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Physical Activity and Substance Use Disorders: A Narrative Review of Health Benefits and Therapeutic Perspectives

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Abstract:

Substance Use Disorders (SUDs) are chronic conditions which cause a significant number of physical, psychological and social challenges all over the world. While pharmacological and psychological interventions remain crucial to the treatment process, relapse rates are still high and highlight a need for a set of complementary strategies. The physical activity has proved to be a promising non-pharmacological approach which offers multidimensional advantages. This includes not only the modulation of reward pathways, stress reduction, the improvement of both the cardiovascular and the metabolic health, the enhanced cognitive function but the emotional well-being as well. This narrative review synthesizes current evidence on the role of physical activity in the prevention and management of SUDs, discussing its neurobiological and physiological mechanisms, impact on cravings and relapse prevention, and practical considerations for implementation in rehabilitation programs. Despite variability in study design and limited long-term data, findings support the integration of structured exercise as a safe, accessible, and cost-effective adjunct to conventional treatments. Further research is strongly needed so as to establish standardized exercise prescriptions, elucidate underlying mechanisms and optimize long-term results.

Keywords: Physical activity; Exercise; Substance use disorders; Addiction management; Neurobiological effects; Rehabilitation; Relapse prevention

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1. INTRODUCTION

Substance Use Disorders (SUDs) represent a major public health challenge all over the world, and which, affects each and all age groups as well as all socioeconomic backgrounds (World Health Organization, 2023). According to international health organizations, the prevalence of substance abuse continues to rise up at an alarming rate and contributes significantly to morbidity, mortality, and social burden (United Nations Office on Drugs and Crime, 2023; GBD 2019 Substance Use Collaborators, 2022). Apart from their directly toxic effects, psychoactive substances negatively impact physical health, mental well-being and overall life quality. Moreover, they increase the risk of both chronic diseases, disability and mainly premature death (Rehm et al., 2020; Degenhardt et al., 2018).

The conventional approaches of the SUDs management primarily and foremost rely on pharmacological treatments and psychosocial interventions (American Society of Addiction Medicine, 2020; NICE, 2019). In spite of the fact that the previously mentioned strategies have proved to be efficient, relapse rates remain high. Furthermore, long-term adherence to the treatment process is still a major challenge (McLellan et al., 2000; Sinha, 2011). A fact that highlights an urgent need for both complementary and non-pharmacological interventions which can enhance treatment outcomes, improve physical health, and thus, support long-term recovery (Linke & Ussher, 2015).

In this context, physical activity has emerged as a promising therapeutic strategy in both the prevention and management of substance use disorders (Linke & Ussher, 2015). Regular physical activity is well known for its beneficial effects on cardiovascular, metabolic, and musculoskeletal health, as well as for its role in reducing inflammation and improving immune function (Pedersen & Saltin, 2015; Warburton et al., 2006). Besides, exercise induces neurobiological adaptations which include the modulation of neurotransmitter systems such as dopamine and endorphins, which are directly involved in both reward pathways and addictive behaviors (Meeusen & De Meirleir, 1995; Greenwood et al., 2011).

There is a growing evidence which suggests that physical activity may well reduce substance cravings, alleviate withdrawal symptoms, and even improve psychological well-being in individuals with substance use disorders (Linke & Ussher, 2015; Li et al., 2023). In addition, structured exercise programs have been associated with ameliorated treatment adherence, reduced relapse rates, and enhanced quality of life during rehabilitation (Hallgren et al., 2017; Zschucke et al., 2012). Despite this increasing body of research, findings remain

heterogeneous, and the mechanisms through which physical activity exerts its beneficial effects in this population are not yet fully understood.

Therefore, the aim of this narrative review is to analyze the role of physical activity in both the prevention and management of substance use disorders. It focuses on the biological and physiological effects of the physical activity, its therapeutic potential within the addiction treatment programs and the practical considerations for its implementation. By synthesizing current evidence, this article seeks to highlight the relevance of physical activity as an accessible, cost-effective, and complementary strategy in the comprehensive care of individuals with substance use disorders.

