits on mental health. Fitness and exercise professions, therefore, have the opportunity to significantly influence the mental health of populations by using their expertise to implement safe, research-based exercise activities.

Executive Summary

This brief literature review for AUSactive explored the association between exercise and mental health through four key questions; (a) What is the rate of mental illness in those who regularly exercise, compared to those who do not? (b) Can regular exercise prevent or minimise the risk of developing mental illness? (c) How does/can exercise reduce/manage the symptoms of mental illness? (d) What outcomes can be identified in those with a mental illness who engage in regular exercise? To answer the question two types of literature review were performed; the first question was answered using a narrative approach and the remaining questions were answered using a rapid systematic literature review method to scope findings in current research on the relationship between exercise and mental health. The latter approach was focused on locating evidence that was of high quality in order to increase confidence in the strength of our findings.

The field of enquiry has a burgeoning literature and engages top scholarship the world over to study this phenomenon. Importantly, Australia is among the leaders in this field. The review concludes there is a substantial association between mental health and exercise, and specifically that:

1. Though mixed results exist, evidence generally suggests a positive effect of exercise on mental health conditions such as anxiety and depression in different age groups.
2. There is a preventive effect of exercise on various mental health conditions.
3. Low exercise engagement is associated with an increased incidence of mental illness.
4. Including exercise in programs for people with severe mental illnesses tends to improve outcomes.
5. Elderly people with depression report better mental health when part of group exercise programs.
6. Children and adolescents report less symptoms of mental illness and greater self-esteem from physical activity.
7. Exercise programs should be tailored to the individual and their needs, taking into account any obstacles that may prevent them from engaging in regular exercise.
8. Many studies report the importance of supervised exercise which provides opportunities for the fitness and exercise professions to significantly influence the mental health of populations through both practice and research while offering environments in which exercise interventions can be conducted safely.

Few of the systematic reviews or meta-analyses identified by this literature review explicitly examined or discussed the mechanisms underlying the findings (the *why* and *how* of the relationship between exercise and mental health) and many of the authors recommended this avenue as of importance for future research. Most studies selected specific populations for their studies whereas prospective trials at the population level on exercise and mental health have not yet appeared in the literature. So, both population-level exercise interventions and the mechanisms of how exercise improves mental health are fruitful areas for further research.

The review suggests there is a promising opportunity for exercise, fitness, and physical activity professionals to collaborate in research to further examine the influence of exercise on mental health over both the long and short terms and with diverse populations and types of exercise. Similarly, these professional groups could lead interventions to improve the physical and mental health and wellbeing among the population.



Scope of Review

AUSactive requested a review of the contemporary literature to summarise the relationship between exercise and mental health. The aim of this document is to identify the most salient evidence-based factors that explain the relationship between exercise and mental health specifically in response to four key areas. We present a brief literature review of contemporary research findings addressing the following research questions:

- i. What is the rate of mental illness in those who regularly exercise, compared to those who do not?
- ii. Can regular exercise prevent or minimise the risk of developing mental illness?
- iii. How does/can exercise reduce/manage the symptoms of mental illness?
- iv. What outcomes can be identified in those with a mental illness who engage in regular exercise?

Definitions

There are often inconsistencies in the literature as to how physical activity is defined. In this report, we draw on the work by Caspersen and colleagues (1985) to disentangle the terminology. Specifically, we understand physical activity to be an over-arching category referring to “any bodily movement produced by skeletal muscles that results in energy expenditure” (p. 126) and includes sport and exercise, as well as incidental movement required in leisure activities, household chores, or work tasks. Exercise, in comparison, is a more specific subset of physical activity that is “planned, structured, repetitive, and purposive” (p. 128). The aim of this report is focused at the level of exercise, which will be the preferred terminology used where possible. However, as this report gathers evidence from published research studies, we rely on the definitions and explanations of the interventions as they are used by the authors of the original literature. As such, in some instances, the type of exercise undertaken in the studies is not specified so we defer to the authors’ terminology to avoid assumptions. In instances where the authors use the term ‘physical activity’ but provide enough information about the intervention methodology to determine that a classification of ‘exercise’ is more appropriate, we use the latter.

Report Structure and Approach

This report is structured to answer the research questions in the order they were posed. Whilst there is a vast literature on mental health and exercise and variations on those themes, there is not an extensive body of research that can be considered of the most convincing and strongest evidence base according to international frameworks on evidence. The top level of evidence (Level I) is Randomised Control Trials (RCTs) which involve allocating people to groups such as intervention or treatment type and where the researchers are blind to which groups the participants are allocated (refer to Table 1 for the varying levels of evidence). RCTs would provide the strongest evidence for a link between mental health and exercise and where they exist, they have been included in the review. The search on the first question, however, surfaced no such studies so the evidence of association there is derived from research published in peer reviewed journals. This lower level of evidence is categorized at V or five below as they have no controls or non-intervention (exercise vs no exercise) groups with which to compare findings.



Levels of Evidence from Sackett

Level	Type of evidence
I	Large RCTs with clear cut results
II	Small RCTs with unclear results
III	Cohort and case-control studies
IV	Historical cohort or case-control studies
V	Case series, studies with no controls

Note. Adapted from Sackett (1989).

Table 1

Rationale

The increase in mental health conditions following COVID-19 ranges between 20 and 35% according to some sources (Bryant, 2021). However, insufficient time has passed yet to be certain of precise prevalence rates, though the Australian Bureau of Statistics (ABS) has published a report in April 2021. The most recent ABS statistics that indicate the prevalence of health conditions and exercise patterns were published in 2018. However, the 2021 study by the ABS does provide emerging evidence of trends on the household impacts of the COVID-19 pandemic. Notwithstanding the effects of lockdown and illness on exercise and mental health, evidence has accrued over the recent decades on the way in which exercise can assist in protecting against or ameliorating the effects of mental illness on individuals and societies. A useful guide produced by the Mental Health Foundation UK (n.d.), outlines the benefits of exercise on anxiety and depression. Similarly, while the of mental illness of 1 in 5 (20%) have been reported in Australia (Australian Institute of Health and Welfare, 2021), the burden of such disease on individuals, families and communities is difficult to fully estimate given the ripple effects through families, workplaces, and economies. Exercise is available to everyone regardless of their abilities and is an inexpensive prescription. Therefore, this review for AUSactive is both timely and important given the ongoing incidence of mental health conditions among all levels of the population in Australia. Moreover, given the growing base of fitness industry and exercise professionals, these individuals provide an expert resource on whom to draw to engage diverse populations in exercise to prevent, treat or reduce the impact of mental health conditions.

Literature Review Method

A rapid systematic literature review was conducted in April and May of 2021, and again in August 2021, to scope current understandings of the relationship between exercise and mental ill-health using high-quality research evidence. Due to time constraints, the search was contained to one database in addition to literature obtained via a preliminary Google Scholar search and select research recommended from experts in the field. The use of one database in a time-restricted systematic review is consistent with practices in the literature (Lal & Adair, 2014). To determine which database would yield the most relevant research results (according to the guiding research questions), the method sections of already-published systematic reviews on mental illness and exercise were scanned. The most common database in this field of research was PubMed, so this database was selected for use in the current literature review.

The literature review was conducted in a systematic, albeit condensed manner following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. The following search string was used for both PubMed and Google Scholar searches:



(Exercise OR exercize OR "physical activity" OR fitness OR gym) AND ("mental health" OR "mental illness") AND ("systematic review" OR "meta-analysis" OR "randomised control trial" OR "randomized control trial")

As another limitation of the time constraints on this review, specific mental health diagnoses (e.g., depression, anxiety, schizophrenia) were not included in this search string. However, the research located for this review nonetheless captured many of these mental health diagnoses at both clinical and non-clinical levels within the search terms specified.

Google Scholar was only used to supplement the PubMed search with any key articles in the field that were not located in the database. The search was conducted with the following inclusion criteria: published between 2011 and August 2021 in a peer-reviewed journal; the research was either a RCT, meta-analysis, or systemic literature review; available in English; human participants only. All search results from PubMed were imported into Endnote.

721 records were identified through database searching. On further review, research was rejected if there was no or minimal discussion on mental health, only a study protocol was presented, only the effects of exercise on physical health were investigated, the focus was on participants with a comorbid physical health condition (e.g., cancer, diabetes, etc.), the effects on mental health were not a primary outcome, or it was already used in the analysis of an included meta-analysis review. As a result, 57 records were included in the following literature review (refer to Figure 1 for the PRISMA flow diagram of this selection process).

