Review Psikiyatride Güncel Yaklaşımlar-Current Approaches in Psychiatry 2025; 17(3):429-444
doi: 10.18863/pgy.1458867

Therapeutic Effect of Exercise on Mental Health

Egzersizin Ruh Sağlığı Üzerindeki Terapötik Etkisi

Sinem Parlakyıldız[1]

[1]Nevşehir Hacı Bektaş Veli University, Nevşehir

ABSTRACT

Mental health is an integral part of well-being and a fundamental human right. It is known that a substantial number of people worldwide struggle with mental illness, and a large proportion of these individuals live in low- and middle-income countries. Depression and anxiety are among the most common mental health problems. Considering the positive effects of exercise on neurobiological mechanisms, it can be considered as an alternative or complementary therapy in the treatment of mental illnesses such as depression and anxiety. Exercise also increases neurogenesis and neuroplasticity, improves cognitive function, and protects brain health, reducing the risk of various neurological diseases. By regulating levels of neurochemicals such as dopamine, serotonin, and norepinephrine, exercise positively affects mood and can lead to favorable emotional and behavioral changes. The use of exercise as a nonpharmacological treatment option has important advantages such as ease of access, low cost, and low risk of adverse effects. In conclusion, exercise is a safe, accessible, and inexpensive nonpharmacological therapeutic option that provides neurobiological benefits and can play a crucial role in mental health treatment and promotion. Integrating exercise into clinical practice is important to improve treatment success and patient outcomes.

Keywords: Anxiety, depression, exercise, stress

ÖZ

Ruh sağlığı, refahın ayrılmaz bir parçası ve temel bir insan hakkıdır. Dünya genelinde çok sayıda insanın ruhsal bozukluklarla mücadele ettiği ve bu bireylerin büyük bir kısmının düşük ve orta gelirli ülkelerde yaşadığı bilinmektedir. Sık görülen ruhsal bozukluklar arasında depresyon ve anksiyete yer almaktadır. Egzersizin, nörobiyolojik mekanizmalar üzerindeki olumlu etkileri göz önüne alındığında, depresyon ve anksiyete gibi ruhsal bozuklukların tedavisinde alternatif veya tamamlayıcı bir terapi yöntemi olarak değerlendirilebileceği söylenebilir. Ayrıca egzersiz, çeşitli nörolojik hastalıkların riskini azaltıp beyin sağlığını koruyarak nörogenez ve nöroplastisiteyi artırmakta ve bilişsel işlevleri iyileştirmektedir. Dopamin, serotonin ve norepinefrin gibi nörokimyasalların seviyelerini düzenleyerek ruh halini olumlu yönde etkileyen egzersizin olumlu duygusal ve davranışsal değişikliklere yol açan etkileri de bulunmaktadır. Egzersizin farmakolojik olmayan bir tedavi seçeneği olarak kullanılması, tedaviye erişimin kolay ve maliyetinin düşük olmasının yanı sıra yan etki riskinin az olması gibi önemli avantajlar sunmaktadır. Sonuç olarak, egzersizin mental sağlık sorunlarının tedavisinde, nörobiyolojik faydalar sağlamasının yanı sıra düşük maliyetli, erişilebilir ve yan etkisi az olan farmakolojik olmayan bir tedavi seçeneği olarak önemli bir rol oynayabileceği görülmektedir. Bu nedenle, egzersizin klinik uygulamalara entegre edilmesinin önemli bir rol oynayacağı söylenebilir.

Anahtar sözcükler: Anksiyete, depresyon, egzersiz, stres

Introduction

Approximately 970 million people struggle with mental health problems globally, and 82% of this population lives in low- and middle-income countries (Global Burden of Disease [GBD]) (GBD 2019 Mental Disorders Collaborators 2022). More specifically, an estimate from before the COVID-19 pandemic stated that 193 million people had major depressive disorder and 298 million people had an anxiety disorder (World Health Organization [WHO] 2022a). The GBD 2019 Mental Disorders Collaborators (2022) predicted a substantial increase in major depressive and anxiety disorders as a result of the pandemic, and given the uncertainties surrounding epidemiological predictions of mental disorders in major emergencies, this increase was considered significant (Salari et al. 2020). The psychosocial effects of the pandemic itself combined with related factors such as social restrictions and economic losses led to a significant increase in cases of depression and anxiety (Santomauro et al. 2021). Post-pandemic data suggest that the number of people with major depressive disorder reached 246 million and that of people with anxiety disorders reached 374 million. This corresponds to 28% increase in depressive disorders and 26% increase in anxiety disorders (WHO 2022a).

Yazışma Adresi /Address for Correspondence: Sinem Parlakyıldız, Nevşehir Haci Bektaş Veli University School of Sport Sciences and Technology, Nevşehi, Türkiye **E-mail:** sinemparlakyildiz@nevsehir.edu.tr
Geliş tarihi/Received: 10.04.2024 | **Kabul tarihi/Accepted:**24.08.2024

Although major depressive and anxiety disorders are approximately 50% more common among women than men throughout life, men are more likely to have substance use disorders, which constitute a large part of mental health problems. Therefore, mental disorders affect women only slightly more than men overall (13.5% vs. 12.5%) (WHO 2021). Refugees are another population with a high incidence of mental health problems (Bas-Sarmiento et al. 2017, Giammusso et al. 2018, Yetim 2024). According to 2021 data, there are approximately 3.7 million Syrian refugees living under temporary protection in Turkiye, and although they are at higher risk for mental health conditions, they are less likely to seek or receive treatment (WHO 2022a).

Mental health problems are conditions characterized by a clinically significant impairment in cognitive function, emotional regulation, or behavior, and are often associated with distress or functional impairment in important areas of life (WHO 2021). They range broadly from mood disorders such as anxiety and depression to bipolar disorder, schizophrenia, eating disorders, posttraumatic stress disorder, behavioral disorders, and neurodevelopmental disorders (WHO 2022b). Anxiety disorders are behavioral disorders associated with excessive fear and worry (American Psychiatric Association [APA] 2013). Similarly, depression is characterized by symptoms such as a constant feeling of sadness or loss of interest. Posttraumatic stress disorder occurs following exposure to traumatic events and includes re-experiencing, avoidance, and hypervigilance (APA 2013). Despite the existence of effective prevention and treatment options, many individuals with mental illness do not receive adequate care and face stigmatization, discrimination, and human rights violations (WHO 2022b). In this context, it is important to develop effective strategies to enhance the well-being of individuals and societies. Exercise has been suggested as an alternative or complementary therapeutic method because of its positive impact on mental health (Noetel et al. 2024).

Physical activity is defined as any bodily movement produced by the skeletal muscles that results in energy expenditure above basal level and includes sports-related activities, household chores, and occupational activity. In contrast, physical exercise is defined as a subset of physical activity that is planned, structured, repetitive, and aims to improve or maintain physical fitness (Caspersen 1985), and this concept is also used extensively in the literature (Matei et al. 2023, Valenzuela et al. 2023). Therefore, it can be said that physical activity and exercise are related but distinct constructs, as physical exercise can always be considered physical activity, but physical activity cannot always be considered exercise, and this distinction has important implications when conducting and interpreting research (Budde et al. 2016).

The benefits of regular exercise include improved mental health (Blumenthal and Rozanski 2023), enhanced neurocognitive function (Smith et al 2010), improved sleep quality, increased energy levels, and better overall cardiovascular health (Emery et al. 2005). In particular, recent research highlights the positive effects of exercise on physical and mental health (D'Onofrio et al. 2023, Ross et al. 2023, Wu et al. 2023). Especially in the treatment of depression, the use of physical exercise together with antidepressants and psychotherapy appears to be a promising option (Wegner et al. 2014, 2020). These results show that the effects of exercise improve mood and reduce stress levels. However, factors such as the spread of technology and the preference for motor vehicles have led to a more sedentary lifestyle in modern societies (Santos et al. 2023). Many physical and mental health problems occur in societies with high inactivity. Considering the positive health effects of regular exercise and the harm caused by a sedentary lifestyle, exercise should be regarded as the key to health (Katzmarzyk 2023).

Many studies have highlighted the positive effects of exercise on mood and cognition (Kramer et al. 2005, Erickson et al. 2011, Suwabe et al. 2021, White et al. 2023). Furthermore, the importance of exercise in the treatment of mental disorders such as depression and anxiety is being increasingly recognized (Harvey et al. 2018). Research shows that regular exercise is effective in alleviating symptoms of depression and anxiety (Bartholomew et al. 2005). Understanding the effects of exercise on mental health is an important step in guiding treatment approaches.

The role of neuroinflammation in the pathogenesis of mental disorders such as depression and anxiety further increases the importance of exercise. Neuroinflammation is significant in depression pathogenesis because microglia are considered the main immune cells in the brain. The activation of microglia leads to decreased neurogenesis and increased production of proinflammatory factors, which can lead to depression and anxiety (Yirmiya et al. 2015, Bassett et al. 2021). Stress can increase microglial activation and trigger the release of proinflammatory factors, thus forming the neurobiological basis of depression. Some research suggests that exercise has anti-inflammatory effects (Kim et al. 2017, Stein et al. 2017). Studies on the effects of exercise on neuroinflammation emphasize its positive contributions to mental health (Kim et al. 2017).