2. Substance Use Disorders: Definitions and Health Consequences

Substance use disorders (SUDs) are complex, chronic conditions characterized by the compulsive use of psychoactive substances despite harmful consequences (APA, 2013; Volkow et al., 2016). They encompass a wide range of behaviors, including the misuse of alcohol, illicit drugs, prescription medications, and other addictive substances (WHO, 2023; UNODC, 2023). The Diagnostic and Statistical Manual of Mental Disorders, (DSM-5), defines SUDs as based on a pattern of impaired control, social impairment, risky use, and pharmacological criteria such as tolerance and withdrawal (APA, 2013). These criteria provide a standardized framework for diagnosis and research which facilitates the comparison of the findings across populations and interventions (Hasin et al., 2013).

The health consequences of SUDs are profound and multidimensional (Volkow et al., 2016; Rehm et al., 2013). Physiologically, chronic substance use adversely affects multiple organ systems, including the cardiovascular, hepatic, renal, and central nervous systems (Rehm et al., 2013; Sheron, 2016). For example, alcohol abuse can lead to liver cirrhosis and cardiomyopathy, whereas opioid misuse is associated with respiratory depression and increased risk of infectious diseases (Sheron, 2016; Strang et al., 2020). Additionally, substance use can disrupt metabolic processes, exacerbate inflammatory responses, and impair immune function, thereby increasing vulnerability to comorbid conditions (Kolla et al., 2020).

Regardless physical health, SUDs have significant psychological and behavioral impacts (Volkow et al., 2016; Verdejo-García et al., 2019). Individuals often experience mood disorders, anxiety, cognitive deficits, and impaired decision-making, that in turn contribute to poor adherence to treatment and increased risk of relapse (McLellan et al., 2000; Sinha, 2011). Socially, a substance abuse is linked to a reduced occupational functioning, strained interpersonal relationships,



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and heightened engagement in risky behaviors, further compounding its public health burden (WHO, 2023; UNODC, 2023).

The chronic and relapsing nature of SUDs underscores the need for comprehensive management strategies that address both the physiological and psychological dimensions of addiction (McLellan et al., 2000; Volkow et al., 2016). While pharmacological and psychosocial interventions remain central, there is a growing recognition of the value of complementary approaches, such as physical activity, which may mitigate health consequences, improve functional outcomes, and support long-term recovery (ASAM, 2020; NICE, 2019; Linke & Ussher, 2015).

3. Biological and Physiological Effects of Physical Activity

Physical activity exerts a wide range of biological and physiological effects that are particularly relevant in the context of substance use disorders (Pedersen & Saltin, 2015; Warburton et al., 2006). Regular exercise induces systemic adaptations that enhance cardiovascular, metabolic, and musculoskeletal health, while it also promotes neurobiological changes that may mitigate addictive behaviors (Greenwood et al., 2011).

3.1 Neurobiological Mechanisms

Exercise stimulates the release of key neurotransmitters, including dopamine, serotonin, and endorphins, which play central roles in reward pathways and mood regulation (Meeusen & De Meirleir, 1995; Greenwood et al., 2011). In individuals with substance use disorders, these neurochemical effects can partially compensate for the dysregulation of the brain's reward system caused by chronic substance use. Specifically, physical activity has been shown to increase dopamine availability in the mesolimbic pathway, and thereby to reduce cravings and promote positive reinforcement through natural rewards rather than drug-related stimuli (Linke & Ussher, 2015; Greenwood et al., 2011).

3.2 Stress Regulation

Chronic substance use is often associated with heightened stress responsiveness and dysregulation of the hypothalamic-pituitary-adrenal (HPA) axis (Sinha, 2024; Bruijnzeel et al., 2009). Physical activity modulates stress responses by reducing circulating cortisol levels, improving autonomic balance, and enhancing resilience to psychosocial stressors (Sothmann et al., 1996; Biddle & Asare, 2011). These effects contribute to a better emotional regulation and a reduced susceptibility to relapse during withdrawal or recovery phases (Gerber M, PühseU., 2009).