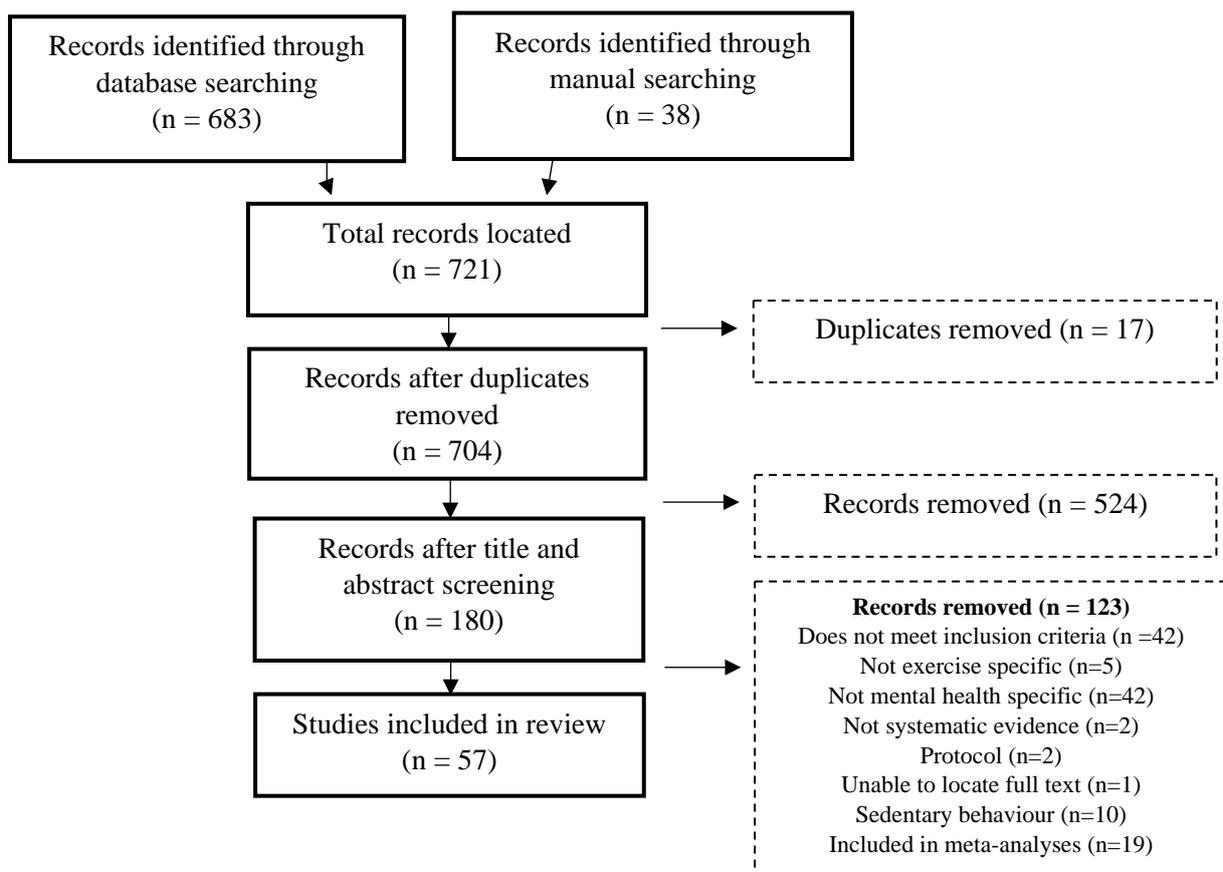


Figure 1: PRISMA Flow Diagram for the Systematic Literature Review on the Effects of Exercise on Mental Ill-Health.



Feedback from subject matter experts added another eleven references (Cooney et al., 2013; Doré et al., 2019; Eime et al., 2013a; Gerber et al., 2014; Harvey et al., 2018; Mikkelsen et al., 2017; Morgan et al., 2013; Seino et al., 2019; Siefken et al., 2019; ten Have et al., 2011; Vieten et al., 2021) upon review of the draft report.

Results

Substantial published research has investigated the effects of exercise on mental health, as indicated by the breadth of systematic reviews and meta-analyses in the area. Although the type of exercise varies across studies and does not suggest a particular interest in any one type, the literature is clearly skewed regarding the type of mental health under investigation. Specifically, most of the research identified in this literature review was focused on clinical or non-clinical depression (Ashdown-Franks et al., 2020; Choi et al., 2019; Cooney et al., 2013; Czosnek et al., 2019; Gong et al., 2015; Gordon et al., 2018; Josefsson et al., 2014; Liu et al., 2015; Mammen & Faulkner, 2013; Morres et al., 2018; Nakamura et al., 2019; Park et al., 2014; Pascoe & Parker, 2019; Radovic et al., 2017; Schuch et al., 2018; Seo & Chao, 2015). Other research focused to a lesser extent on psychosis and schizophrenia (Brokmeier et al., 2020; Czosnek et al., 2019; Kurebayashi et al., 2021; Shannon et al., 2020; Vogel et al., 2019), suicide attempts and ideation (Felez-Nobrega et al., 2020; Morris et al., 2018), OCD and related disorders (Brierley et al., 2021), anxiety (Ramos-Sanchez et al., 2021; Schuch et al., 2019; Stubbs et al., 2017; Zika & Becker, 2021), or general wellbeing (e.g., Eime et al., 2013b; Hendriks et al., 2017; Kim et al., 2012).

As aforementioned, the types of exercise activities observed in the research were diverse and included: circuit training interventions (Ahn & Fedewa, 2011); Qigong (Chang et al., 2019; Liu et al., 2015); Tai Chi (Liu et al., 2015; Wang et al., 2014; Zhang et al., 2019); team-based sports (Eime et al., 2013b); Pilates (Fleming & Herring, 2018); High Intensity Interval Training (HIIT; Korman, Armour, et al., 2020; Martland et al., 2020); yoga (Gong et al., 2015; Hendriks et al., 2017); walking (Kadariya et al., 2019); aquatic-based exercise (Campos et al., 2021); running (Pereira et al., 2021); virtual reality exergames (Yen & Chiu, 2021); and resistant exercise training (Gordon et al., 2017, 2018).

Research Questions

Question 1.

What are the Rates of Mental Illness in Those Who Regularly Exercise, Compared to Those Who Do Not?

Method

Systematic reviews, meta-analyses, and RCTs that confirmed a positive effect for exercise on mental health compared with those who do not exercise were not located. Comparing rates of mental health are different among those with mental illness who exercise has been explored, however, not to the extent that exercise was proven to improve mental health. Therefore, to answer this question: (a) a narrative review was performed which involved key word search (mental illness, physical activity, comparisons); (b) expert suggestions were provided for work that is considered strong in the field to discuss this association; and (c) articles and resources referenced in articles were sourced. The rigour of this review is not of the standard of a systematic or rapid review; however, articles selected were moving towards revealing comparison in exercise rates. Some additional articles have been included to reveal the interest in research in exercise and mental health service consumers in Australia. The Queensland group at QIMR and Queensland Mental Health services are focused on this area and made some suggestions for this review. Some population data from the Australian Bureau of Statistics (ABS) and study findings are presented in dot point form though no comparison studies were found.



Results

- A large cross-sectional study in the USA found that individuals who exercised (in any activity type) reported fewer days of poor mental health than those who did not exercise (Chekroud et al., 2018).
- An Australian-led multi-author study noted that a plethora of varied interventions are used to promote exercise in settings for people with severe mental-health conditions with the aim of reducing sedentary behaviour (Lederman et al., 2017). However, it is the pragmatic and effective implementation of the programs that determines the increased access to exercise interventions for mental-health service users. Specifically, programs should be supervised by qualified professionals, be designed for individuals' illness type and severity, involve multidisciplinary teams, monitor cardiometabolic states, are supported by organisational leaders and staff as well as engage participants and those with lived experience in the implementation. In such conditions, exercise programs can improve outcomes for mental and physical health. Importantly, safe and acceptable programs can be implemented at low cost by collaboration among settings, the community, and providers.
- The challenge of measuring physical activity among people with psychosis was explored by Queensland researchers (Suetani et al., 2020). The authors confirmed three tools (i.e., GENEActiv, SIMPAQ, and the 6MWT) that might be useful measures to use when people have cognitive impairments through psychosis. They further supported the notion that observation could provide additional nuanced details.
- Data from the ABS (2018) though not predictive does indicate that mental health conditions are increasing while only a small number of people are meeting physical activity guidelines. Recent restrictions through the COVID-19 pandemic have seen an increase in mental health conditions and in general less social and work activities as well as less exercise.
- Among people aged "18 years and over with co-existing mental and behavioural and physical health conditions, almost three-quarters (72.8%) reported no or low levels of exercise. This statistic compared with around two-thirds (67.8%) of adults with one mental and behavioural condition and 65.6% of adults with one or more physical health conditions only." (ABS, 2020). (The reader is referred to Appendix and ABS (2016) for more details.)
- Chapman et al. (2018) noted that exercise has diverse benefits for physical and mental health and can reduce symptoms of mental illness. They explored how best to promote exercise to those with mental illness. The group compared supervised exercise interventions which provide high support and autonomous motivation which is necessary for the maintenance of exercise behaviours. The results from this study are pending (J. Chapman, personal communication, 2021).
- A 2019 longitudinal cohort study (Level III evidence; Sackett, 1989) assessed the relationships between physical activity and mental wellbeing or mental health disorders in adolescents (Bell et al., 2019). While no relationships were found between physical activity and mental wellbeing or an overall measure of mental health disorders, an association was found between physical activity and the anxiety and depression subset of mental health disorders. The authors therefore suggest that physical activity may potentially be a protective factor against the development of depression and anxiety symptoms in adolescents.
- While not comparing the mental health of those who exercise or those who do not, a 2013 study did compare the effects of group versus home exercises on the mental health of elderly people (Mortazavi et al., 2013). The study found that a twice weekly

(16 sessions) program for two months improved the mental health of both groups as measured by the GHQ-28. However, the group-based intervention had a significantly better effect after adjusting for pre-test status. The study builds on the findings of Blumenthal and colleagues (1999) who found that exercise training was as effective as antidepressant medication for older people with major depression disorder diagnoses. Crucially, the latter study found that after 10 months, the relapse rate was significantly lower in the exercise group (Babyak et al., 2000).