Neurobiological research provides clues to understand the effects of exercise on mental health in more depth. In particular, acute exercise has been found to improve cognitive function related to the prefrontal cortex and

positively influence mood (Lambourne and Tomporowski 2010, Chang et al. 2012, Liao et al. 2015). Hashimoto et al. (2024) reported that even a single weight-lifting exercise session strengthens the connections in the hippocampus responsible for memory and strengthens memory, resulting in higher memory test scores. The increased muscle mass that occurs with fitness training also contributes substantially to cognitive function. Muscles play an important role in enhancing energy and iron metabolism and producing a molecule called brain-derived neurotrophic factor, which promotes healthy neuronal function (Sui et al. 2020; Sui et al. 2022; Lu et al. 2023). Studies on neurological and neurochemical changes demonstrated an increase in the release of happiness hormones such as dopamine and serotonin after a single exercise session (Meeusen et al. 2001). These changes are believed to be part of the effects of exercise that improve mood and reduce stress levels (Reed and Ones 2016). Furthermore, low-intensity acute exercise was shown to reduce depressive and anxiety-like behaviors and potentially optimize brain function (Pagliari and Peyrin 1995, Otsuka et al. 2016). Therefore, it is important to consider exercise-based interventions as an alternative or complement to conventional treatments such as pharmacotherapy and psychotherapy (Stein et al. 2017). Utilizing exercise as a nonpharmacological treatment option also offers advantages such as facilitating access to treatment and reducing the risk of adverse effects. This supports its feasibility and importance as a public health strategy. The aim of the present study was to evaluate the favorable effects of regular exercise in people with mental health problems. It also addresses how the impact of exercise on neurobiological mechanisms can be utilized as an alternative or complementary approach in the treatment of mental disorders such as depression and anxiety.

Exercise

Exercise is considered a subcategory of physical activity that is planned, structured, repetitive, and purposefully focused on improving or maintaining one or more components of physical fitness (Mittal et al. 2017). Physical fitness is defined as the acquired qualities associated with the ability to perform physical activity (muscle endurance, muscle strength, cardiorespiratory endurance, flexibility, and body composition) (Warburton et al. 2006). Fibbins et al. (2020) stated that exercise is physical effort that enables the body to reach a healthy or healthier level of physical fitness in terms of both mental and physical health. Physical activity and physical fitness show a strong dose-response relationship with positive health outcomes, but the relationship between physical fitness and health outcomes is more pronounced (Blair and Jackson 2001, Williams 2001, Bayles 2023).

Exercise programs are generally heterogeneous in terms of the types, intensities, durations, and frequencies of physical activity. Exercise is basically divided into aerobic and anaerobic. Aerobic forms of exercise are rhythmic, sustainable, and utilize large muscle groups (Hootman et al. 2002), including activities such as running, walking, dancing, cycling, and swimming. Aerobic exercise increases cardiorespiratory fitness while improving endurance (Bayles 2023). In contrast, anaerobic exercise refers to the need for energy production in oxygen-deficient conditions and involves movements that require quick and intense exertion (Yıldız 2012). For example, climbing stairs quickly is a type of anaerobic exercise. Anaerobic energy production results in the accumulation of lactic acid in the body, which causes fatigue (Güzel Erdoğan and Aslan 2021). Types of exercise examined in clinical trials include walking (Mota-Pereira et al. 2011, Chen et al. 2015; Liu et al. 2021), cycling (Hanssen et al. 2018, Imboden et al. 2020), swimming (Pfaff et al. 2014), running (Schuch et al. 2015, Olson et al. 2017, Toups et al. 2017, Gujral et al. 2019), jumping rope (Danielsson et al. 2014), step aerobics, cardio kickboxing (Schneider et al. 2016), resistance exercises (Pfaff et al. 2014), flexibility exercises (Hallgren et al. 2015, Helgadóttir et al. 2017), weight-lifting exercises (Stanton and Reaburn 2014), yoga (Helgadóttir et al. 2016, Lu et al. 2020), and pilates (Park et al. 2023). In a study conducted by Schuch et al. (2011), participants were presented with various types of exercise to increase their fitness. They reported aerobic exercise was the most preferred intervention method.

As the intensity of exercise increases, so does oxygen demand, which requires greater oxygen consumption (Gupta and Elumalai 2017). Basso and Suziki (2017) proposed four basic measures for the standardization of exercise studies. First, exercise durations can be classified as short (1-15 minutes), intermediate (16-45 minutes), and long (46 minutes and longer). Second, exercise intensity can be graded as low (less than 40% of VO2 max), moderate (40-59% of VO2 max), and high (60% of VO2 max or greater), with heart rate data recorded during exercise to help determine actual VO2 max percentages. Finally, the Borg Ratings of Perceived Exertion Scale can be used to measure perceived difficulty. An exercise program has five main features: the activity type, frequency, duration, progression, and intensity (Bayles 2023). In the development of exercise programs, these five components are stated to be applicable for all individuals regardless of age, functional capacity, or the presence of coronary heart disease and related risk factors. In health adults, the ideal exercise prescription should encompass a combination of strength, endurance, flexibility, cardiorespiratory (aerobic) fitness, and neuromotor fitness (Garber et al. 2011).

Reducing inactivity is recommended for a healthy life (Bayles 2023). Hallal et al. (2012) stated that approximately 31% of adults worldwide are inactive, which corresponds to the weighted average of inactivity in 122 countries, but information is not available from approximately one-third of countries due to a lack of data, especially from low-income regions such as Africa and Central Asia. Inactivity activates muscle degradation mechanisms, and this atrophy is readily apparent after only a few days of inactivity (Monti et al. 2021, Sarto et al. 2021). A sudden cessation of exercise is associated with rapid onset of insulin resistance in muscle tissue, decreased utilization of muscle glucose, and consequently muscle atrophy and muscle protein degradation (Mazzucco et al. 2010, Reidy et al. 2021). Inactivity causes reductions in cardiorespiratory conditioning, bone mineral content, and physical functioning, and may increase the risk of disorders such as cardiovascular disease, type 2 diabetes, cancer, osteoporosis, and mental disorders (Sanchis-Gomar et al. 2015, Brooks et al. 2020).

It is argued that exercise can improve overall health and contribute to the tolerance of physical and mental health problems (Pišot 2021). Individuals who exercise regularly are observed to be healthier and more independent than those who are sedentary (Wickham and Amarasekara 2020). Wegner et al. (2020) emphasized that this can be achieved only with exercise, not physical activity. Various types of exercise, such as yoga, resistance, and aerobic exercise, have been shown to have positive mental health effects in the young population (Pascoe and Parker 2019). Similarly, mind-body, aerobic, and resistance exercises have been reported to be used as effective complementary methods in reducing depressive symptoms and anxiety (Blumenthal et al. 2016, Sherwood et al. 2016). Birinci et al. (2023) emphasized that exercise exerts positive effects on mental health via brain-derived neurotrophic factors and may be an effective strategy in preventing or delaying the onset of mental diseases. However, they noted that it is difficult to create a standard exercise program due to the variable effects of different exercise types and combinations.

It is still unclear whether exercise can be used as an intervention in the treatment of mental health problems (Gronwald and Budde 2019). Studies conducted during the COVID-19 pandemic indicated an increase in depression, anxiety, stress, suicidal thoughts, and self-harm tendencies (Tang et al. 2020, Günlü et al. 2021, Muyor-Rodríguez 2021). It is thought that exercise can provide long-term benefits as well as having short-term effects on these mental problems. Exercise can also be utilized in addition to methods such as cognitive therapy and pharmacological support to prevent or alleviate the symptoms of these major psychological problems (Eckshtain et al. 2020, Wegner et al. 2020). It has been observed that aerobic exercise has antidepressant and anxiolytic effects, protects against stress, and can be an effective intervention for patients resistant to traditional psychological treatments (Salmon 2001). Especially in the treatment of depression, the combination of antidepressant drugs, psychotherapy, and physical exercise is said to be a promising option (Wegner et al. 2014). Therefore, exercise should be regarded as playing an important role in coping with mental health problems.

Positive Effects of Exercise on Mental Health Problems

Mental health is recognized as a major global concern (Richardson et al. 2021). Complete mental health does not only mean the absence of disease, but also includes feeling that life is valuable and meaningful (Iasiello and Van Agteren 2020). Although drugs currently form the basis of treatment for most mental disorders, they can be associated with problems such as adverse side effects, risk of addiction, high cost, and poor patient adherence. Research shows that drug therapy generally does not provide adequate satisfaction and can even seriously impair patients' quality of life (Maj et al. 2020). Therefore, nonpharmacological approaches, especially methods such as psychotherapy, play an important role in the treatment of depressive symptoms (Eckshtain et al. 2020). Antidepressant therapy may be required for patients with severe symptoms (Wegner et al. 2020). However, the potential adverse effects of this treatment can be seen in all age groups (Taurines et al. 2011). Exercise is considered effective in the prevention and treatment of mental health problems due to its accessibility, low cost, and benefits it provides (Sigwalt et al. 2011, Higuera-Hernández et al. 2018). As a nonpharmacological treatment method, exercise has been shown to effectively alleviate depressive symptoms comparably to medication and other psychological interventions (Harvey et al. 2018). Different results have been reported regarding the effect of different types of exercise on depression. Recently, more research has focused on structural and functional changes in certain regions of the central nervous system that form the anatomical basis of depression (Cervenka et al. 2017, Li et al. 2018).

Certain exercise programs have been associated with reduced levels of inflammatory markers (Wang 2023). For example, aerobic exercise programs lowered inflammatory cytokine levels and were associated with a reduction in depressive symptoms (Liu et al. 2013). Oxidative stress has been associated with endothelial damage and is implicated in the development of diseases such as late-onset and vascular depression. Moderate-intensity

aerobic exercise has been shown to reduce oxidative stress, reduce inflammation, and repair endothelial damage (Luca and Luca 2019). Furthermore, exercise decreases the concentration of inflammatory markers while increasing the activity of antioxidant enzymes. Animal and clinical studies show that exercise can reduce symptoms of depression and oxidative stress (Brocardo et al. 2012). For example, a study in depressed older adults showed that exercise reduced both depression and oxidative stress (Meziat et al. 2019, Silva et al. 2019).