3.3 Cardiovascular and Metabolic Benefits

Exercise improves cardiovascular function by enhancing cardiac output, vascular elasticity, and endothelial function (Warburton et al., 2006; Pedersen & Saltin, 2015). Metabolically, it increases insulin sensitivity, reduces systemic inflammation, and supports energy balance, which are particularly important in individuals recovering from substance abuse who often present with metabolic and cardiovascular comorbidities (Zschucke et al., 2012; Pedersen & Saltin, 2015). By mitigating these physiological risks, physical activity contributes to the overall health restoration and functional recovery (Warburton et al., 2006).

3.4 Neuroplasticity and Cognitive Function

Physical activity promotes neuroplasticity through increased expression of brain-derived neurotrophic factor (BDNF) and other growth factors, which support neuronal survival, synaptic plasticity, and cognitive function (Erickson et al., 2011; Voss et al., 2013). Improved cognitive flexibility and executive function can enhance decision-making, impulse control, and adherence to treatment protocols, all of which are critical factors in the management of substance use disorders (Best et al., 2010).

3.5 Immunological Effects

Chronic substance use impairs immune function, increasing susceptibility to infections and delaying recovery (Agarwal et al., 2022). Exercise has immunomodulatory effects, including enhanced natural killer cell activity, improved antibody response, and reduced chronic inflammation (Nieman, 1997; Gleeson, 2007). These adaptations support general health and may facilitate the rehabilitation process in individuals with SUDs (Agarwal et al., 2022).

Physical activity, therefore, exerts multidimensional effects that address both the neurobiological dysregulation and the systemic health impairments associated with substance use disorders (Linke & Ussher, 2015; Pedersen & Saltin, 2015). These mechanisms provide a physiological rationale for integrating structured exercise programs into prevention and treatment strategies (Linke & Ussher, 2015).



4. Physical Activity and Addiction Management

Physical activity has emerged as a valuable adjunct in the management of substance use disorders that complements pharmacological and psychosocial interventions (Linke & Ussher, 2015). Evidence from both clinical and experimental studies suggests that a regular exercise can reduce substance cravings, alleviate withdrawal symptoms, and support long-term recovery (Zschucke et al., 2012; Linke & Ussher, 2015).

4.1 Reduction of Craving and Withdrawal Symptoms

Engagement in physical activity has been associated with decreased intensity and frequency of substance cravings (Linke & Ussher, 2015). The neurochemical effects of exercise, particularly the activation of dopaminergic and endorphin pathways, contribute to this reduction by providing alternative sources of reward and reinforcing positive behaviors (Sinha, 2011; Linke & Ussher, 2015). Additionally, exercise has been shown to alleviate withdrawal-related anxiety, irritability, and sleep disturbances, which are key factors in the relapse risk (Gerber M, PühseU., 2009).

4.2 Prevention of Relapse

Structured exercise programs have demonstrated efficacy in reducing relapse rates among individuals in rehabilitation programs (Zschucke et al., 2012; Ussher et al., 2004). A regular physical activity promotes behavioral activation, increases self-efficacy, and fosters the development of healthy routines, which together reduce vulnerability to triggers and high-risk situations (Linke & Ussher, 2015). Group-based exercise sessions can also provide social support and a sense of community, further reinforcing recovery efforts (Ussher et al., 2004).

4.3 Psychological and Emotional Benefits

Physical activity improves mood, reduces symptoms of depression and anxiety, and enhances the overall psychological well-being (Biddle & Asare, 2011; Zschucke et al., 2012). By addressing affective states that often contribute to substance use, exercise serves as a non-pharmacological tool for emotional regulation. Mind-body activities such as yoga, tai chi, and pilates may be particularly beneficial in reducing stress and promoting mindfulness, which can complement conventional therapy (Ussher et al., 2004).

4.4 Integration into Treatment Programs

Exercise interventions can be implemented in various formats that include aerobic training, resistance exercises, and mixed-modality programs (Pedersen & Saltin, 2015; Linke & Ussher, 2015). The choice of exercise type, intensity, frequency, and duration should be tailored to individual preferences, physical capacity, and treatment goals (Biddle & Asare, 2011). Importantly, adherence is maximized when activities are enjoyable, socially engaging, and supervised by trained professionals (Linke & Ussher, 2015).