- A single arm prospective study again led by Queensland researchers provides promising results of the effect of a student-led diet and exercise program for people with severe mental illness in residential settings (Korman, Fox, et al., 2020). The sessions were led by two fourth (final) year exercise physiology (EP) students at each site undertaking a 12-week practicum placement. The students were supervised by university lecturers and a part time accredited exercise physiologist (AEP). The authors found “significant improvements in functional exercise capacity, volume of exercise, general psychiatric symptoms, and negative psychotic symptoms” (p. 2) over the 10-week period. Blood markers did not change because of the intervention. The authors noted a decline in motivation for and perceived value of exercise which indicates support for the notion that individuals with mental illness require autonomous motivation to derive long term benefits from exercise programs.
- Chapman et al. (2021) observed that people with mental illness and reduced physical activity are vulnerable to decline because of the COVID-19 pandemic and associated restrictions. They designed an intervention aimed to improve/maintain well-being and exercise in this population. The study found that more than half of the 59 respondents reported that during the pandemic their mental health and physical activity declined. Individual exercise instruction in-person in a park was the preferred form of exercise. Elements of the program particularly useful were noted as “incentivization, provision of exercise equipment and fitness devices, and daily exercise programs” (p. 175). The authors concluded that enabling strategies for exercise included providing equipment and self-monitoring devices though assistance with the latter would be necessary for some.
- Combining studies on sedentary behaviour (the other side of the coin to physical activity) and drawing on a sample of over 1500 people, Biddle et al. (2021) found an association between sitting for long periods and mental health. Wearable devices were used to measure physical activity and sedentary behaviour which were compared with measures of mental health. Results indicated that total and prolonged sitting were associated with higher depression, and prolonged and worse health state scores. Total and prolonged sitting were associated with a 14% increased odds of being in the borderline/abnormal category for depression. Results for anxiety and sitting were not significant.

Although the evidence located to answer this research question is not of the highest quality (i.e., not from RCT studies), it nonetheless suggests that exercise has the potential to improve mental health among diverse populations. Further, RCT evidence may not be feasible or even appropriate to answer this question due to the difficulties in randomly assigning different populations to exercise interventions for extended periods of time.

There is an opportunity for fitness and exercise professionals to play a role in helping people design and engage with exercise programs that could provide benefits for their mental health. Future research could specifically explore the role of the fitness and exercise professions in encouraging and guiding participation in exercise while measuring mental health outcomes. Furthermore, collaboration among the exercise and fitness professions and university researchers who study mental health and exercise is clearly justified to discover new understandings.



Question 2.***Can Regular Exercise Prevent or Minimise the Risk of Developing Mental Illness?***

The evidence used to help answer this question and the questions following is based on the rapid systematic literature review process already described. In general, research has demonstrated a preventative effect of exercise on the later development of mental illness. Specifically, exercise has shown protective effects for depression (Kadariya et al., 2019; Mammen & Faulkner, 2013; Rebar et al., 2015; Schuch et al., 2018), postpartum depression for women who exercise during pregnancy (Nakamura et al., 2019), and anxiety, Post-Traumatic Stress Disorder (PTSD), and agoraphobia (Rebar et al., 2015; Schuch et al., 2019; Stubbs et al., 2017). These protective effects were shown across the lifespan and cross-culturally (Doré et al., 2019; Schuch et al., 2018, 2019; Stubbs et al., 2017). For instance, a prospective survey of Dutch adults found a protective effect of exercise on the development of mood and anxiety disorders, but not substance use disorders (ten Have et al., 2011). Overall, regular exercise has holistic effects, including improved wellbeing, self-esteem, and social functioning, as well as reduced stress and distress (Bjørnarå et al., 2021; Eime et al., 2013b). In fact, research has found evidence that one of the motivating factors to engage in exercise is to manage or improve mental health (Pereira et al., 2021).

Alternatively, in their systematic review, Suetani and colleagues (2019) caution against assuming that physical inactivity is a risk factor for mental illness development. Vancampfort et al. (2018) similarly bring nuance into the relationship between mental health and physical activity by observing a protective effect against suicidal ideation for adults, but mixed findings for adolescents and older adults.

To better understand what contributes to the effects of exercise on mental health, research has attempted to isolate specific intervention and exercise program variables. Regarding frequency, Chekroud et al. (2018) reported that an exercise event lasting more than three hours leads to poorer mental health effects than no exercise and that three to five exercise events a week are considered ideal for maintaining mental health. Kim et al. (2012) demonstrated that mental health benefits are maximised when individuals engage in physical activity for five to seven hours a week. For those with pre-existing mental health conditions, Morgan et al. (2013) recommend that moderate-to-vigorous exercise should occur three times a week for at least 8 weeks at 30 minutes duration for each session and that the type of exercise should be tailored to the individual. Mammen and Faulkner (2013) reported in their systematic review that any level of physical activity is beneficial for preventing future onset of depression while Siefken and colleagues (2019) find that depression symptoms may be higher for those who do not meet World Health Organisation (WHO) requirements (i.e., 150 mins of moderate-intensity physical activity per week; WHO, 2020). In a cohort study in Norway using a sample of over 22,000 adults, engaging in exercise for at least one hour per week was found to be protective of future depression (although no effects were found regarding anxiety; Harvey et al., 2018).

Considering the necessary levels of intensity required to achieve the mental health benefits of exercise, Gerber et al. (2014) demonstrated that over a seven-day period, undergraduate students who engaged in vigorous-intensity physical activity experienced lower anxiety, pain, and depressive symptoms as well as better quality sleep than those who engaged in an equivalent moderate-intensity physical activity. There is, however, evidence in the literature of a 'diminishing returns' or even detrimental effect to mental health once exercise frequency or intensity exceeds a certain point (Bjørnarå et al., 2021; Harvey et al., 2018; Vieten et al., 2021). Further complicating understandings of what components of exercise programs influence mental health is that the effectiveness of the former may differ as a result of gender, age, the presence of comorbid medical conditions, or various other individual and cultural variables (Campos et al., 2021; Pereira et al., 2021).

The types of exercise that may enhance this protective relationship is also subject to discussion. A cross-sectional study conducted by Chekroud et al. (2018) demonstrated that

individuals were less likely to report poor mental health when they participated in team sports, followed by cycling, and aerobic and gym activities. Additionally, exercises that have a mindfulness component (such as yoga and Tai Chi) (Chekroud et al., 2018; Hendriks et al., 2017; Zhang et al., 2019), resistance training (Gordon et al., 2017, 2018), recreational running (Pereira et al., 2021), and other outdoor-based exercises (Eigenschenk et al., 2019) have all also shown improved mental health. A literature review from Mikkelsen and colleagues (2017) finds evidence that both aerobic and non-aerobic exercise are equally effective for increasing mental wellbeing while a comprehensive scoping review of 1,444 peer-reviewed studies has provided evidence that the beneficial effects of physical activity on mental health and psychological wellbeing are present across an extensive and diverse range of activity types (Vieten et al., 2021).

Finally, recent emerging evidence during the COVID-19 pandemic found a relationship between low physical activity and greater mood disturbances (anxiety, stress, and depression) and sleep disruptions (Violant-Holz et al., 2020). However, during this tumultuous time, exercise was an effective coping strategy for the adverse effects of the pandemic. Additionally, the maintenance of routines involving regular physical activity was shown to be a protective factor against depression and anxiety during COVID-19 (Wolf et al., 2021).

Question 3.

How Does/Can Exercise Reduce/Manage the Symptoms of Mental Illness?

As discussed further in the section entitled “*Limitations of the Reviewed Research*”, conclusions across meta-analysis and systematic review literatures report that the research is lacking in identifying the mechanisms such as “how” and “why” to explain the relationships between exercise and mental illness. In general, researchers posit that it is unlikely the result of one mechanism acting in isolation, rather the interaction of psychosocial and neurochemical mechanisms (Ashdown-Franks et al., 2020; Rebar et al., 2015; Schuch et al., 2018; Zhang et al., 2019). Postulated mechanisms include: a sense of mastery and achievement, increases in confidence and self-esteem (Mason & Holt, 2012; Mikkelsen et al., 2017), cardiorespiratory fitness (Cadenas-Sanchez et al., 2021), increases in self-awareness (Morris et al., 2018; Zhang et al., 2019), promotion of neurogeneration (Schuch et al., 2019), exercise as providing a sense of structure (Morgan et al., 2013), increased dopamine (Marques et al., 2021), and regulation of heart rate variability (Zhang et al., 2019).