Stress

Stress, or a maladaptive internal response to stressors (Renna et al. 2020), is recognized as a psychological factor with major impacts on physical and mental health (Howland et al. 2017). Stress occurs when an individual perceives a situation as a threat to or excessive drain of their resources (Wiklund et al. 2010). As stress is an unavoidable part of life, knowing how to effectively cope with stress and the individual differences that arise with exposure to stressful events is important (Renna et al. 2020). Authors have suggested that the link between social stress and health-related outcomes may be mediated by several factors, primarily coping skills and social support (Matud et al. 2020). Coping refers to the thoughts and behaviors an individual uses to manage the demands of a stressful situation, and studies indicate that an individual's method of stress coping is a determinant of psychological, social, and physical well-being (Folkman 2010).

Exercise appears to be effective in reducing stress levels (Civan et al. 2018, Churchill et al. 2022). This effect manifests as a decrease in stress-related blood pressure responses in response to various laboratory stress tests (Hamer et al. 2006). Brownley et al. (2003) determined that acute exercise likely suppresses the sympathetic nervous system response to stress. The hypothalamus is a part of the brain known to secrete corticotropin-releasing hormone (CRH) in response to stress. CRH stimulates the anterior pituitary to secrete adrenocorticotropic hormone, which in turn stimulates the adrenal cortex, crossing the blood-brain barrier and releasing a glucocorticoid steroid hormone called cortisol (Budde et al. 2015). These effects were observed in studies of mice (Girard and Garland 2002) and humans (Rojas Vega et al. 2006). Acute exercise in humans stimulates the hypothalamic-pituitary-adrenal axis in proportion to intensity, causing elevated cortisol levels after exercise equivalent to approximately 60% of VO2 max for 10 minutes or longer. Peripheral cortisol levels reach a peak about 30 minutes after exercise ends and remain high for about 2 hours (Hill et al. 2008). Both behavioral observations and physiological measurements have shown that acute exercise is effective in mitigating the harmful effects of stress (Zschucke et al. 2015). Individuals who exercise acutely show a decrease in stress-induced cortisol levels compared to those who do not exercise. Chronic exercise has been shown to produce antidepressant and anxiolytic effects in mouse models (Fulk et al. 2004, Duman et al. 2008). Greenwood and Fleshner (2008) investigated the mechanisms of exercise on stress resistance (Greenwood et al., 2008). They stated that exercise can increase stress resistance by enhancing the plasticity of serotonin neurons (Greenwood and Fleshner 2011). In a study by Siette et al. (2014) examining the effects of a single exercise session on contextual fear conditioning, it was suggested that acute exercise could reduce the fear response and might serve as a new therapeutic method. Mika et al. (2015) suggested that this effect may occur through dopaminergic mechanisms. Acute exercise helps regulate the humoral stress response, suggesting that it may serve as a useful intervention for stress management, especially in individuals who exercise regularly, and could be an effective strategy to mitigate psychological symptoms caused by acute stressors. Furthermore, acute exercise causes increased activity in certain brain regions associated with stress response, including the hippocampus and prefrontal cortex, and is also associated with improved mood (Herman et al. 2005). Acute exercise has been shown to help alleviate the symptoms of anxiety, depression, schizophrenia, and post-traumatic stress disorder (Bartholomew et al. 2005, Heggelund et al. 2014).

Depression

Mood disorders are defined by Rihmer and Angst (2007) as syndromes consisting of groups of signs and symptoms lasting from weeks to months that significantly impact a person's functioning and recur periodically or cyclically. Depression is characterized by low mood, anhedonia, and loss of interest. It is a very common condition that impacts a person both mentally and physically and creates a serious burden on individuals, families, and society (Chand and Arif 2023). Depression tends to become chronic, affects a substantial proportion of the population, and when not treated properly causes high treatment costs and high mortality and morbidity rates, leading to serious social problems (Helvacı Çelik and Hocaoğlu 2016). The disease places a heavy burden on society in terms of treatment cost, but the true burden includes costs associated with the treatment process as well as factors such as disability and suicide (Olchanski et al. 2013). The economic burden of depression is enormous. Annual losses attributed to depression and anxiety have been estimated at $1.15 trillion worldwide and were expected to triple by 2030 (Chisholm et al., 2016). Depression treatment and prevention is

a broad topic that is still being investigated. Although research has generally focused on adults, the age at onset of exercise also has a significant effect on depression (Budde et al., 2018). Wegner et al. (2020) stated that small to moderate but consistently positive effects make exercise a promising and beneficial alternative for children and adolescents with clinical and subclinical depression.

Treatments for depression include pharmacotherapy, psychotherapy, biological interventions, and naturopathic interventions (Xie and Wang 2021). Antidepressants are central to the treatment of depression, but their use is associated with certain disadvantages, including high rates of long-lasting adverse effects, poor drug adherence, increased cardiovascular disease risk, low rates of remission, and high rates of recurrence (Cipriani et al. 2018, Hanssen et al. 2018). Only half of patients using antidepressants demonstrate a clinical response, which means a 50% or more reduction in depressive symptoms (Pigott 2015). Drug discontinuation rates are 15% to 132% higher than with placebos (Cipriani et al. 2018). Concerns about the efficacy and tolerability of antidepressants have increased the interest in nonpharmacological treatments for depression (Farah et al. 2016). In a study including people with depression, half of the participants indicated psychotherapy as their first choice among treatment options such as relaxation, psychotherapy, meditation/yoga, acupuncture, natural remedies, psychotropic drugs, and electroconvulsive therapy (Riedel-Heller et al. 2005). Nonpharmaceutical interventions may reduce post-treatment relapse rates and cause fewer adverse effects (Farah et al. 2016). There are studies in the literature showing that exercise can alleviate depressive symptoms and can be used both as a complementary and stand-alone treatment method (Clarke et al. 2015, Schuch et al. 2016, Song et al. 2018).

Pharmacological and psychological interventions form the basis of depression treatment. The current literature provides evidence that exercise prevents depression and reduces symptoms in people with depression (Schuch and Stubbs 2019). In a study by Toups et al. (2017), exercise was found to improve positive valence symptoms in the treatment of depression, and this improvement was positively correlated with the overall treatment outcome. In their meta-regression study, Heissel et al. (2023) stated that exercise was highly effective in reducing depressive symptoms and should be considered a valid treatment option for depression. Although it is known that exercise has a positive effect on depression, it has been emphasized that larger studies are needed to confirm the effectiveness of exercise in patients with major depressive disorder (Gerber et al., 2016). Sarris et al. (2014) suggested that pharmacological or psychological interventions alone are not effective in the treatment of depression and pointed out that a holistic approach involving lifestyle modification with exercise and diet programs should be regarded as a routine part of treatment and prevention. In a study of 141 patients with depression and/or anxiety disorders, running regularly 2 or 3 times a week was found to be at least as effective as antidepressants in relieving depression and anxiety symptoms (Verhoeven et al. 2023). Similarly, Gordon et al. (2018) reported that weight-lifting was as effective as antidepressants in coping with depression.

Anxiety

Anxiety disorders are common and widely studied psychiatric diseases (WHO 2022a). Anxiety disorders are characterized by perceptions of situations or objects encountered in daily life being more dangerous or threatening than they actually are and feelings of excessive worry when faced with these situations (Şahin 2019). High levels of anxiety symptoms, which include emotional (fear, worry) and physiological (e.g., rapid heartbeat, tremor) indicators, are a common feature in various anxiety disorders. However, the diagnostic criteria for these disorders vary considerably in terms of factors such as the frequency and severity of symptoms and the specificity of triggers (Penninx et al. 2021). Anxiety is a risk factor for various physical health problems, particularly cardiovascular disease, and is associated with decreased health-related quality of life and increased all-cause mortality rates (Stein et al. 2005, Tolmunen et al. 2014). There is a complex and multifaceted relationship between anxiety and depression (Cage 2021). This relationship can be attributed to the interaction of various factors. In addition to biological, psychosocial, and environmental factors, genetic predisposition also plays a role in this relationship. Dysregulation of neurotransmitters such as serotonin, dopamine, and norepinephrine and chemical imbalances in the brain play an important role in these disorders. In addition, a significant overlap between anxiety and depression symptoms has been observed (Basso and Suziki 2017).

Exercise is seen as a promising, economical, and easily accessible treatment option for individuals with anxiety. In a study by De Moor et al. (2006) including 19288 participants, individuals who exercised at a moderate level for 240 minutes a week reported less anxiety and neuroticism compared to those who did not exercise. Studies show that exercise can be considered as a potential treatment option in reducing anxiety symptoms (Esquivel et al. 2008, Strickland and Smith 2014). Intervention studies in healthy individuals have demonstrated a reduction in anxiety levels immediately following a single exercise session (Ströhle et al. 2006). Studies conducted among people with subclinical anxiety levels suggest that regular exercise may reduce anxiety levels (Tsai et al. 2003).

Effect of Exercise on Chemical Changes and Hormones in the Brain

Studies have shown that exercise may protect against age-related brain deterioration and reduce the risk of certain neurological disorders (Kramer et al. 2006, Voss et al. 2013, Vivar 2015). The neurogenic effects of exercise suggest that it contributes to memory consolidation and learning, especially by promoting the growth of new neurons in the hippocampus (Ünal 2021). Özocak et al. (2019) stated that exercise may play a therapeutic role in neuroplastic changes and has positive effects on neuroplasticity, treatment potential, and cognitive functions. Ünal (2021) noted the importance of avoiding over-exercise and not creating stress, because excessive stress can negatively impact neurogenesis. Meta-analysis studies examining the effect of a single acute exercise session on human behavior point to an overall small but positive effect on cognitive functions, particularly those related to the prefrontal cortex (Sibley and Etnier 2003, Lambourne and Tomporowski 2010, Chang et al. 2012).

