



## Review article

## Exercise and mental health



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## ABSTRACT

There is a growing body of literature that recognizes the positive effects of exercise on mood states such as anxiety, stress and depression, through physiological and biochemical mechanisms, including endorphins, mitochondria, mammalian target of rapamycin, neurotransmitters and the hypothalamic-pituitary-adrenal axis, and via the thermogenic hypothesis. In addition, psychological mechanisms influence the effects of exercise on mood states, as suggested by both the distraction hypothesis and the self-efficacy hypothesis. Exercise has also been shown to reduce inflammation via several different processes (inflammation, cytokines, toll-like receptors, adipose tissue and via the vagal tone), which can contribute to better health outcomes in people suffering from mood disorders.

## 1. Introduction

There are many studies advocating the positive effects of exercise on mental health [1–8]. The general outcome from research indicates that exercise can bring about many physiological changes which result in an improvement in mood state, self-esteem and lower stress and anxiety levels. The physical effects of exercise include reduction of blood pressure, enhanced cardiovascular fitness, weight loss, and prevention of chronic diseases such as cancer, diabetes, hypertension, obesity, osteoporosis and cognitive conditions like Alzheimer's [9–13]. As yet, there is no conclusive proof that implicates a single mechanism or group of mechanisms that reliably affect the exercise-mood relationship, nor does it seem that the nature of exercise being either aerobic or anaerobic is a significant factor as both forms of exercise can bring about an improvement in mental health [14–16].

It appears that the benefits of exercise come about by numerous physiological or psychological changes. Physiological effects of exercise can include an increase in endorphin levels [17–20], body temperature [21–24], mitochondrial function and mitochondriogenesis [25–27], an increase in the mammalian target of rapamycin (mTor) signalling [28–30], neurotransmitter production [31–34] and attenuation of the hypothalamic pituitary-adrenal (HPA) axis response to stress [15,27,31]. Whilst psychological effects may include a distraction from feelings of depression and anxiety [35–37] and positive feelings associated with mastery and self-efficacy [8,38–40]. There is much evidence that inflammation and inflammatory diseases contribute to mood

disorders and poor mental health, and it seems that exercise may help to lower inflammation and be beneficial in contributing to better mental health outcomes in patients who suffer from inflammatory disorders [1,41–44]. The purpose of this article is to highlight current and developing knowledge of the positive effects of exercise on mental health.

## 2. Methodology

This review article presents current knowledge of the benefits associated with exercise on mental health and the physiological and psychological mechanisms contributing to these benefits. PubMed, Google Scholar and Medline were searched for relevant articles using the following key terms: Exercise OR physical activity AND mental health, exercise OR physical activity AND depression, exercise OR physical activity AND stress, exercise OR physical activity AND anxiety, exercise AND inflammation, exercise AND inflammatory disease. Publications in the last 10 years are mostly cited.

## 3. Exercise and mental health

There has been much research into the effects of exercise on mental health [45,46]. This research repeatedly suggests that regular physical activity can significantly improve mental health and lessen symptoms of depression anxiety and stress [14,47–50]. It is even suggested that physical activity can enhance mental wellbeing as equally as

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psychotherapy [49]. In fact, just 20–40 min of aerobic exercise can improve anxiety and mood for several hours, although people suffering from acute anxiety have been shown to respond better than those suffering from chronic anxiety [48,49]. In addition, physical activity tends to occur less in people who suffer from depression and the mental health benefits of exercise are more pronounced in people suffering from anxiety and depression compared to those that do not [51]. Panic disorder is also improved with physical activity. Furthermore, depressed mood, which is associated with increased anger, confusion, fatigue, tension, and reduced vigour, could be alleviated by exercise (as measured by the profile of mood states psychological rating scale); although this was more pronounced in patients who suffered depressed mood prior to exercise compared to those who did not [11]. Likewise, the beneficial effects of exercise are also seen in the elderly and adolescents with depression or anxiety, although such reports are limited [48]. On the contrary, exercise can have a detrimental effect on the mental health of people who become overly addicted. Exercising to an excessive degree can result in mood and behavioural disorders and a decline in physical health [49].

### 3.1. Aerobic versus non-aerobic exercise regimes

It is important when considering the effect of exercise on mental health that the definition of “exercise” is understood. Often the term exercise is used as an umbrella term to encompass both physical activity and exercise, yet exercise is essentially a subcategory of physical activity. Physical activity involves bodily movement produced by skeletal muscles which expends energy, whereas exercise is described as “planned, structured, repetitive and purposive in the sense of improvement or maintenance of one or more components of physical fitness” [52]. Physical fitness, by contrast, is a set of attributes that people set out to achieve or innately possess. Physical fitness can be divided into health-related fitness (cardiorespiratory and muscular endurance, muscular strength, body composition, flexibility) and skill related fitness (agility, balance, co-ordination, speed, power, reaction time). It is necessary to make the distinction between health and skill related fitness, when defining the nature of the physical activity in order to improve mental health.