Further, a literature review conducted by Mikkelsen et al. (2017) identified potential physiological, psychological, and immune system mechanisms including: endorphin levels, body temperature, neuroplasticity, mammalian target of rapamycin (mTOR), neurotransmitter levels, hypothalamic pituitary-adrenal (HPA) axis, exercise as a distraction from mental health problems, cytokine release, visceral fat mass, toll-like receptors, and strengthened vagal tone. Increased brain-derived neurotrophic factor (BDNF) has also been implicated as a potential mechanism by which exercise may improve mental ill-health (Brierley et al., 2021; Kurebayashi et al., 2021).

Fleming and Herring (2018) reported reductions in depressive symptoms, anxiety symptoms, and fatigue and an increase in energy due to engagement in Pilates. The authors suggested that these effects can be attributed to increased serotonin levels as well as the opportunities for socialisation within Pilates groups. Indeed, the psychosocial benefits of exercise engagement have been identified as a potential mechanism for improvement in mental ill-health (Eime et al., 2013a, 2013b; Harvey et al., 2018; Mammen & Faulkner, 2013; Mason & Holt, 2012; Seino et al., 2019; Vieten et al., 2021). For instance, in Japan, older adults who exercised with others reported higher mental health scores than those who exercised alone which, in turn, was higher than those who did not exercise at all (Seino et al., 2019). Similarly, a systematic review of the effects of sports participation on children and adolescents observed a range of benefits including self-esteem, social skills, confidence, competence, and fewer depressive symptoms. The authors suggested that these benefits might be stronger for those who are involved in team sports (Eime et al., 2013a). Siefken et al. (2019)

also report lower depression and anxiety scores for indoor team athletes (as opposed to outdoor teams and individual athletes), however these findings were highly variable and dependent on context.

The results reported under Question 1 offer less strong evidence though solid findings for the benefits of exercise on symptoms of mental illness.

Question 4.

What Outcomes Can Be Identified in Those With a Mental Illness Who Engage in Regular Exercise?

In their meta-review of meta-analyses on mental health and exercise, Ashdown-Franks et al. (2020) found that exercise is beneficial for a range of mental health diagnoses, including binge-eating, anorexia nervosa/bulimia, PTSD, and alcohol use disorders/substance use disorders (although the evidence supporting the last of these disorders is mixed). The evidence for the beneficial effects of exercise on different types of mental health disorders is presented in more detail below:

Depression

There is a general trend toward the ameliorative effects of exercise on depression symptomatology. In their meta-review, Czosnek et al. (2019) showed that depression symptoms can be moderated using exercise interventions; however, it is most effective when part of a comprehensive treatment plan. These reductions in depression symptoms hold not only for singular diagnoses of depression, but also for comorbid diagnoses and alcohol use disorders/substance use disorders where depression symptoms also occur. However, the authors also reported equivocal evidence about whether the improvement in symptoms is maintained in the long-term and whether the intervention should be undertaken with supervision from a qualified professional. Alternatively, Gordon and colleagues (2018) provided evidence in their meta-analysis for the benefits of professional supervision on reducing depressive symptoms during RCTs of resistance exercise training. Additional intervention program variables that may assist in the treatment of depression include moderate intensity exercise, completed three times a week for at least nine weeks (Stanton & Reaburn, 2014). In contrast, Morres et al. (2013) provided evidence that short-term aerobic exercise interventions of four weeks duration may result in improved depression symptoms. Choi and colleagues (2019) also showed that physical activity is a protective factor for Major Depressive Disorder only when it is measured using objective means rather than subjective self-reporting.

Other systematic and meta-analytic reviews across varied activity types have supported the findings that exercise improves depression symptomatology (Bjørnarå et al., 2021; Josefsson et al., 2014). A meta-analysis of RCTs on the effects of exercise on diagnosed depression in adults found a moderate clinical effect as compared with no treatment or control (although there was no difference when compared with psychological and pharmacological treatment; Cooney et al., 2013). Ashdown-Franks et al. (2020) reported reduced Major Depressive Disorder symptoms across the lifespan when diagnosed individuals engaged in exercise. Like Gordon et al. (2018), the authors also found benefits when the exercise was supervised.

The effects of exercise on depression outcomes can be observed across the lifespan. For example, exercise interventions have demonstrated an improvement in depression symptoms for older adults both with (Seo & Chao, 2015) and without (Park et al., 2014) a comorbid chronic disease diagnosis. Pascoe and colleagues (2020) presented evidence from a scoping review and meta-analysis that showed how moderate-to-vigorous intensity exercise may be beneficial for depression symptoms in young adults and adolescents.

A number of specific types of exercise have been identified as particularly beneficial for managing depression. These include High Intensity Interval Training (HIIT; Korman, Armour, et al., 2020; Martland et al., 2020), yoga (Gong et al., 2015), and Qigong (Liu et al., 2015;

although Chang and colleagues [2019] provide evidence that Qigong is not beneficial for depression or general mental health). Finally, an emerging area of interest is the mental health benefits of virtual reality (VR) exergames, which are computerised games that require bodily movement in order to play. One systematic review and meta-analysis found a reduction in depressive symptoms and an increase in memory and general cognition for older adults who engaged in VR exergames (Yen & Chiu, 2021). The authors found that these effects were more pronounced in interventions that had a duration of more than six weeks.

Suicide Attempts

Reporting low heterogeneity in responses across 48 countries, Felez-Nobrega et al. (2020) reported that while regular, moderate intensity exercise decreased the likelihood of suicide attempts for adolescent boys, it was related to an increased likelihood of suicide attempts of adolescent girls. The authors postulate that this finding for girls may be related to body image dissatisfaction and low self-esteem.

Schizophrenia and Psychosis

Although physical activity may not act as a protective factor for the onset of psychosis or schizophrenia (Brokmeier et al., 2020), there is evidence that schizophrenia symptoms can be improved through the engagement in moderate-intensity and supervised exercise (Ashdown-Franks et al., 2020; Chang et al., 2019) as well as mind-body exercises, such as yoga and Tai Chi (Vogel et al., 2019). Shannon et al. (2020) reported that group-based exercises may be particularly useful for reducing the severity of psychiatric symptoms of psychosis, as well as comorbid depression symptoms. The use of HIIT for reducing schizophrenia symptom severity has demonstrated mixed evidence, with some research showing improvements in global and social functioning and negative symptoms (Martland et al., 2020) and some research showing no differences to control treatments (Korman, Armour, et al., 2020). Morgan and colleagues' (2013) literature review identifies exercise as having a positive effect on some of the mental health symptoms of schizophrenia, as well as psychosocial and physical health.

Finally, a RCT (Kurebayashi et al., 2021) in Japan allocated 18 in-patients with schizophrenia diagnoses to either an eight-week aerobic/Tai Chi intervention or a control condition. The sessions were within a supervised group format and involved an hour of exercise twice a week. At follow-up, those in the intervention condition demonstrated improved cognitive functioning as compared to the control group.

Anxiety Related Disorders

There is emerging evidence that involvement in exercise can reduce anxiety and PTSD symptoms in both clinical and non-clinical populations (Bjørnarå et al., 2021; Czosnek et al., 2019; Martland et al., 2020; Zika & Becker et al., 2021). Military veterans have reported finding exercise useful for coping with PTSD and for reducing symptoms (Whitworth & Ciccolo, 2016). Regarding specific exercise interventions, there is also evidence that both Qigong and Tai Chi (Chang et al., 2019; Wang et al., 2014), aquatic-based exercises (Campos et al., 2021), and aerobic exercise and resistance training (Ramos-Sanchez et al., 2021) can improve anxiety symptoms. Ashdown-Franks and colleagues (2020) reported that exercise-based interventions are equivalent to other active treatments with regards to their effects on anxiety.

OCD and Related Disorders

There are currently few empirical research studies that examine the effects of exercise interventions on Obsessive-Compulsive Disorders (OCD). One systematic review has shown some symptom improvement with yoga or structured aerobic exercise programs however they may be most effective when included alongside psychotherapeutical and pharmacological interventions (Brierley et al., 2021).

Substance Use Disorders

There is some research assessing the effect of exercise engagement for individuals with substance abuse disorder diagnoses. A systematic review conducted by Morris and colleagues (2018) presented emerging evidence that exercise may lower depression and

anxiety scores for methamphetamine users. Exercise has also shown some improvements for depression symptoms for individuals with substance use disorders more generally (Martland et al., 2020).

Children and Adolescents

Ahn and Fedewa (2011) found that across different intervention designs, children who were clinically diagnosed with a mental illness received more benefit (reductions in symptoms of depression, anxiety, PTSD, and emotional disturbance, as well as increases in self-esteem and self-concept) from physical activity programs than children who did not have a clinical diagnosis. Similar to the findings on depression as reported above, the largest effects were found for interventions that were supervised by teachers or qualified specialists.