Exercise positively impacts memory and cognition (Ravari et al. 2021). Improved cognitive function is likely attributable to enhanced cerebral blood circulation, which increases volume and cell regeneration in areas of the brain critical to efficient cognitive function such as the hippocampus (Guiney et al. 2015). Thomas et al. (2016) reported that sedentary young people and middle-aged adults showed an increase in the volume of the anterior hippocampus after 6 weeks of participation in a regular exercise program (30 minutes of cycling 5 sessions/week). Therefore, aerobic exercise in particular might enhance cognitive function through vascular changes in the brain (Leyland et al. 2019). Pontifex et al. (2021) determined that 20 minutes of moderate-intensity aerobic exercise improved cognitive function and performance in individuals with high or low anxiety.

In a study conducted by Moon et al. (2016), cognitive/behavioral, neurophysiological, and neurochemical changes were comprehensively examined after a single session of physical exercise. Although it is difficult to compare the effects of acute exercise in humans, marked results such as improved executive function, improved mood, and decreased stress levels have been noted. The relationship between the central neurochemical changes studied extensively in mice and the behavioral outcomes observed in humans is a subject that needs to be clarified (Malisch et al. 2007). Understanding the effects of exercise in this context is vital to optimize brain function both in the clinic and in healthy populations, but its potential to increase attention, mood, and stress resistance suggests a wide range of applications beyond nonclinical contexts (Goekint et al. 2012).

It has been emphasized that acute exercise improves emotional affect and positively impacts mood (Liao et al. 2015). It also alters dopamine, serotonin, and norepinephrine levels. These changes may be a factor in the behavioral effects associated with acute exercise (Basso and Suziki 2017). An increase in peripheral monoamine and hormone levels was observed in people during exercise. However, the study of these changes in the human brain is limited by technical challenges (Meeusen et al. 2001, McMorris 2016). Acute exercise leads to an increase in mood and decrease in stress levels (Reed and Ones 2016). The results of a few studies show that acute exercise improves emotional memory, which is related to the amygdala (Segal et al. 2012, Weinberg et al. 2014). Exercise triggers the release of happiness hormones such as dopamine and serotonin. Serotonin is a hormone neurotransmitter that helps defend against both anxiety and depression, and is considered the key to positive mood and happiness (Herr et al., 2017). Raising serotonin levels is believed to be important for happiness and well-being, which are protective against mental and physical disorders.

In mice, a single exercise session results in marked increases in dopamine and its metabolites in numerous brain regions such as the prefrontal cortex, hippocampus, striatum, midbrain, pons, and medulla (Meeusen et al. 2001). Dopamine levels remain above basal levels for about two hours after the exercise ends (Greenwood et al. 2011, Park et al. 2016). High-running mouse lines have an irregular dopamine system compared to control lines, with high dopamine and low dopamine receptor gene expression levels (Rhodes et al. 2005, Mathes et al. 2010). Interestingly, it was also shown that dopaminergic and noradrenergic reuptake inhibitors before exercise improve performance or stamina in endurance exercise in humans (Roelands et al. 2012, Cordery et al. 2017). In a mouse treadmill study conducted by Ercan et al. (2023), exercise significantly reduced stress-related behavioral disorders and molecular changes in the brain, supporting the positive effects of exercise on mental health.

Mouse studies show that acute exercise results in elevated serotonin and metabolite levels in the hippocampus, frontal cortex, striatum, and midbrain (Gomez-Merino et al. 2001). However, in a study of rats running on a treadmill at a speed of 20 m/min for 60 minutes, no increase in hippocampal serotonin levels was observed (Goekint et al. 2012). This finding indicates the need for a certain intensity of exercise to enhance central serotonin levels. In humans, serotonin is believed to be involved in the antidepressant and anxiolytic effects of exercise, and chronic exercise was reported to be as effective as antidepressant therapy (Babyak et al. 2000). In a mouse study by Otsuka et al. (2016), low-running mice exhibited significantly greater reductions in both

depressive and anxiety-like behaviors compared to high-running mice. Based on those findings, the researchers concluded that low-intensity acute exercise is superior for stimulating serotonergic activity and improving mood.

Acute exercise has different effects on norepinephrine depending on the brain region. Levels increase in some regions (cortex, striatum, preoptic area) but decrease in others (hippocampus, brainstem, pons-medulla, hypothalamus). This may be related to differences in environmental conditions or the exercise protocols used (Basso and Suzuki 2017). For example, high-intensity and prolonged exercise may increase norepinephrine levels and sustain its effect longer (Pagliari and Peyrin 1995). Furthermore, peripheral epinephrine levels are associated with norepinephrine levels in the brain, suggesting that epinephrine levels may be an indicator of exercise-induced noradrenergic changes (Meeusen and De Meirleir 1995). A study in humans found a positive association between exercise-related improvements and peripheral epinephrine levels (McMorris et al. 2008).

Conclusion

Exercise has positive effects both on cognitive function and mental health. Pandemics, natural disasters, social crises, personal traumas, and uncertainties about life and the future can lead to stress and negative impact on mental health. These kinds of situations make the role of exercise even more important. Although research into the effects of exercise on mental health are ongoing, the results of studies conducted to date have been promising. It can be said that regular exercise may be an important support for mental health.

Common mental health problems such as depression and anxiety seriously affect individuals' quality of life and impose a significant burden on societies. Traditional pharmacotherapy methods have several disadvantages, thus increasing the importance of nonpharmaceutical interventions. Exercise may offer an effective strategy for alleviating depression and anxiety symptoms. This is supported by findings that regular exercise has positive effects on biological, psychosocial, and environmental factors and can play an important role in reducing neuroinflammation. In this context, it can be concluded that exercise-based interventions have important potential in mental health promotion and the treatment of mental disorders.

The positive effects of exercise on cognitive functions have been associated with neurological changes, especially an increase in brain anterior hippocampal volume. Aerobic exercise increases cerebral vascular blood flow, which can improve cognitive function and has the potential to protect mental health at the same time. From a mental health perspective, exercise appears to contribute to reducing stress, increasing energy levels, alleviating symptoms of anxiety and depression, and lowering the incidence of depression. In terms of neurocognitive function, exercise has many benefits, such as increasing brain volume, supporting neuroprotective function, enhancing attention and processing speed, improving executive function, and strengthening memory.

Acute exercise exhibits a small but positive effect on cognitive function, especially those associated with the prefrontal cortex. It also has the potential to improve mood and reduce stress levels. In terms of neurochemical mechanisms of acute exercise, it is seen to support these effects by increasing the release of happiness hormones such as dopamine, serotonin, and norepinephrine. Studies in mice show that acute exercise increases dopamine, serotonin, and norepinephrine levels in the brain, leading to corresponding behavioral changes. These findings suggest that acute exercise has the potential to optimize brain function, improve mood, and increase stress resistance. However, there is a need for further research in this area and a better understanding of the effects of acute exercise on humans.

The exercise programs described in the literature show considerable heterogeneity. Although there is no standard program, some authors have examined certain characteristics of the programs (exercise type, intensity, duration, and frequency), but there is no mention of clinical prescriptions for exercise. Moderate-intensity exercise is reported to be the most popular option, but there is also no standard definition of moderate-intensity exercise. Moreover, high-intensity and low-intensity exercise can also yield positive results. Yoga, stretching, and mechanical and combined exercises are among the low-intensity exercises generally used in control groups. High- and moderate-intensity exercise programs are generally thought to have a stronger antidepressant effect. However, higher intensity programs usually have lower adherence and higher discontinuation rates. For this reason, exercise prescriptions should be made taking various factors into account, such as the intensity, duration, and sustainability of the exercise. This points to the importance of individualized exercise programs in mental health promotion and treatment.

Antidepressants are an important component of depression treatment but have several major drawbacks. Concerns about the efficacy and tolerability of antidepressants have led to increased interest in

nonpharmacological treatments for depression, especially for drug-averse patients. Psychotherapy seems to be the preferred treatment option among patients. Of the other nonpharmacological interventions, exercise reduces post-treatment relapse rates and has fewer adverse effects than drug therapy. Exercise is gaining recognition as a viable and cost-effective option for the treatment of depression. It is readily accessible, has minimal adverse effects, can prevent relapses, and has positive effects on overall body function. Considering that there is no social stigma associated with the therapeutic use of exercise, this effective strategy can be used either as a complementary or stand-alone intervention method in the treatment of depression. It is observed that exercise improves mental health and mood, reduces the risk of depression, and increases overall well-being. For this reason, regular promotion and support of exercise should be considered an important public health priority for both individuals and society. The use of proposed criteria for the standardization of exercise studies could ensure that the results of future research are more consistent and comparable..

References

APA (2013) Diagnostic and Statistical Manual Of Mental Disorders, 5th edition (DSM-5™). Washington DC, American Psychiatric Association.

Babyak M, Blumenthal JA, Herman S, Khatri P, Doraiswamy M, Moore K et al. (2000) Exercise treatment for major depression: maintenance of therapeutic benefit at 10 months. Psychosom Med, 62:633–638.

Bartholomew JB, Morrison D, Ciccolo JT (2005) Effects of acute exercise on mood and well-being in patients with major depressive disorder. Med Sci Sports Exerc, 37:2032–2037.

Bas-Sarmiento P, Saucedo-Moreno MJ, Fernández-Gutiérrez M, Poza-Méndez M (2017) Mental health in immigrants versus native population: a systematic review of the literature. Arch Psychiatr Nurs, 31:111-121.

Bassett B, Subramaniyam S, Fan Y, Varney S, Pan H, Carneiro AMD et al. (2021) Minocycline alleviates depression-like symptoms by rescuing decrease in neurogenesis in dorsal hippocampus via blocking microglia activation/phagocytosis. Brain Behav Imm, 91:519–530.

Basso JC, Suzuki WA (2017) The effects of acute exercise on mood, cognition, neurophysiology, and neurochemical pathways: a review. Brain Plast, 2:127–152.

Bayles MP (2023) ACSM's Exercise Testing and Prescription. Philadelphia, PA, Lippincott Williams & Wilkins.