4.5 Clinical Evidence

Several randomized controlled trials and observational studies have reported positive outcomes of exercise interventions in SUD populations (Zschucke et al., 2012; Ussher et al., 2004). Benefits include both reduced drug and alcohol consumption, improved physical health markers, enhanced psychological well-being, and increased retention in treatment programs (Linke & Ussher, 2015). Despite the variability in study design and sample characteristics, the cumulative evidence supports the inclusion of physical activity as a core component of comprehensive addiction management strategies (Zschucke et al., 2012; Linke & Ussher, 2015).

Physical activity, therefore, represents a practical, accessible, and cost-effective intervention that addresses both the physiological and psychological dimensions of substance use disorders (Linke & Ussher, 2015; Pedersen & Saltin, 2015). Its integration into rehabilitation programs has the potential to enhance treatment outcomes and support sustainable recovery (Linke & Ussher, 2015).

5. Types of Physical Activity and Practical Considerations

The effectiveness of physical activity in the management of substance use disorders depends not only on participation but also on the type, intensity, frequency, and duration of the exercise program (Pedersen & Saltin, 2015; Zschucke et al., 2012). Careful consideration of these parameters ensures safety, adherence, and optimal therapeutic benefit (Linke & Ussher, 2015).



5.1 Types of Physical Activity

1. **Aerobic Exercise:** Activities such as walking, running, cycling, or swimming improve cardiovascular fitness, metabolic health, and neurochemical balance (Pedersen & Saltin, 2015; Zschucke et al., 2012). Aerobic exercise has been widely studied in individuals with substance use disorders and is associated with reductions in craving and improvements in mood and cognitive function (Linke & Ussher, 2015).
2. **Resistance Training:** Strength-based exercises, including weightlifting and bodyweight exercises, enhance muscular strength, endurance, and metabolic function (Pedersen & Saltin, 2015). Resistance training may also support mental well-being by promoting self-efficacy, body awareness, and a sense of accomplishment (Biddle & Asare, 2011).
3. **Mind-Body Activities:** Practices such as yoga, tai chi, and Pilates combine physical movement with mindfulness and breath control. These modalities are particularly effective in reducing stress, improving emotional regulation, and enhancing self-control (Ussher et al., 2004; Biddle & Asare, 2011), which are critical components in preventing relapse.
4. **Mixed-Modal Programs:** Combining aerobic, resistance, and mind-body exercises can provide comprehensive benefits, targeting multiple physiological and psychological domains simultaneously (Zschucke et al., 2012). Such programs are adaptable and can be personalized according to individual preferences and treatment goals (Linke & Ussher, 2015).

5.2 Exercise Prescription Parameters

- **Intensity:** Moderate-intensity exercise (e.g., 50–70% of maximum heart rate) is generally safe and effective, although higher-intensity exercise may be used when appropriate and supervised (Pedersen & Saltin, 2015; Warburton et al., 2006).
- **Frequency:** Most studies recommend 3–5 sessions per week to achieve meaningful physiological and psychological effects (Ussher et al., 2004).
- **Duration:** Sessions of 30–60 minutes are commonly used, with flexibility depending on the individual's physical condition and tolerance (Pedersen & Saltin, 2015).



- **Progression:** Gradual increases in intensity or duration help prevent injury and enhance adherence.

5.3 Safety Considerations

Prior to initiating an exercise program, individuals should undergo a medical and functional assessment, particularly if they have comorbid conditions (ACSM, 2018; Pedersen & Saltin, 2015). Exercise interventions should be supervised by trained professionals, with attention to contraindications, monitoring of vital signs, and adaptation to physical limitations (Zschucke et al., 2012). Special consideration should be given to withdrawal symptoms, fatigue, and nutritional status (Pedersen & Saltin, 2015).

5.4 Enhancing Adherence

Adherence is a critical determinant of the effectiveness of physical activity interventions (Linke & Ussher, 2015). Strategies to improve adherence include tailoring activities to personal preferences (Biddle & Asare, 2011), incorporating social support and group-based sessions (Ussher et al., 2004), setting realistic goals and providing feedback (Linke & Ussher, 2015), and ensuring enjoyable and varied exercise routines (Biddle & Asare, 2011).