In their meta-analysis, Zang (2019) found evidence that physical activity may be beneficial for children with Attention Deficit Hyperactivity Disorder (ADHD) diagnoses, particularly in terms of managing anxiety and depression symptoms, social problems, and aggressive behaviours.

Barriers

While Morgan et al. (2013) echo findings that exercise can be beneficial across a range of mental health conditions, they also highlight the need for healthcare professionals to be aware of the barriers that those with mental ill-health may experience when attempting to engage in regular exercise. These barriers may include the impacts of group-based exercise on someone with a social phobia, indoor-based exercise for those with agoraphobia diagnoses, or the effects of any simultaneous psychological or pharmacological treatments (Hickingbotham et al., 2021; Morgan et al., 2013). Similarly, Hickingbotham and colleagues (2021) identify a number of barriers that deter children with mental health diagnoses from participating in physical activity. For instance, children with Autism Spectrum Disorder (ASD) diagnosis showed a tendency to dislike activities that were group-based and involved a lot of environmental stimuli. Other barriers included parental concerns for safety as well as a lack of awareness and experience among physical activity supervisors of ASD. The authors also report that low time and monetary resources, low self-efficacy, or a general aversion to exercise could operate as barriers for children with a range of mental health diagnoses.

Finally, Mikkelsen et al. (2017) caution for the adverse effects of exercise including: exercise addictions (including using exercise as an unhealthy weight management strategy) and the dysregulation of immune system functioning in long-term high-intensity exercise.

Limitations of the Reviewed Research

Very few of the systematic reviews or meta-analyses identified by this literature review discussed the mechanisms underlying the findings (the *why* and *how* of the relationship between exercise and mental health) which may reflect that the research the authors used in their own analyses did not consider this aspect of their results. Indeed, several authors (Ashdown-Franks et al., 2020; Bjørnarå et al., 2021; Brierley et al., 2021; Gordon et al., 2017; Mammen & Faulkner, 2013; Siefken et al., 2019; Vancampfort et al., 2018; Vieten et al., 2021) also make this observation, noting that further research is required to identify how and why exercise affects mental health. There is also insufficient evidence to determine what dosage (i.e., duration and intensity) and type of exercise should be recommended to prevent or manage different mental health conditions (Cooney et al., 2013; Morgan et al., 2013; Ramos-Sanchez et al., 2021). The focus on cross-sectional data (particularly survey data at one point in time) also precludes strong conclusions to be made about the direction of the relationship between mental health and exercise (Bjørnarå et al., 2021; Cadenas-Sanchez et al., 2021; Eime et al., 2013a).

Most of the authors included in the current literature review also noted the heterogeneity of the interventions that they analysed in their research. They identified little consistency across intervention design, measurement, and outcomes which limited their ability to make conclusive, strong claims about the relationship between mental health and exercise (e.g., Ashdown-Franks et al., 2020; Cadenas-Sanchez et al., 2021; Eigenschenk et al., 2019; Eime et

al., 2013b; Fleming & Herring, 2018; Hendriks et al., 2017; Liu et al., 2015; Morris et al., 2018; Nakamura et al., 2019; Radovic et al., 2017; Suetani et al., 2019; Vogel et al., 2019). The quality of evidence assessed was also reported as moderate-to-low on average, with critiques that the original authors did not provide enough detail about the methodological considerations of their interventions or the lack of RCTs (Brierley et al., 2021; Chang et al., 2019; Gordon et al., 2017; Hendriks et al., 2017; Nakamura et al., 2019; Pascoe et al., 2020; Wang et al., 2014). However, while RCTs may be considered the ‘gold standard’ of evidence, it may not always be appropriate or even feasible to conduct these types of controlled studies within this context (Bjørnara et al., 2021). In such cases, longitudinal studies may be preferred.

Additionally, the research was critiqued for relying on self-report measures of exercise (Cooney et al., 2013; Kadariya et al., 2019; Mammen & Faulkner, 2013; Schuch et al., 2019, 2018; Suetani et al., 2019; Vancampfort et al., 2018; Whitworth & Ciccolo, 2016). Finally, Cooney et al. (2013) recommend that interventions need to report *both* beneficial and adverse effects, as well as any costs associated with exercise engagement to enable practitioners and clients to make informed decisions about whether exercise programs will be helpful for their needs.

Conclusion

As demonstrated in this report, exercise has the potential to provide mental health benefits to both clinical and non-clinical populations. It is a generally low-risk intervention that poses few adverse side-effects for engagement and can be easily modified to account for the requirements of the individual. Exercise interventions are not a ‘one size fits all’ approach and should take into consideration variables such as: mental health condition and status, preferred exercise type, and the time and resources available to be able to engage in regular, structured exercise. These needs may include a comprehensive treatment plan of which exercise interventions only make up one part. However, research shows that exercise interventions in-and-of themselves may be comparable to other types of mental health treatment options and often show significantly more improvement in symptoms than control conditions (that is, where no exercise is undertaken). The specific program characteristics vary, although exercise that is supervised by a professional appears to consistently contribute to larger and more positive effects. Additionally, although the literature in this area is vast, there is a need for more rigorous and high-quality research, particularly that which seeks to understand the mechanisms of the relationship between exercise and mental health. Nonetheless, the evidence is clear that exercise can be beneficial for a variety of mental health conditions across different populations.



References

- Australian Bureau of Statistics (February 2016). *4329.0.00.004 - National Health Survey: Mental health and co-existing physical health conditions, Australia, 2014 – 15*. Retrieved August 9, 2021, from <https://www.abs.gov.au/AUSSTATS/abs@.nsf/ProductsbyCatalogue/C0A4290EF1E7E7FDCA257F1E001C0B84?OpenDocument>
- Australian Bureau of Statistics (December 2018). *National Health Survey first results, 2017-2018 financial year*. Retrieved April 1, 2021, from <https://www.abs.gov.au/statistics/health/health-conditions-and-risks/national-health-survey-first-results/latest-release>
- Australian Bureau of Statistics (May 2021). *Household impacts of COVID-19 survey*. Retrieved May 11, 2021, from <https://www.abs.gov.au/statistics/people/people-and-communities/household-impacts-covid-19-survey/latest-release>
- Australian Bureau of Statistics (June 2020). *Mental health*. Retrieved April 12, 2021, from <https://www.abs.gov.au/statistics/health/mental-health>
- Ahn & Fedewa, (2011). A meta-analysis of the relationship between children’s physical activity and mental health. *Journal of Pediatric Psychology, 36*(4), 385-397. <https://doi.org/10.1093/jpepsy/jsq107>
- Ashdown-Franks, G., Firth, J., Carney, R., Carvalho, A. F., Hallgren, M., Koyanagi, A., Rosenbaum, S., Schuch, F. B., Smith, L., & Solmi, M. (2020). Exercise as medicine for mental and substance use disorders: a meta-review of the benefits for neuropsychiatric and cognitive outcomes. *Sports Medicine, 50*(1), 151-170. <https://doi.org/10.1007/s40279-019-01187-6>
- Australian Institute of Health and Welfare (2021). *Mental health services in Australia*. Retrieved from https://www.aihw.gov.au/reports/mental-health-services/mental-health-services-in-australia/report-contents/summary-of-mental-health-services-in-australia/prevalence-impact-and-burden#1_prevalence
- Babiyak, M., Blumenthal, J. A., & Herman, S. (2000). Exercise treatment for major depression: Maintenance of therapeutic benefits at 10 months. *Psychosom Med., 62*, 633-638.
- Bell, S. L., Audrey, S., Gunnell, D., Cooper, A., & Campbell, R. (2019). The relationship between physical activity, mental wellbeing and symptoms of mental health disorder in adolescents: A cohort study. *International Journal of Behavioral Nutrition and Physical Activity, 16*(138). <https://doi.org/10.1186/s12966-019-0901-7>
- Biddle, S. J. H., Henson, J., Davies, M. J., Khunti, K., Sutton, S., Yates, T., & Edwardson, C. L. (2021). Device-assessed total and prolonged sitting time: Associations with anxiety, depression, and health-related quality of life in adults. *Journal of Affective Disorders, 287*, 107-114. <https://doi.org/10.1016/j.jad.2021.03.037>
- Blumenthal, J. A., Babyak, M. A., Moore, K. A., Craighead, W. E., Herman, S., Khatri, P., Waugh, R., Napolitano, M. A., Forman, L. M., Appelbaum, M., Doraiswamy, M., & Krishnan, K. R. (1999). Effects of exercise training on older patients with major depression. *Archives of Internal Medicine, 159*, 2349-2356. <https://doi.org/10.1001/archinte.159.19.2349>
- Bjørnarå, H. B., Westergren, T., Sejersted, E., Torstveit, M. K., Hansen, B. H., Berntsen, S., & Bere, E. (2021). Does organized sports participation in childhood and adolescence positively influence health? A review of reviews. *Preventative Medicine Reports, 23*. <https://doi.org/10.1016/j.pmedr.2021.101425>
- Brierley, M. E., Thompson, E. M., Albertella, L., & Fontenelle, L. F. (2021). Lifestyle interventions in the treatment of Obsessive-Compulsive and Related Disorders: A systematic review. *Psychosomatic Medicine. https://doi.org/10.1097/psy.0000000000000988*
- Brokmeier, L. L., Firth, J., Vancampfort, D., Smith, L., Deenik, J., Rosenbaum, S., Stubbs, B., & Schuch, F. B. (2020). Does physical activity reduce the risk of psychosis? A systematic review and meta-analysis of prospective studies. *Psychiatry Research, 284*. <https://doi.org/10.1016/j.psychres.2019.112675>
- Bryant, R. (2021, February 26). *COVID’s mental health fallout will last a long time. Here’s how we’re targeting pandemic depression and anxiety*. The Conversation. Retrieved from <https://theconversation.com/covids-mental-health-fallout-will-last-a-long-time-heres-how-were-targeting-pandemic-depression-and-anxiety-155734>
- Cadenas-Sanchez, C., Mena-Molina, A., Torres-Lopez, L. V., Migueles, J. H., Rodriguez-Ayllon, M., Lubans, D. R., & Ortega, F. B. (2021). Healthier minds in fitter bodies: A systematic review and meta-analysis of the association between physical fitness and mental health in youth. *Sports Medicine. https://doi.org/10.1007/s40279-021-01520-y*