Birinci YZ, Sagdilek E, Şahin Ş (2023) Egzersiz-kaynaklı BDNF'nin mental sağlık üzerindeki etkisinin değerlendirilmesi: sistematik derleme. Uludağ Üniversitesi Tıp Fakültesi Dergisi, 49:115-124.

Blair SN, Jackson AS (2001) Physical fitness and activity as separate heart disease risk factors: a meta-analysis. Med Sci Sports Exerc, 33:762–764.

Blumenthal JA, Feger BJ, Smith PJ, Watkins LL, Jiang W, Davidson J et al. (2016). Treatment of anxiety in patients with coronary heart disease: Rationale and design of the UNderstanding the benefits of exercise and escitalopram in anxious patients WIth coroNary heart Disease (UNWIND) randomized clinical trial. Am Heart J, 176:53–62.

Blumenthal JA, Rozanski A (2023) Exercise as a therapeutic modality for the prevention and treatment of depression. Prog Cardiovasc Dis, 77:50-58.

Brocardo PS, Boehme F, Patten A, Cox A, Gil-Mohapel J, Christie BR (2012) Anxiety- and depression-like behaviors are accompanied by an increase in oxidative stress in a rat model of fetal alcohol spectrum disorders: Protective effects of voluntary physical exercise. Neuropharmacology, 62:1607–1618.

Brooks SK, Webster RK, Smith LE, Woodland L, Wessely S, Greenberg N et al. (2020) The psychological impact of quarantine and how to reduce it: rapid review of the evidence. Lancet, 395:912–920.

Brownley KA, Hinderliter AL, West SG, Girdler SS, Sherwood A, Light KC (2003) Sympathoadrenergic mechanisms in reduced hemodynamic stress responses after exercise. Med Sci Sports Exerc, 35:978–986.

Budde H, Machado S, Ribeiro P, Wegner M (2015) The cortisol response to exercise in young adults. Front Behav Neurosci, 9:13-24.

Budde H, Schwarz R, Velasques B, Ribeiro P, Holzweg M, Machado S et al. (2016) The need for differentiating between exercise, physical activity, and training. Autoimmun Rev, 15:110–111.

Budde H, Velasques B, Ribeiro P, Machado S, Emeljanovas A, Kamandulis S (2018). Does intensity or youth affect the neurobiological effect of exercise on major depressive disorder? Neurosci Biobehav Rev, 84:492-494.

Caspersen CJ, Powell KE, Christenson GM (1985) Physical activity, exercise, and physical fitness: definitions and distinctions for health-related research. Public Health Rep, 100:126–131.

Cervenka I, Agudelo LZ, Ruas JL (2017) Kynurenines: Tryptophan's metabolites in exercise, inflammation, and mental health. Science, 357:eaaf9794.

Chand SP, Arif H (2023). Depression (Nursing). Treasure Island, FL, StatPearls Publishing..

Chang YK, Labban JD, Gapin JI, Etnier JL (2012) The effects of acute exercise on cognitive performance: a meta-analysis. Brain Res, 1453:87–101.

Chen HM, Tsai CM, Wu YC, Lin KC, Lin CC (2015) Randomised controlled trial on the effectiveness of home-based walking exercise on anxiety, depression and cancer-related symptoms in patients with lung cancer. Br J Cancer, 112:438–445.

Chisholm D, Sweeny K, Sheehan P, Rasmussen B, Smit F, Cuijpers P et al. (2016) Scaling-up treatment of depression and anxiety: a global return on investment analysis. Lancet Psychiatry, 3:415-424.

Churchill R, Teo K, Kervin L, Riadi I, Cosco TD (2022) Exercise interventions for stress reduction in older adult populations: a systematic review of randomized controlled trials. Health Psychol Behav Med, 10:913–934.

Cipriani A, Furukawa TA, Salanti G, Chaimani A, Atkinson LZ, Ogawa Y et al. (2018) Comparative efficacy and acceptability of 21 antidepressant drugs for the acute treatment of adults with major depressive disorder: a systematic review and network meta-analysis. Lancet, 391:1357-1366.

Civan A, Özdemir İ, Gencer YG, Durmaz M (2018) Egzersiz ve stres hormonları. Türkiye Spor Bilimleri Dergisi, 2:1-14.

Clarke K, Mayo-Wilson E, Kenny J, Pilling S (2015) Can non-pharmacological interventions prevent relapse in adults who have recovered from depression? A systematic review and meta-analysis of randomised controlled trials. Clin Psychol Rev, 39:58–70.

Cordery P, Peirce N, Maughan RJ, Watson P (2017) Dopamine/noradrenaline reuptake inhibition in women improves endurance exercise performance in the heat. Scand J Med Sci Sports, 27:1221–1230.

Danielsson L, Papoulias I, Petersson EL, Carlsson J, Waern M (2014) Exercise or basic body awareness therapy as add-on treatment for major depression: a controlled study. J Affect Disord, 168:98–106.

De Moor MH, Beem AL, Stubbe JH, Boomsma DI, De Geus EJ (2006) Regular exercise, anxiety, depression and personality: a population-based study. Prev Med, 42:273–279.

D'Onofrio G, Kirschner J, Prather H, Goldman D, Rozanski A (2023) Musculoskeletal exercise: Its role in promoting health and longevity. Prog Cardiovas Dis, 77:25-36.

Duman CH, Schlesinger L, Russell DS, Duman RS (2008) Voluntary exercise produces antidepressant and anxiolytic behavioral effects in mice. Brain Res, 1199:148–158.

Eckshtain D, Kuppens S, Ugueto A, Ng MY, Vaughn-Coaxum R, Corteselli K et al. (2020) Meta-analysis: 13-year follow-up of psychotherapy effects on youth depression. J Am Acad Child Adolesc Psychiatry, 59:45–63.

Emery CF, Kiecolt-Glaser JK, Glaser R, Malarkey WB, Frid DJ (2005) Exercise accelerates wound healing among healthy older adults: a preliminary investigation. J Geront A Biol Sci Med Sci, 60:1432–1436.

Ercan Z, Bulmus O, Kacar E, Serhatlioglu I, Zorlu G, Kelestimur H (2023) Treadmill exercise improves behavioral and neurobiological alterations in restraint-stressed rats. J Mol Neurosci, 73:831-842.

Erickson KI, Voss MW, Prakash RS, Basak C, Szabo A, Chaddock L et al. (2011) Exercise training increases size of hippocampus and improves memory. Proc Natl Acad Sci USA, 108:3017-3022.

Esquivel G, Díaz-Galvis J, Schruers K, Berlanga C, Lara-Muñoz C, Griez E (2008) Acute exercise reduces the effects of a 35% CO2 challenge in patients with panic disorder. J Affect Disord, 107: 217–220.

Farah WH, Alsawas M, Mainou M, Alahdab F, Farah MH, Ahmed AT et al. (2016) Non-pharmacological treatment of depression: a systematic review and evidence map. Evid Based Med, 21: 214-221.

Fibbins H, Lederman O, Rosenbaum S (2020) Get moving: Physical activity and exercise for mental health. In Badcock JC, Paulik G (Eds). A clinical introduction to psychosis: Foundations for clinical psychologists and neuropsychologists (pp. 493–510). New York, Elsevier Academic Press.

Folkman S (2010) Stress, coping and hope. Psychooncology, 19:901–908.

Fulk LJ, Stock HS, Lynn A, Marshall J, Wilson MA, Hand GA (2004) Chronic physical exercise reduces anxiety-like behavior in rats. Int J Sports Med, 25:78–82.

Garber CE, Blissmer B, Deschenes MR, Franklin BA, Lamonte MJ, Lee IM et al. (2011) American College of Sports Medicine position stand. Quantity and quality of exercise for developing and maintaining cardiorespiratory, musculoskeletal, and neuromotor fitness in apparently healthy adults: guidance for prescribing exercise. Med Sci Sports Exerc, 43:1334–1359.

GBD 2019 Mental Disorders Collaborators (2022) Global, regional, and national burden of 12 mental disorders in 204 countries and territories, 1990-2019: a systematic analysis for the Global Burden of Disease Study 2019. Lancet Psychiatry, 9:137–150.

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!. Neuropsychiatr Dis Treat, 12:1977-1981.

Giammusso I, Casadei F, Catania N, Foddai E, Monti MC, Savoja G et al. (2018) Immigrants psychopathology: emerging phenomena and adaptation of mental health care setting by native language. Clin Pract Epidemiol Ment Health, 14:312–322.

Girard I, Garland TJ (2002) Plasma corticosterone response to acute and chronic voluntary exercise in female house mice. J Appl Physiol (1985), 92:1553–1561.

Goekint M, Bos I, Heyman E, Meeusen R, Michotte Y, Sarre S (2012) Acute running stimulates hippocampal dopaminergic neurotransmission in rats, but has no influence on brain-derived neurotrophic factor. J App Physiol, 112: 535–541.

Gomez-Merino D, Béquet F, Berthelot M, Chennaoui M, Guezennec CY (2001) Site-dependent effects of an acute intensive exercise on extracellular 5-HT and 5-HIAA levels in rat brain. Neurosci Lett, 301:143–146.

Gordon BR, McDowell CP, Hallgren M, Meyer JD, Lyons M, Herring MP (2018) Association of efficacy of resistance exercise training with depressive symptoms: meta-analysis and meta-regression analysis of randomized clinical trials. JAMA Psychiatry, 75:566–576.

Greenwood BN, Fleshner M (2008) Exercise, learned helplessness, and the stress-resistant brain. Neuromolecular Med, 10:81–98.

Greenwood BN, Fleshner M (2011) Exercise, stress resistance, and central serotonergic systems. Exerc Sport Sci Rev, 39:140–149.

Greenwood BN, Foley TE, Le TV, Strong PV, Loughridge AB, Day HE et al. (2011) Long-term voluntary wheel running is rewarding and produces plasticity in the mesolimbic reward pathway. Behav Brain Res, 217:354–362.