Most studies which ascertain the effects of exercise on mental health, use an exercise program focussing largely on cardiorespiratory conditioning, utilizing aerobic exercise forms which use prolonged activity of large muscle groups, eg. treadmills [1,5]. There are fewer studies on alternate forms of physical training which work on muscular strength, flexibility, agility, balance and co-ordination. This type of training can come in the form of yoga, tai chi, dance, martial arts etc. However, such non-aerobic exercise forms also show increased benefits to mood outcomes. Indeed, yoga and swimming activity was shown to greatly improve anger, confusion, tension, and depression in people when compared to those that did not partake in any physical activity [47]. Hence, aerobic exercise may not be the only form of exercise which can positively affect mood enhancement. In a randomized controlled study of 79 participants with anxiety disorders, the effects of aerobic (brisk walks or jogging) versus non-aerobic (muscular strength, flexibility and relaxation) exercise regimes showed that anxiety scores were improved similarly in both groups [16]. Likewise, 91 inpatients with major depression, dysthymic disorder or depressive disorder were randomly assigned to aerobic versus non aerobic exercise regimes for 8 weeks and depression scores were reduced in both groups. There were no differences between the groups, hence, the anti-depressive effects noted are not restricted to the aerobic physical activity regime [53]. Furthermore, aerobic exercise and meditation-relaxation therapies could be as effectual in decreasing symptoms of depression as psychotherapy. A study involving 74 participants with clinical depression were randomly allocated to either running therapy, psycho-therapy or meditation-relaxation therapy for 12 weeks. Symptoms of depression were reduced significantly in all 3 groups but statistical comparisons

between the 3 groups were non-significant [54]. Oh et al. conducted a study which set out to understand the relationship between different types of exercise and quality of life of 7550 patients in Korea suffering from metabolic syndrome. The study compared resistance training, flexibility and walking on 5 subsets of quality of life (mobility, self-care, usual activities, pain/discomfort, anxiety/depression). It was noted that all exercise regimes showed improved quality of life than those who did not exercise, and walking exercise was found to further increase quality of life in those patients who suffered from metabolic syndrome than those who did not [55].

The consistency of exercise may also play a part in positive health outcomes. Data from several waves of the Taiwanese longitudinal study on ageing, dating from 1996 to 2007, was retrospectively analysed. It was concluded that consistent exercise, even if the duration was as short as 15 min, 3 times a week was significantly associated with lower risk of depressive symptoms [7]. It is apparent that exercise improves mental disorder symptomatology and both aerobic and non-aerobic exercise regimes appear to be similarly effective.

### 3.2. Beneficial effects of exercise on mental health

One of the most common mental health disorders is anxiety, which affects a person's ability to concentrate, sleep and carry out daily tasks. Studies indicate that exercise can reduce anxiety levels, whereas those who are not physically active are associated with higher levels of anxiety. Indeed, a meta-analysis study of 42,264 persons showed that exercise improved anxiety levels, with exercise being more beneficial to those with anxiety compared to those with non-clinical, normal range psychological disorder [51]. Furthermore, depression which is categorized into a range of different types can be prevented if exercise is included on a regular basis. Exercise can also be used to treat symptoms of mild depression. In fact, regular exercise is significantly associated with lower depression and anxiety frequency in a cross sectional study of 269 adults [56]. Likewise, in healthy adults, qigong exercise was shown to relieve anxiety and reduce stress levels in a systematic review of 7 randomized controlled studies [57]. In 18 male runners with exercise addiction, during exercise withdrawal for 2 weeks there was an increase in depression, fatigue, anger and confusion and decreased vigour mood compared to control non-withdrawal group [58]; such symptoms improved once exercise resumed. In addition, in a meta-analysis study of 48,207 participants, it was shown that exercise improved depression [51]. In a systematic review of 8 randomized clinical trials, reduction of anxiety symptoms were noted but was less effective to anti-depressant medication, although exercise combined with medication significantly improved clinical global impression outcomes [59]; in these studies there were no differences in aerobic versus non-aerobic exercise regimes. In cancer patients, a home-based exercise regime 3 days/week for 40 min over 12 weeks significantly improved anxiety and depression levels compared to the usual care group of patients [60]. In addition, patients with end stage renal disease randomized to either endurance or resistance training 3 times/week for 6 months significantly improved mood and reduced anxiety [61]. Furthermore, individuals with posttraumatic stress disorder who completed 2 weeks of stationary bike aerobic exercise reported significant clinical reductions in posttraumatic stress disorder severity [62]. Even after a single bout of exercise (either yoga or aerobic exercise) in patients with schizophrenia, showed significant decreased anxiety and psychological stress and increased subjective wellbeing compared to patients with schizophrenia with no exercise [63]. Similarly, 41 participants who completed a single session of 30 min aerobic exercise showed significant reductions in all dimensions of anxiety sensitivity but not intolerance of uncertainty or distress compared to control subjects [64]. Thus, exercise seems effective to improve certain mental health vulnerabilities, and may be a viable adjunctive treatment for psychotherapy.

As depression and anxiety are commonly seen in the ageing

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