Campos, D. M., Ferreira, D. L., Gonçalves, G. H., Farche, A. C. S., de Oliveira, J. C., & Ansai, J. H. (2021). Effects of aquatic physical exercise on neuropsychological factors in older people: A systematic review. *Archives of Gerontology and Geriatrics*, 96. <https://doi.org/10.1016/j.archger.2021.104435>

Chapman, J. J., Hielscher, E., Patterson, S., Reavley, N., Brown, W. J., Wyder, M., Childs, S., Russell, A., Suetani, S., & Scott, J. G. (2021). Preferences of people with mental illness for engaging in exercise programs under COVID-19 restrictions. *Australasian Psychiatry*, 29(2), 175-179. <https://doi.org/10.1177/1039856220975299>

Chapman, J. J., Suetani, S., Siskind, D., Kisely, S., Breakspear, M., Byrne, J. H., & Patterson, S. (2018). Protocol for a randomised controlled trial of interventions to promote adoption and maintenance of physical activity in adults with mental illness. *BMJ Open*, 8, e023460. <https://doi.org/10.1136/bmjopen-2018-023460>

Chang, P. S., Knobf, T., Oh, B., & Funk, M. (2019). Physical and psychological health outcomes of qigong exercise in older adults: A systematic review and meta-analysis. *American Journal of Chinese Medicine*, 47(2), 301-322. <https://doi.org/10.1142/s0192415x19500149>

Chekroud, S. R., Gueorguieva, R., Zheutlin, A. B., Paulus, M., Krumholz, H. M., Krystal, J. H., & Chekroud, A. M. (2018). Association between physical exercise and mental health in 1.2 million individuals in the USA between 2011 and 2015: A cross-sectional study. *The Lancet Psychiatry*, 5(9), 739-746. [https://doi.org/10.1016/S2215-0366\(18\)30227-X](https://doi.org/10.1016/S2215-0366(18)30227-X)

Choi, K. W., Chen, C. Y., Stein, M. B., Klimentidis, Y. C., Wang, M. J., Koenen, K. C., & Smoller, J. W. (2019). Assessment of bidirectional relationships between physical activity and depression among adults: A 2-sample mendelian randomization study. *JAMA Psychiatry*, 76(4), 399-408. <https://doi.org/10.1001/jamapsychiatry.2018.4175>

Cooney, G. M., Dwan, K., Greig, C. A., Lawlor, D. A., Rimer, J., Waugh, F. R., McMurdo, M., & Mead, G. E. (2013). Exercise for depression. *Cochrane Database of Systematic Reviews*, 9 (CD004366). <https://doi.org/10.1002/14651858.CD004366.pub6>

Czosnek, L., Lederman, O., Cormie, P., Zopf, E., Stubbs, B., & Rosenbaum, S. (2019). Health benefits, safety and cost of physical activity interventions for mental health conditions: A meta-review to inform translation efforts. *Mental Health and Physical Activity*, 16, 140-151. <https://doi.org/10.1016/j.mhpa.2018.11.001>

Doré, I., Sabiston, C. M., Sylvestre, M-P., Brunet, J., O'Loughlin, J., Nader, P. A., Gallant, F., & Bélanger, M. (2019). Years participating in sports during childhood predicts mental health in adolescence: A 5-year longitudinal study. *Journal of Adolescent Health*, 64, 790-796. <https://doi.org/10.1016/j.jadohealth.2018.11.024>

Eigenschenk, B., Thomann, A., McClure, M., Davies, L., Gregory, M., Dettweiler, U., & Inglés, E. (2019). Benefits of outdoor sports for society. a systematic literature review and reflections on evidence. *International Journal of Environmental Research and Public Health*, 16(6). <https://doi.org/10.3390/ijerph16060937>

Eime, R. M., Young, J. A., Harvey, J. T., Charity, M. J., & Payne, W. R. (2013a). A systematic review of the psychological and social benefits of participation in sport for children and adolescents: Informing development of a conceptual model of health through sport. *International Journal of Behavioral Nutrition and Physical Activity*, 10(135). <https://doi.org/10.1186/1479-5868-10-98>

Eime, R. M., Young, J. A., Harvey, J. T., Charity, M. J., & Payne, W. R. (2013b). A systematic review of the psychological and social benefits of participation in sport for adults: Informing development of a conceptual model of health through sport. *International Journal of Behavioral Nutrition and Physical Activity*, 10(135). <https://doi.org/10.1186/1479-5868-10-135>

Felez-Nobregam M., Haro, J. M., Vancampfort, D., & Koyanagi, A. (2020). Sex difference in the association between physical activity and suicide attempts among adolescents from 48 countries: A global perspective. *Journal of Affective Disorders*, 266, 311-318. <https://doi.org/10.1016/j.jad.2020.01.147>

Fleming, K.M. & Herring, M. P. (2018). The effects of pilates on mental health outcomes: A meta-analysis of controlled trials. *Complementary Therapies in Medicine*, 37, 80-95. <https://doi.org/10.1016/j.ctim.2018.02.003>



- Gerber, M., Brand, S., Herrmann, C., College, F., Holsboer-Trachsler, E., & Pühse, U. (2014). Increased objectively assessed vigorous-intensity exercise is associated with reduced stress, increased mental health and good objective and subjective sleep in young adults. *Physiology & Behavior, 135*, 17-24. <https://doi.org/10.1016/j.physbeh.2014.05.047>
- Gong, H., Ni, C., Shen, X., Wu, T., & Jiang, C. (2015). Yoga for prenatal depression: A systematic review and meta-analysis. *BMC Psychiatry, 15*. <https://doi.org/10.1186/s12888-015-0393-1>
- Gordon, B. R., McDowell, C. P., Hallgren, M., Meyer, J. D., Lyons, M., & Herring, M. P. (2018). Association of efficacy of resistance exercise training with depressive symptoms: Meta-analysis and meta-regression analysis of randomized clinical trials. *JAMA Psychiatry, 75*(6), 566-576. <https://doi.org/10.1001/jamapsychiatry.2018.0572>
- Gordon, B. R., McDowell, C. P., Lyons, M., & Herring, M. P. (2017). The effects of resistance exercise training on anxiety: A meta-analysis and meta-regression analysis of randomized controlled trials. *Sports Medicine, 47*(12), 2521-2532. <https://doi.org/10.1007/s40279-017-0769-0>
- Harvey, S. B., Øverland, S., Hatch, S. L., Wessely, S., Mykletun, A., & Hotopf, M. (2018). Exercise and the prevention of depression: Results of the HUNT cohort study. *American Journal of Psychiatry, 175*, 28-36. <https://doi.org/10.1176/appi.ajp.2017.16112223>
- Hendriks, T., de Jong, J., & Cramer, H. (2017). The effects of yoga on positive mental health among healthy adults: A systematic review and meta-analysis. *Journal of Alternative and Complementary Medicine, 23*(7), 505-517. <https://doi.org/10.1089/acm.2016.0334>
- Hickingbotham, M. R., Wong, C. J., & Bowling, A. B. (2021). Barriers and facilitators to physical education, sport, and physical activity program participation among children and adolescents with psychiatric disorders: A systematic review. *Translational Behavioral Medicine*. <https://doi.org/10.1093/tbm/ibab085>
- Josefsson, T., Lindwall, M., & Archer, T. (2014). Physical exercise intervention in depressive disorders: Meta-analysis and systematic review. *Scandinavian Journal of Medicine & Science in Sports, 24*(2), 259-272. <https://doi.org/10.1111/sms.12050>
- Kadariya, S., Gautam, R., & Aro, A. R. (2019). Physical activity, mental health, and wellbeing among older adults in South and Southeast Asia: A scoping review. *BioMed Research International*. <https://doi.org/10.1155/2019/6752182>
- Kim, Y. S., Park, Y. S., Allegrante, J. P., Marks, R., Ok, H., Cho, K. O., & Garber, C. E. (2012). Relationship between physical activity and general mental health. *Preventative Medicine, 55*(5), 458-463. <https://doi.org/10.1016/j.ypmed.2012.08.021>
- Korman, N., Fox, H., Skinner, T., Dodd, C., Suetani, S., Chapman, J., Parker, S., Dark, F., Collins, C., Rosenbaum, S., & Siskind, D. (2020). Feasibility and acceptability of a student-led lifestyle (diet and exercise) intervention within a residential rehabilitation setting for people with severe mental illness, GO HEART (Group Occupation, Health, Exercise and Rehabilitation Treatment). *Frontiers in Psychiatry, 11*(319). <https://doi.org/10.3389/fpsy.2020.00319>
- Korman, N., Armour, M., Chapman, J., Rosenbaum, S., Kisley, S., Suetani, S., Firth, J., & Siskind, D. (2020). High Intensity Interval training (HIIT) for people with severe mental illness: A systematic review & meta-analysis of intervention studies- considering diverse approaches for mental and physical recovery. *Psychiatry Research, 284*. <https://doi.org/10.1016/j.psychres.2019.112601>
- Kurebayashi, Y., Mori, K., & Otaki, J. (2021). Effects of mild-intensity physical exercise on neurocognition in inpatients with schizophrenia: A pilot randomized controlled trial. *Perspectives in Psychiatric Care*. <https://doi.org/10.1111/ppc.12896>
- Lal, S. & Adair, C. E. (2014). E-mental health: A rapid review of the literature. *Psychiatric Services, 65*(1), 24-32. <https://doi.org/10.1176/appi.ps.201300009>
- Lederman, O., Suetani, S., Stanton, R., Chapman, J., Korman, N., Rosenbaum, S., Ward, P. B., & Siskind, D. (2017). Embedding exercise interventions as routine mental health care: Implementation strategies in residential, inpatient and community settings. *Australian Psychiatry, 25*(5), 451-455.