Gronwald T, Budde H (2019) Commentary: physical exercise as personalized medicine for dementia prevention? Front Physiol, 10:1358.

Guiney H, Lucas SJ, Cotter JD, Machado L (2015) Evidence cerebral blood-flow regulation mediates exercise-cognition links in healthy young adults. Neuropsychology, 29:1–9.

Gujral S, Aizenstein H, Reynolds CF, Butters MA, Grove G, Karp JF et al. (2019) Exercise for depression: a feasibility trial exploring neural mechanisms. Am J Geriatr Psychiatry, 27:611–616.

Gupta SK, Elumalai SP (2017) Size-segregated particulate matter and its association with respiratory deposition doses among outdoor exercisers in Dhanbad City, India. J Air Waste Manag Assoc, 67:1137–1145.

Günlü A, Asıcı E, Çetinkaya M (2021) Türkiye'de covid-19 salgınının ikinci evresinde ebeveynlerde depresyon, anksiyete, stres ve travma sonrası stres bozukluğunun incelenmesi. Aile Psikolojik Danışmanlığı Dergisi, 4:94-124.

Güzel Erdoğan D, Aslan İ (2021) Egzersiz ve egzersizin homeostatik fizyolojik etkileri. INSAC Academic Developments on Health Sciences (Ed R Soylu): 67-72. İzmir, Duvar Yayınları.

Hallal PC, Andersen LB, Bull FC, Guthold R, Haskell W, Ekelund U (2012) Lancet Physical Activity Series Working Group. Global physical activity levels: surveillance progress, pitfalls, and prospects. Lancet, 380:247–257.

Hallgren M, Kraepelien M, Öjehagen A, Lindefors N, Zeebari Z, Kaldo V et al. (2015) Physical exercise and internet-based cognitive-behavioural therapy in the treatment of depression: randomised controlled trial. Br J Psychiatry, 207:227–234.

Hamer M, Taylor A, Steptoe A (2006) The effect of acute aerobic exercise on stress related blood pressure responses: a systematic review and meta-analysis. Biol Psychol, 71:183–190.

Hanssen H, Minghetti A, Faude O, Schmidt-Trucksäss A, Zahner L, Beck J et al. (2018) Effects of endurance exercise modalities on arterial stiffness in patients suffering from unipolar depression: a randomized controlled trial. Front Psychiatry, 8:311.

Harvey SB, Øverland S, Hatch SL, Wessely S, Mykletun A, Hotopf M (2018) Exercise and the prevention of depression: results of the HUNT cohort study. Am J Psychiatry, 175:28–36.

Hashimoto T, Hotta R, Kawashima R (2024) Enhanced memory and hippocampal connectivity in humans 2 days after brief resistance exercise. Brain Behav, 14:3436.

Heggelund J, Kleppe KD, Morken G, Vedul-Kjelsås E (2014) High aerobic intensity training and psychological States in patients with depression or schizophrenia. Front Psychiatry, 5:148.

Heissel A, Heinen D, Brokmeier LL, Skarabis N, Kangas M, Vancampfort D et al. (2023) Exercise as medicine for depressive symptoms? A systematic review and meta-analysis with meta-regression. Br J Sports Med, 57: 1049–1057.

Helgadóttir B, Forsell Y, Hallgren M, Möller J, Ekblom Ö (2017) Long-term effects of exercise at different intensity levels on depression: A randomized controlled trial. Prev Med, 105:37–46.

Helgadóttir B, Hallgren M, Ekblom Ö, Forsell Y (2016) Training fast or slow? Exercise for depression: A randomized controlled trial. Prev Med, 91:123–131.

Helvacı Çelik F, Hocaoğlu Ç (2016). Major depresif bozukluk' tanımı, etyolojisi ve epidemiyolojisi: bir gözden geçirme. Çağdaş Tıp Dergisi, 6:51-66.

Herman JP, Ostrander MM, Mueller NK, Figueiredo H (2005) Limbic system mechanisms of stress regulation: hypothalamo-pituitary-adrenocortical axis. Prog Neuropsychopharmacol Biol Psychiatry, 29:1201–1213.

Herr N, Bode C, Duerschmied D (2017) The effects of serotonin in ımmune cells. Front Cardiovas Med, 4:48-61.

Higuera-Hernández MF, Reyes-Cuapio E, Gutiérrez-Mendoza M, Rocha NB, Veras AB, Budde H et al. (2018) Fighting obesity: Non-pharmacological interventions. Clin Nutr ESPEN, 25:50–55.

Hill EE, Zack E, Battaglini C, Viru M, Viru A, Hackney AC (2008) Exercise and circulating cortisol levels: the intensity threshold effect. J Endocrinol Invest, 31:587–591.

Hootman JM, Macera CA, Ainsworth BE, Addy CL, Martin M, Blair SN (2002) Epidemiology of musculoskeletal injuries among sedentary and physically active adults. Med Sci Sports Exerc, 34:838–844.

Howland M, Armeli S, Feinn R, Tennen H (2017) Daily emotional stress reactivity in emerging adulthood: temporal stability and its predictors. Anxiety Stress Coping, 30:121–132.

Iasiello M, Van Agteren J (2020) Mental health and/or mental illness: A scoping review of the evidence and implications of the dual-continua model of mental health. J Evid Rev Key Policy Areas, 1:1-45.

Imboden C, Gerber M, Beck J, Holsboer-Trachsler E, Pühse U, Hatzinger M (2020) Aerobic exercise or stretching as add-on to inpatient treatment of depression: Similar antidepressant effects on depressive symptoms and larger effects on working memory for aerobic exercise alone. J Affect Disord, 276:866–876.

Kafes AY (2021) Depresyon ve anksiyete bozuklukları üzerine bir bakış. Humanistic Perspective, 3:186-194.

Katzmarzyk PT (2023) Expanding our understanding of the global impact of physical inactivity. Lancet Glob Health, 11:2-3.

Kim TK, Kim JE, Choi J, Park JY, Lee JE, Lee EH et al. (2017) local ınterleukin-18 system in the basolateral amygdala regulates susceptibility to chronic stress. Mol Neurobiol, 54:5347–5358.

Kramer AF, Colcombe SJ, McAuley E, Scalf PE, Erickson KI (2005) Fitness, aging and neurocognitive function. Neurobiol Aging, 26:124-127.

Kramer AF, Erickson KI, Colcombe SJ (2006) Exercise, cognition, and the aging brain. J Appl Physiol, 101:1237–1242.

Lambourne K, Tomporowski P (2010) The effect of exercise-induced arousal on cognitive task performance: a meta-regression analysis. Brain Res, 1341:12–24.

Leyland LA, Spencer B, Beale N, Jones T, van Reekum CM (2019) The effect of cycling on cognitive function and well-being in older adults. PloS One, 14:0211779.

Li BJ, Friston K, Mody M, Wang HN, Lu HB, Hu DW (2018) A brain network model for depression: From symptom understanding to disease intervention. CNS Neurosci Ther, 24:1004–1019.

Liao Y, Shonkoff ET, Dunton GF (2015) The acute relationships between affect, physical feeling states, and physical activity in daily life: a review of current evidence. Front Psychol, 6:1975.

Liu W, Sheng H, Xu Y, Liu Y, Lu J, Ni X (2013) Swimming exercise ameliorates depression-like behavior in chronically stressed rats: relevant to proinflammatory cytokines and IDO activation. Behav Brain Res, 242:110-116.

Liu YH, Chang CF, Hung HM, Chen CH (2021) Outcomes of a walking exercise intervention in postpartum women with disordered sleep. J Obstet Gynaecol Res, 47:1380–1387.

Lu X, Liu L, Yuan R (2020) Effect of the ınformation support method combined with yoga exercise on the depression, anxiety, and sleep quality of menopausal women. Psychiatr Danub, 32:380–388.

Lu Y, Bu FQ, Wang F, Liu L, Zhang S, Wang G et al. (2023) Recent advances on the molecular mechanisms of exercise-induced improvements of cognitive dysfunction. Transl Neurodegener, 12:9.

Luca M, Luca A (2019) Oxidative stress-related endothelial damage in vascular depression and vascular cognitive impairment: beneficial effects of aerobic physical exercise. Oxid Med Cell Longev, 2019:8067045.

Maj M, Stein DJ, Parker G, Zimmerman M, Fava GA, De Hert M et al. (2020). The clinical characterization of the adult patient with depression aimed at personalization of management. World Psychiatry, 19:269-293.

Malisch JL, Saltzman W, Gomes FR, Rezende EL, Jeske DR, Garland T (2007) Baseline and stress-induced plasma corticosterone concentrations of mice selectively bred for high voluntary wheel running. Physiol Biochem Zool, 80:146–156.

Matei D, Trofin D, Iordan DA, Onu I, Condurache I, Ionite C et al. (2023) The endocannabinoid system and physical exercise. Int J Mol Sci, 24:1989.

Mathes WF, Nehrenberg DL, Gordon R, Hua K, Garland T, Pomp D (2010) Dopaminergic dysregulation in mice selectively bred for excessive exercise or obesity. Behav Brain Res, 210:155–163.

Matud MP, Díaz A, Bethencourt JM, Ibáñez I (2020) Stress and psychological distress in emerging adulthood: a gender analysis. J Clin Med, 9:2859.

Mazzucco S, Agostini F, Biolo G (2010) Inactivity-mediated insulin resistance is associated with upregulated pro-inflammatory fatty acids in human cell membranes. Clin Nutr, 29:386–390.

McMorris T (2016) Developing the catecholamines hypothesis for the acute exercise-cognition interaction in humans: Lessons from animal studies. Physiol Behav, 165:291–299.

McMorris T, Collard K, Corbett J, Dicks M, Swain JP (2008) A test of the catecholamines hypothesis for an acute exercise-cognition interaction. Pharmacol Biochem Behav, 89:106–115.