5.5 Practical Implementation

Integration of physical activity into rehabilitation programs can occur in inpatient, outpatient, or community settings (Zschucke et al., 2012). Structured programs can be complemented by home-based exercises and lifestyle recommendations (Linke & Ussher, 2015). Collaborative efforts among healthcare providers, exercise professionals, and mental health specialists optimize outcomes and ensure holistic care (Pedersen & Saltin, 2015). Physical activity interventions, when carefully planned and implemented, provide a safe, adaptable, and highly beneficial component of comprehensive treatment programs for individuals with substance use disorders (Linke & Ussher, 2015; Zschucke et al., 2012).

6. Limitations and Future Research Directions

While the benefits of physical activity in the prevention and management of substance use disorders are increasingly recognized, several limitations in the current body of research must be acknowledged. First, the majority of studies are heterogeneous in terms of study design, sample size, population characteristics,



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and exercise modalities. This variability limits the generalizability of findings and complicates the establishment of standardized exercise prescriptions.

6.1 Scarcity of Long-Term Studies

Second, there is a scarcity of long-term studies evaluating the sustainability of physical activity interventions and their impact on relapse prevention over extended periods. Most available research focuses on short-term outcomes, leaving questions about durability of effects and optimal program duration unanswered. Additionally, studies often rely on self-reported measures of physical activity, which may introduce bias and affect the accuracy of results (Pedersen & Saltin, 2015).

6.2 Limited Mechanistic Understanding

Third, mechanistic studies exploring the neurobiological and physiological pathways through which exercise influences substance use behaviors remain limited (Sinha, 2011; Zschucke et al., 2012). While evidence suggests modulation of neurotransmitters, stress response, and neuroplasticity, the precise interactions and dose-response relationships are not fully understood. Further research is required to elucidate these mechanisms and to identify potential biomarkers of responsiveness to exercise interventions (Linke & Ussher, 2015).

6.3 Practical Challenges in Implementation

Finally, practical challenges in implementing exercise programs, such as participant adherence, comorbidities, and accessibility of facilities, can limit the effectiveness of interventions in real-world settings (Linke & Ussher, 2015; Pedersen & Saltin, 2015). Tailoring programs to individual capabilities, preferences, and environmental constraints is essential, but guidance on best practices remains limited (Zschucke et al., 2012).

6.4 Future Research Directions

Future research directions should focus on:

- Conducting large-scale, randomized controlled trials with standardized protocols.
- Investigating the long-term effects of different types, intensities, and frequencies of exercise.



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- Exploring neurobiological, physiological, and psychosocial mechanisms underlying exercise benefits.
- Developing strategies to improve adherence and accessibility in diverse populations.
- Integrating physical activity with existing pharmacological and psychosocial interventions to evaluate synergistic effects.

Addressing these gaps will enhance the evidence base, support the development of evidence-based guidelines, and facilitate the integration of physical activity as a core component of comprehensive care for individuals with substance use disorders.

Conclusion

Physical activity represents a promising, non-pharmacological strategy in the prevention and management of substance use disorders. Its multifaceted benefits encompass neurobiological, physiological, and psychological domains, including modulation of reward pathways, stress reduction, improved cardiovascular and metabolic health, enhanced cognitive function, and emotional well-being. Evidence from clinical and experimental studies supports the integration of structured exercise programs into rehabilitation protocols, highlighting reductions in cravings, withdrawal symptoms, and relapse rates, as well as improvements in quality of life.

Despite the growing body of research, further studies are required to establish standardized exercise prescriptions, elucidate underlying mechanisms, and evaluate long-term outcomes. Addressing these gaps will strengthen the scientific foundation for physical activity interventions and optimize their implementation in diverse populations affected by substance use disorders.

Incorporating physical activity into comprehensive treatment programs offers a safe, accessible, and cost-effective approach that complements existing pharmacological and psychosocial interventions. By promoting both physical and mental health, exercise serves as a valuable tool in supporting sustainable recovery and enhancing overall well-being in individuals with substance use disorders.



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