Liu, X., Clark, J., Siskind, D., Williams, G. M., Byrne, G., Yang, J. L., & Doi, S. A. (2015). A systematic review and meta-analysis of the effects of Qigong and Tai Chi for depressive symptoms. *Complementary Therapies in Medicine*, 23(4), 516-534. <https://doi.org/10.1016/j.ctim.2015.05.001>

Mammen, G. & Faulkner, G. (2013). Physical activity and the prevention of depression: A systematic review of prospective studies. *American Journal of Preventative Medicine*, 45(5), 649-647. <https://doi.org/10.1016/j.amepre.2013.08.001>

Martland, R., Mondelli, V., Gaughran, F., & Stubbs, B. (2020). Can high intensity interval training improve health outcomes among people with mental illness? A systematic review and preliminary meta-analysis of intervention studies across a range of mental illnesses. *Journal of Affective Disorders*, 263, 629-660. <https://doi.org/10.1016/j.jad.2019.11.039>

Marques, A., Marconcin, P., Werneck, A. O., Ferrari, G., Gouveia É, R., Kliegel, M., Peralta, M., & Ihle, A. (2021). Bidirectional association between physical activity and dopamine across adulthood: A systematic review. *Brain Sciences*, 11(7). <https://doi.org/10.3390/brainsci11070829>

Mason, O. J. & Holt, R. (2012). Mental health and physical activity interventions: a review of the qualitative literature. *Journal of Mental Health*, 21(3), 274-284. <https://doi.org/10.3109/09638237.2011.648344>

Mental Health Foundation (n.d.). *How to look after your mental health using exercise*. Retrieved April 2, 2021, from <https://www.mentalhealth.org.uk/publications/how-to-using-exercise>

Mikkelsen, K., Stojanovska, L., Polenakovic, M., Bosevski, M., & Apostolopoulos, V. (2017). Exercise and mental health. *Maturitas*, 106, 48-56. <https://doi.org/10.1016/j.maturitas.2017.09.003>

Morgan, A. J., Parker, A. G., Alvarez-Jimenez, M., & Jorm, A. F. (2013). Exercise and mental health: An exercise and sports science Australia commissioned review. *Journal of Exercise Physiology*, 16(4), 64-73.

Morres, I. D., Hatzigeorgiadis, A., Stathi, A., Comoutos, N., Arpin-Cribbie, C., Krommidas, C., & Theodorakis, Y. (2019). Aerobic exercise for adult patients with major depressive disorder in mental health services: A systematic review and meta-analysis. *Depression and Anxiety*, 36(1), 39-53. <https://doi.org/10.1002/da.22842>

Morris, L., Stander, J., Ebrahim, W., Eksteen, S., Meaden, O. A., Ras, A., & Wessels, A. (2018). Effect of exercise versus cognitive behavioural therapy or no intervention on anxiety, depression, fitness and quality of life in adults with previous methamphetamine dependency: A systematic review. *Addiction Science & Clinical Practice*, 13(4). <https://doi.org/10.1186/s13722-018-0106-4>

Mortazavi, S. S., Shati, M., Ardebili, H. E., Mohammad, K., Beni, R. D., & Keshteli, A. H. (2013). Comparing the effects of group and home-based physical activity on mental health in the elderly. *International Journal of Preventive Medicine*, 4(11), 1282-1289.

Nakamura, A., van der Waerden, J., Melchior, M., Bolze, C., El-Khoury, F., & Pryor, L. (2019). Physical activity during pregnancy and postpartum depression: Systematic review and meta-analysis. *Journal of Affective Disorders*, 246, 29-41. <https://doi.org/10.1016/j.jad.2018.12.009>

Park, S. H., Han, K. S., & Kang, C. B. (2014). Effects of exercise programs on depressive symptoms, quality of life, and self-esteem in older people: A systematic review of randomized controlled trials. *Applied Nursing Research*, 27(4), 219-226. <https://doi.org/10.1016/j.apnr.2014.01.004>

Pascoe, M., Bailey, A. P., Craike, M., Carter, T., Patten, R., Stepto, N., & Parker, A. (2020). Physical activity and exercise in youth mental health promotion: A scoping review. *BMJ Open Sport & Exercise Medicine*, 6(1). <https://doi.org/10.1136/bmjsem-2019-000677>

Pascoe, M. C. & Parker, A. G. (2019). Physical activity and exercise as a universal depression prevention in young people: A narrative review. *Early Intervention in Psychiatry*, 13(4), 733-739. <https://doi.org/10.1111/eip.12737>

Pereira, H. V., Palmeira, A. L., Encantado, J., Marques, M. M., Santos, I., Carraa, E. V., & Teixeira, P. J. (2021). Systematic review of psychological and behavioral correlates of recreational running. *Frontiers in Psychology*, 12. <https://doi.org/10.3389/fpsyg.2021.624783>

Radovic, S., Gordon, M. S., & Melvin, G. A. (2017). Should we recommend exercise to adolescents with depressive symptoms? A meta-analysis. *Journal of Paediatrics and Child Health*, 53(3), 214-220. <https://doi.org/10.1111/jpc.13426>