Meeusen R, De Meirleir K (1995) Exercise and brain neurotransmission. Sports Med, 20:160–188.

Meeusen R, Piacentini MF, De Meirleir K (2001) Brain microdialysis in exercise research. Sports Med, 31:965–983.

Meziat C, Boulghobra D, Strock E, Battault S, Bornard I, Walther G et al. (2019) Exercise training restores eNOS activation in the perivascular adipose tissue of obese rats: Impact on vascular function. Nitric Oxide, 86:63–67.

Mika A, Bouchet CA, Bunker P, Hellwinkel JE, Spence KG, Day HE et al. (2015) Voluntary exercise during extinction of auditory fear conditioning reduces the relapse of fear associated with potentiated activity of striatal direct pathway neurons. Neurobiol Learn Mem, 125:224–235.

Mittal VA, Vargas T, Osborne KJ, Dean D, Gupta T, Ristanovic I et al. (2017) Exercise treatments for psychosis: a review. Curr Treat Options Psychiatry, 4:152–166.

Monti E, Reggiani C, Franchi MV, Toniolo L, Sandri M, Armani A et al. (2021) Neuromuscular junction instability and altered intracellular calcium handling as early determinants of force loss during unloading in humans. J Physiol, 599:3037–3061.

Moon HY, Becke A, Berron D, Becker B, Sah N, Benoni G et al. (2016) Running-induced systemic cathepsin B secretion is associated with memory function. Cell Metab, 24:332-340.

Mota-Pereira J, Silverio J, Carvalho S, Ribeiro JC, Fonte D, Ramos J (2011) Moderate exercise improves depression parameters in treatment-resistant patients with major depressive disorder. J Psychiatr Res, 45:1005–1011.

Muyor-Rodríguez J, Caravaca-Sánchez F, Fernández-Prados JS (2021) COVID-19 fear, resilience, social support, anxiety, and suicide among college students in Spain. Int J Environm Res Pub Health, 18:8156.

Noetel M, Sanders T, Gallardo-Gómez D, Taylor P, del Pozo Cruz B, Van Den Hoek D et al. (2024). Effect of exercise for depression: systematic review and network meta-analysis of randomised controlled trials. BMJ, 384:e075847.

Olchanski N, McInnis Myers M, Halseth M, Cyr PL, Bockstedt L, Goss TF et al. (2013) The economic burden of treatment-resistant depression. Clin Ther, 35:512–522.

Olson RL, Brush CJ, Ehmann PJ, Alderman BL (2017) A randomized trial of aerobic exercise on cognitive control in major depression. Clin Neurophysiol, 128:903–913.

Otsuka T, Nishii A, Amemiya S, Kubota N, Nishijima T, Kita I (2016) Effects of acute treadmill running at different intensities on activities of serotonin and corticotropin-releasing factor neurons, and anxiety- and depressive-like behaviors in rats. Behav Brain Res, 298:44–51.

Özocak O, Başçıl SG, Gölgeli A (2019). Egzersiz ve nöroplastisite. Düzce Üniversitesi Sağlık Bilimleri Enstitüsü Dergisi, 9:31-38.

Pagliari R, Peyrin L (1995) Norepinephrine release in the rat frontal cortex under treadmill exercise: a study with microdialysis. J Appl Physiol (1985), 78:2121–2130.

Park HY, Jung K, Jung WS, Kim SW, Kim J, Lim K (2023) Effects of online pilates and face-to-face pilates ıntervention on body composition, muscle mechanical properties, cardiometabolic parameters, mental health, and physical fitness in middle-aged women with obesity. Healthcare, 11:2768.

Park YM, Kanaley JA, Padilla J, Zidon T, Welly RJ, Will MJ et al. (2016) Effects of intrinsic aerobic capacity and ovariectomy on voluntary wheel running and nucleus accumbens dopamine receptor gene expression. Physiol Behav, 164:383–389.

Pascoe MC, Parker AG (2019) Physical activity and exercise as a universal depression prevention in young people: A narrative review. Early Interv Psychiatry, 13:733–739.

Penninx BW, Pine DS, Holmes EA, Reif A (2021) Anxiety disorders. Lancet, 397:914–927.

Pfaff JJ, Alfonso H, Newton RU, Sim M, Flicker L, Almeida OP (2014) ACTIVEDEP: a randomised, controlled trial of a home-based exercise intervention to alleviate depression in middle-aged and older adults. Br J Sports Med, 48:226–232.

Pigott HE (2015) The STAR*D trial: it is time to reexamine the clinical beliefs that guide the treatment of major depression. Can J Psychiatry, 60:9–13.

Pišot R (2021) Physical inactivity - the human health's greatest enemy. Zdr Varst, 61:1–5.

Pontifex MB, Parks AC, Delli Paoli AG, Schroder HS, Moser JS (2021) The effect of acute exercise for reducing cognitive alterations associated with individuals high in anxiety. Int J Psychophysiol, 167:47–56.

Ravari A, Mirzaei T, Bahremand R, Raeisi M, Kamiab Z (2021) The effect of Pilates exercise on the happiness and depression of elderly women: a clinical trial study. J Sports Med Phys Fitness, 61:131–139.

Reed J, Ones DS (2006) The effect of acute aerobic exercise on positive activated affect: A meta-analysis. Psychol Sport Exerc, 7:477-514.

Reidy PT, Monnig JM, Pickering CE, Funai K, Drummond MJ (2021) Preclinical rodent models of physical inactivity-induced muscle insulin resistance: challenges and solutions. J Appl Physiol, 130:537–544.

Renna ME, Fresco DM, Mennin DS (2020) Emotion regulation therapy and ıts potential role in the treatment of chronic stress-related pathology across disorders. Chronic Stress (Thousand Oaks). 4:2470547020905787.

Rhodes JS, Gammie SC, Garland T (2005) Neurobiology of mice selected for high voluntary wheel-running activity. Integr Comp Biol, 45:438–455.

Richardson M, Passmore HA, Lumber R, Thomas R, Hunt A (2021) Moments, not minutes: The nature-wellbeing relationship. International Journal of Wellbeing, 11:8-33.

Riedel-Heller SG, Matschinger H, Angermeyer MC (2005) Mental disorders—who and what might help? Help-seeking and treatment preferences of the lay public. Soc Psychiatr Psychiatric Epidemiol, 40:167-174.

Rihmer Z, Angst J (2007) Duygudurum bozuklukları: epidemiyoloji. In Türkçe: Kaplan & Sadock's Comprehensive Text book of Psychiatry Türkçesi 8. Baskı. (Çev. Eds. H Aydın, A Bozkurt):1575-1582. Ankara, Güneş Kitabevi.

Roelands B, Watson P, Cordery P, Decoster S, Debaste E, Maughan R et al. (2012) A dopamine/ noradrenaline reuptake inhibitor improves performance in the heat, but only at the maximum therapeutic dose. Scand J Med Sci Sports, 22:e93–e98.

Rojas Vega S, Strüder HK, Vera Wahrmann B, Schmidt A, Bloch W, Hollmann W (2006) Acute BDNF and cortisol response to low intensity exercise and following ramp incremental exercise to exhaustion in humans. Brain Res, 1121:59–65.

Ross RE, VanDerwerker CJ, Saladin ME, Gregory CM (2023). The role of exercise in the treatment of depression: biological underpinnings and clinical outcomes. Mol Psychiatry, 28:298-328.

Salari N, Hosseinian-Far A, Jalali R, Vaisi-Raygani A, Rasoulpoor S, Mohammadi M et al. (2020) Prevalence of stress, anxiety, depression among the general population during the COVID-19 pandemic: a systematic review and meta-analysis. Glob Health, 16:57.

Salmon P (2001) Effects of physical exercise on anxiety, depression, and sensitivity to stress: a unifying theory. Clin Psychol Rev, 21:33–61.

Sanchis-Gomar F, Lucia A, Yvert T, Ruiz-Casado A, Pareja-Galeano H, Santos-Lozano A et al. (2015) Physical inactivity and low fitness deserve more attention to alter cancer risk and prognosis. Cancer Prev Res, 8:105–110.

Santomauro DF, Herrera AMM, Shadid J, Zheng P, Ashbaugh C, Pigott DM et al. (2021) Global prevalence and burden of depressive and anxiety disorders in 204 countries and territories in 2020 due to the COVID-19 pandemic. Lancet, 398:1700-1712.

Santos AC, Willumsen J, Meheus F, Ilbawi A, Bull FC (2023) The cost of inaction on physical inactivity to public health-care systems: a population-attributable fraction analysis. Lancet Glob Health, 11:e32-e39.

Sarris J, O'Neil A, Coulson CE, Schweitzer I, Berk M (2014) Lifestyle medicine for depression. BMC Psychiatry, 14:107.

Sarto F, Monti E, Šimunič B, Pišot R, Narici MV, Franchi MV (2021) Changes in biceps femoris long head fascicle length after 10-d bed rest assessed with different ultrasound methods. Med Sci Sports Exerc, 53:1529–1536.

Schneider KL, Panza E, Handschin B, Ma Y, Busch AM, Waring ME et al. (2016). Feasibility of pairing behavioral activation with exercise for women with type 2 diabetes and depression: the get ıt study pilot randomized controlled trial. Behav Ther, 47:198–212.

Schuch FB, Stubbs B (2019) The role of exercise in preventing and treating depression. Curr Sports Med Rep, 18: 299-304.

Schuch FB, Vancampfort D, Richards J, Rosenbaum S, Ward PB, Stubbs B (2016) Exercise as a treatment for depression: A meta-analysis adjusting for publication bias. J Psychiatr Res, 77:42–51.

Schuch FB, Vasconcelos-Moreno MP, Borowsky C, Fleck MP (2011) Exercise and severe depression: preliminary results of an add-on study. J Affect Disord, 133:615–618.

Schuch FB, Vasconcelos-Moreno MP, Borowsky C, Zimmermann AB, Rocha NS, Fleck MP (2015) Exercise and severe major depression: effect on symptom severity and quality of life at discharge in an inpatient cohort. J Psychiatr Res, 61:25–32.

Segal SK, Cotman CW, Cahill LF (2012) Exercise-induced noradrenergic activation enhances memory consolidation in both normal aging and patients with amnestic mild cognitive impairment. J Alzheimers Dis, 32:1011–1018.

Sherwood A, Blumenthal JA, Smith PJ, Watkins LL, Hoffman BM, Hinderliter AL (2016) Effects of exercise and sertraline on measures of coronary heart disease risk in patients with major depression: results from the SMILE-II randomized clinical trial. Psychosom Med, 78:602–609.

Sibley BA, Etnier JL (2003) The relationship between physical activity and cognition in children: a meta-analysis. Pediatr Exerc Sci, 15:243-256.

Siette J, Reichelt AC, Westbrook RF (2014) A bout of voluntary running enhances context conditioned fear, its extinction, and its reconsolidation. Learn Mem, 21:73–81.

Sigwalt AR, Budde H, Helmich I, Glaser V, Ghisoni K, Lanza S et al. (2011) Molecular aspects involved in swimming exercise training reducing anhedonia in a rat model of depression. Neuroscience, 192: 661–674.

Silva LAD, Tortelli L, Motta J, Menguer L, Mariano S, Tasca G et al. (2019) Effects of aquatic exercise on mental health, functional autonomy and oxidative stress in depressed elderly individuals: A randomized clinical trial. Clinics (Sao Paulo), 74:322.

Smith PJ, Blumenthal JA, Hoffman BM, Cooper H, Strauman TA, Welsh-Bohmer K et al. (2010). Aerobic exercise and neurocognitive performance: a meta-analytic review of randomized controlled trials. Psychosom Med, 72:239–252.

Song YY, Hu RJ, Diao YS, Chen L, Jiang XL (2018) Effects of exercise training on restless legs syndrome, depression, sleep quality, and fatigue among hemodialysis patients: a systematic review and meta-analysis. J Pain Symptom Manage, 55:1184–1195.

Stanton R, Reaburn P (2014) Exercise and the treatment of depression: a review of the exercise program variables. J Sci Med Sport, 17:177–182.

Stein DJ, Vasconcelos MF, Albrechet-Souza L, Ceresér KMM, de Almeida RMM (2017). Microglial over-activation by social defeat stress contributes to anxiety- and depressive-like behaviors. Front Behav Neurosci, 11:207.

Stein MB, Roy-Byrne PP, Craske MG, Bystritsky A, Sullivan G, Pyne JM et al. (2005) Functional impact and health utility of anxiety disorders in primary care outpatients. Med Care, 43:1164–1170.

Strickland JC, Smith MA (2014) The anxiolytic effects of resistance exercise. Front Psychol, 5:753.

Ströhle A, Feller C, Strasburger CJ, Heinz A, Dimeo F (2006) Anxiety modulation by the heart? Aerobic exercise and atrial natriuretic peptide. Psychoneuroendocrinology, 31:1127-1130.

Sui SX, Balanta-Melo J, Pasco JA, Plotkin LI (2022) Musculoskeletal deficits and cognitive ımpairment: epidemiological evidence and biological mechanisms. Curr Osteoporos Rep, 20:260–272.

Sui SX, Williams LJ, Holloway-Kew KL, Hyde NK, Pasco JA (2020) Skeletal muscle health and cognitive function: a narrative review. Int J Mol Sci, 22:255.

Suwabe K, Hyodo K, Fukuie T, Ochi G, Inagaki K, Sakairi Y et al. (2021) Positive mood while exercising influences beneficial effects of exercise with music on prefrontal executive function: A functional NIRS study. Neuroscience, 454:61-71.

Şahin M (2019) Korku, kaygı ve kaygı (anksiyete) bozuklukları. Avrasya Sosyal ve Ekonomi Araştırmaları Dergisi, 6:117-135.

Tang W, Hu T, Yang L, Xu J (2020) The role of alexithymia in the mental health problems of home-quarantined university students during the COVID-19 pandemic in China. Pers Individ Dif, 165:110131.

Taurines R, Gerlach M, Warnke A, Thome J, Wewetzer C (2011) Pharmacotherapy in depressed children and adolescents World J Biol Psychiatry, 12(Suppl 1):11–15.

Thomas AG, Dennis A, Rawlings NB, Stagg CJ, Matthews L, Morris M et al. (2016) Multi-modal characterization of rapid anterior hippocampal volume increase associated with aerobic exercise. Neuroimage, 131:162–170.

Tolmunen T, Lehto SM, Julkunen J, Hintikka J, Kauhanen J (2014) Trait anxiety and somatic concerns associate with increased mortality risk: a 23-year follow-up in aging men. Ann Epidemiol, 24:463-468.

Toups M, Carmody T, Greer T, Rethorst C, Grannemann B, Trivedi MH (2017) Exercise is an effective treatment for positive valence symptoms in major depression. J Affect Disord, 209: 188-194.

Tsai JC, Wang WH, Chan P, Lin LJ, Wang CH, Tomlinson B et al. (2003) The beneficial effects of Tai Chi Chuan on blood pressure and lipid profile and anxiety status in a randomized controlled trial. J Altern Complement Med, 9:747-754.

Ünal M (2021) Egzersiz ve nörogenez İstanbul Tıp Fakültesi Dergisi, 84:264-268.

Valenzuela PL, Saco-Ledo G, Morales JS, Gallardo-Gómez D, Morales-Palomo F, López-Ortiz S et al. (2023) Effects of physical exercise on physical function in older adults in residential care: a systematic review and network meta-analysis of randomised controlled trials. Lancet Healthy Longev, 4:e247-e256.

Verhoeven JE, Han LKM, Lever-van Milligen BA, Hu MX, Révész D, Hoogendoorn AW et al. (2023) Antidepressants or running therapy: Comparing effects on mental and physical health in patients with depression and anxiety disorders. J Affect Disord, 329:19–29.

Vivar C (2015) Adult hippocampal neurogenesis, aging and neurodegenerative diseases: possible strategies to prevent cognitive impairment. Curr Top Med Chem, 15:2175–2192.

Voss MW, Vivar C, Kramer AF, van Praag H (2013) Bridging animal and human models of exercise-induced brain plasticity. Trends Cogn Sci, 17:525–544.

Wang YH, Tan J, Zhou HH, Cao M, Zou Y (2023). Long-term exercise training and inflammatory biomarkers in healthy subjects: a meta-analysis of randomized controlled trials. Front Psychol, 14:1253329.

Warburton DE, Nicol CW, Bredin SS (2006) Health benefits of physical activity: the evidence. CMAJ, 174:801–809.

Wegner M, Amatriain-Fernández S, Kaulitzky A, Murillo-Rodriguez E, Machado S, Budde H (2020) Systematic review of meta-analyses: exercise effects on depression in children and adolescents. Front Psychiatry, 11:81.

Wegner M, Helmich I, Machado S, Nardi AE, Arias-Carrion O, Budde H (2014) Effects of exercise on anxiety and depression disorders: review of meta- analyses and neurobiological mechanisms. CNS Neurol Disord Drug Targets, 13:1002–1014.

Weinberg L, Hasni A, Shinohara M, Duarte A (2014) A single bout of resistance exercise can enhance episodic memory performance. Acta Psychol, 153:13–19.

White RL, Ryan D, Young C, Elston R, Rossi T (2023) How does the context of physical activity influence perceived mood and wellbeing after exercise?. Mental Health Phys Act, 24:100504.

WHO (2021). Supported Living Services for Mental Health: Promoting Person-Centred and Rights-Based Approaches. Geneva, World Health Organization.

WHO (2022a) World Mental Health Report: Transforming Mental Health for All. Geneva, World Health Organization.

WHO (2022b) Mental disorders. https://www.who.int/news-room/fact-sheets/detail/mental-disorders (Accessed 15.02.2024)

Wickham SR, Amarasekara NA (2020) The big three health behaviors and mental health and well-being among young adults: a cross-sectional investigation of sleep, exercise, and diet. Front Psychol, 11:579205.

Wiklund M, Bengs C, Malmgren-Olsson EB, Ohman A (2010) Young women facing multiple and intersecting stressors of modernity, gender orders and youth. Soc Sci Med, 71:1567–1575.

Williams PT (2001) Physical fitness and activity as separate heart disease risk factors: a meta-analysis. Med Sci Sports Exerc, 33:754–761.

Wu K, Wang S, Ding T, Li Y (2023) The direct effect of exercise on the mental health of scientific and technological professionals and the mediating effects of stress, resilience, and social support. Front Public Health, 11:1074418.

Xie Y, Wu Z, Sun L, Zhou L, Wang G, Xiao L et al. (2021) The effects and mechanisms of exercise on the treatment of depression. Front Psychiatry, 12:705559.

Yetim O (2024) Effects of acculturation and ethnic ıdentity on ımmigrant adolescents' mental health. Psikiyatride Güncel Yaklaşımlar, 16:628-643.

Yıldız SA (2012) Aerobik ve anaerobik kapasitenin anlamı nedir? Solunum Dergisi, 14:1-8.

Yirmiya R, Rimmerman N, Reshef R (2015) Depression as a microglial disease. Trends Neurosci, 38:637–658.

Zschucke E, Renneberg B, Dimeo F, Wüstenberg T, Ströhle A (2015) The stress-buffering effect of acute exercise: Evidence for HPA axis negative feedback. Psychoneuroendocrinology, 51:414–425.

Authors Contributions: The author(s) have declared that they have made a significant scientific contribution to the study and have assisted in the preparation or revision of the manuscript
Peer-review: Externally peer-reviewed.
Conflict of Interest: No conflict of interest was declared.
Financial Disclosure: No financial support was declared for this study.