- Ramos-Sanchez, C. P., Schuch, F. B., Seedat, S., Louw, Q. A., Stubbs, B., Rosenbaum, S., Firth, J., van Winkel, R., & Vancampfort, D. (2021). The anxiolytic effects of exercise for people with anxiety and related disorders: An update of the available meta-analytic evidence. *Psychiatry Research, 302*. <https://doi.org/10.1016/j.psychres.2021.114046>
- Rebar, A. L., Stanton, R., Geard, D., Short, C., Duncan, M. J., & Vandelanotte, C. (2015). A meta-meta-analysis of the effect of physical activity on depression and anxiety in non-clinical adult populations. *Health Psychology Review, 9*(3), 366-378. <https://doi.org/10.1080/17437199.2015.1022901>
- Sackett, D. L. (1989). Rules of evidence and clinical recommendations on the use of antithrombotic agents. *Chest, 95*(2), 2S-4S. https://doi.org/10.1378/chest.102.4_Supplement.305S
- Schuch, F. B., Stubbs, B., Meyer, J., Heissel, A., Zech, P., Vancampfort, D., Rosenbaum, S., Deenik, J., Firth, J., Ward, P. B., Carvalho, A. F., & Hiles, S. A. (2019). Physical activity protects from incident anxiety: A meta-analysis of prospective cohort studies. *Depression and Anxiety, 36*(9), 846-858. <https://doi.org/10.1002/da.22915>
- Schuch, F. B., Vancampfort, D., Firth, J., Rosenbaum, S., Ward, P. B., Silva, E. S., Hallgren, M., Ponce De Leon, A., Dunn, A. L., & Deslandes, A. C. (2018). Physical activity and incident depression: A meta-analysis of prospective cohort studies. *American Journal of Psychiatry, 175*(7), 631-648. <https://doi.org/10.1176/appi.ajp.2018.17111194>
- Seino, S., Kitamura, A., Tomine, Y., Tanaka, I., Nishi, M., Taniguchi, Y., Yokoyama, Y., Amano, H., Fujiwara, Y., & Shinkai, S. (2019). Exercise arrangement is associated with physical and mental health in older adults. *Medicine & Science in Sports & Exercise, 1146*-1153. <https://doi.org/10.1249/MSS.0000000000001884>
- Seo, J. Y. & Chao, Y. Y. (2018). Effects of exercise interventions on depressive symptoms among community-dwelling older adults in the united states: A systematic review. *Journal of Gerontological Nursing, 44*(3), 31-38. <https://doi.org/10.3928/00989134-20171024-01>
- Shannon, A., McGuire, D., Brown, E., & O'Donoghue, B. (2020). A systematic review of the effectiveness of group-based exercise interventions for individuals with first episode psychosis. *Psychiatry Research, 293*. <https://doi.org/10.1016/j.psychres.2020.113402>
- Siefken, K., Junge, A., & Laemmle, L. (2019). How does sport affect mental health? An investigation into the relationship of leisure-time physical activity with depression and anxiety. *Human Movement, 20*(1), 62-74. <https://doi.org/10.5114/hm.2019.78539>
- Stanton, R. & Reaburn, P. (2014). Exercise and the treatment of depression: A review of the exercise program variables. *Journal of Science and Medicine in Sport, 17*(2), 177-182. <https://doi.org/10.1016/j.jsams.2013.03.010>
- Stubbs, B., Koyanagi, A., Hallgren, M., Firth, J., Richards, J., Schuch, F., Rosenbaum, S., Mugisha, J., Veronese, N., Lahti, J., & Vancampfort, D. (2017). Physical activity and anxiety: A perspective from the World Health Survey. *Journal of Affective Disorders, 208*, 545-552. <https://doi.org/10.1016/j.jad.2016.10.028>
- Suetani, S., Stubbs, B., McGrath, J. J., & Scott, J. G. (2019). Physical activity of people with mental disorders compared to the general population: A systematic review of longitudinal cohort studies. *Social Psychiatry and Psychiatric Epidemiology, 54*(12), 1443-1457. <https://doi.org/10.1007/s00127-019-01760-4>
- Suetani, S., Chapman, J., Korman, N., Chapman, C., Dodd, C., Dark, F., Parker, S., & Siskind, D. (2020). A comparison study of three physical activity measurement tools examining acceptability in people with psychosis. *Australasian Psychiatry, 28*(2), 175-179. <https://doi.org/10.1177/1039856219881957>
- ten Have, M., de Graaf, R., & Monshouwer, K. (2011). Physical exercise in adults and mental health status: Findings from the Netherlands Mental Health Survey and Incidence Study (NEMESIS). *Journal of Psychosomatic Research, 71*, 342-348. <https://doi.org/10.1016/j.jpsychores.2011.04.001>
- Vancampfort, D., Hallgren, M., Firth, J., Rosenbaum, S., Schuch, F. B., Mugisha, J., Probst, M., van Damme, T., Carvalho, A. F., & Stubbs, B. (2018). Physical activity and suicidal ideation: A systematic review and meta-analysis. *Journal of Affective Disorders, 225*, 438-448. <https://doi.org/10.1016/j.jad.2017.08.070>



Vieten, C., Lubarsky, O., Mansoor, R., Niebauer, E., & Sprengel, M. (2021). *Move your mental health: A review of the scientific evidence on the role of exercise and physical activity on mental health*. John W. Brick Mental Health Foundation. Retrieved August 9, 2021 from, <https://www.johnwbrickfoundation.org/move-your-mental-health-report/>

Violant-Holz, V., Gallego-Jiménez, M. G., González-González, C. S., Muñoz-Violant, S., Rodríguez, M. J., Sansano-Nadal, O., & Guerra-Balic, M. (2020). Psychological health and physical activity levels during the COVID-19 pandemic: A systematic review. *International Journal of Environmental Research and Public Health*, 17(24). <https://doi.org/10.3390/ijerph17249419>

Vogel, J. S., van der Gaag, M., Slofstra, C., Knegtering, H., Bruins, J., & Castelein, S. (2019). The effect of mind-body and aerobic exercise on negative symptoms in schizophrenia: A meta-analysis. *Psychiatry Research*, 279, 295-305. <https://doi.org/10.1016/j.psychres.2019.03.012>

Wang, F., Lee, E. K., Wu, T., Benson, H., Fricchione, G., Wang, W., & Yeung, A. S. (2014). The effects of Tai Chi on depression, anxiety, and psychological well-being: A systematic review and meta-analysis. *International Journal of Behavioral Medicine*, 21(4), 605-617. <https://doi.org/10.1007/s12529-013-9351-9>

Whitworth, J. W. & Ciccolo, J. T. (2016). Exercise and post-traumatic stress disorder in military veterans: A systematic review. *Military Medicine*, 181(9), 953-960. <https://doi.org/10.7205/milmed-d-15-00488>

Wolf, S., Seiffer, B., Zeibig, J. M., Welkerling, J., Brokmeier, L., Atrott, B., Ehring, T., & Schuch, F. B. (2021). Is physical activity associated with less depression and anxiety during the COVID-19 pandemic? A rapid systematic review. *Sports Medicine*, 51(8), 1771-1783. <https://doi.org/10.1007/s40279-021-01468-z>

World Health Organisation (November 2020). *Physical activity*. Retrieved 24 June, 2021, from <https://www.who.int/news-room/fact-sheets/detail/physical-activity>

Yen, H. Y., & Chiu, H. L. (2021). Virtual reality exergames for improving older adults' cognition and depression: A systematic review and meta-analysis of randomized control trials. *Journal of the American Medical Directors Association*, 22(5), 995-1002. <https://doi.org/10.1016/j.jamda.2021.03.009>

Zang, Y. (2019). Impact of physical exercise on children with attention deficit hyperactivity disorders: Evidence through a meta-analysis. *Medicine*, 98(46), e17980. <https://doi.org/10.1097/md.00000000000017980>

Zhang, S., Zou, L., Chen, L. Z., Yao, Y., Loprinzi, P. D., Siu, P. M., & Wei, G. X. (2019). The effect of Tai Chi Chuan on negative emotions in non-clinical populations: A meta-analysis and systematic review. *International Journal of Environmental Research and Public Health*, 16(17). <https://doi.org/10.3390/ijerph16173033>

Zika, M. A., & Becker, L. (2021). Physical activity as a treatment for social anxiety in clinical and non-clinical populations: A systematic review and three meta-analyses for different study designs. *Frontiers in Human Neuroscience*, 15. <https://doi.org/10.3389/fnhum.2021.653108>



Appendix

ABS Data Relating to Physical Activity and Mental Health (extracted directly from reports and websites)

- In terms of mental health conditions prevalence, the ABS reported that in 2017-18, one in five (20.1%) or 4.8 million Australians had a mental or behavioural condition, an increase from 4.0 million Australians (17.5%) in 2014-15.
 - In 2017-18, 3.2 million Australians (13.1%) had an anxiety-related condition, an increase from 11.2% in 2014-15.
 - One in ten people (10.4%) had depression or feelings of depression, an increase from 8.9% in 2014-15.
 - Overall Australians aged 15 years and over exercised 42 minutes per day on average, the largest part of which consisted of walking for transport and walking for exercise (24.6 minutes).
Only a small number met the physical activity guidelines with 1.9% of 15-17 year olds, 15.0% of 18-64 year olds and 17.2% of 65 year olds and over meeting the 2014 Physical Activity Guidelines in 2017-18.

- The ABS's study of COVID-19 in April 2021, social and mental health was important as the association between mental health and social connection is well known (Ref). The study found that
 - Around one in four (23%) Australians reported experiencing one or more personal stressors in the last four weeks due to COVID-19, compared with 38% in October 2020. The rates for Victoria were higher given the higher restrictions.
 - One in 10 (10%) Australians reported experiencing loneliness in the last four weeks, compared with 19% in October 2020.
 - Compared with October 2020, around half as many Australians in April 2021 reported experiencing:
 - problems maintaining a healthy lifestyle (8% compared with 16% in October 2020)
 - problems managing health concerns (6% compared with 11% in October 2020)
 - relationship difficulties (5% compared with 9% in October 2020).

- Mental health services particularly doctors and psychologists had an increase in uptake during COVID-10 such that in April 2021, around one in six (18%) Australians aged 18 years and over reported using at least one mental health or support service since 1 March 2020.
 - More than one in five (22%) women used at least one mental health or support service since 1 March 2020, compared with around one in seven (14%) men.
 - Two in three (67%) people who used a mental health or support service since 1 March 2020, received counselling (ABS, 2018).

- Of people aged 18 years and over with co-existing mental and behavioural and physical health conditions, almost three-quarters (72.8%) reported no or low levels of exercise. This compared with around two-thirds (67.8%) of adults with one mental and behavioural condition only and 65.6% of adults with one or more physical health conditions only."

These findings are related to exercise levels in people with mental illness, rather than rates of mental illness in people who are active/inactive. Anyone can download the data in the 'downloads' section, and see Table 7.1 These data are available for analysis and comparison

