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Sweating for Sobriety: Exploring the Relationship Between Exercise Engagement and Substance Use Disorders

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ABSTRACT

Despite various interventions available for substance use disorders, relapse rates remain substantial and, therefore, alternative strategies for attenuating dependence are needed. This study examined the associations between exercise frequency, illicit substance use, and dependence severity among a large sample of people who use drugs. The study utilized data from the Global Drug Survey 2018 ($N = 57{,}110$) to investigate the relationship between exercise frequency, illicit substance use, and substance dependence severity. Binomial regressions were employed to examine the relationship between exercise and SDS scores for 9 drugs. Greater exercise frequency correlated with reduced severity of substance dependence for specific drugs: cannabis ($\chi2 = 14.75$, $p < .001$), MDMA ($\chi2 = 4.73$, $p = .029$), cocaine ($\chi2 = 8.37$, $p = .015$), amphetamine powder ($\chi2 = 6.39$, $p = .041$), and methamphetamine ($\chi2 = 15.17$, $p < .001$). These findings suggest a potential link between exercise and reduced substance use dependency. Further research is needed to understand the complex dynamics between exercise and substance use, considering potential bidirectional relationships and concurrent factors.

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Introduction

Substance use disorders (SUDs) pose a substantial public health burden (Castelpietra et al. 2022), with high relapse rates post-treatment (Brandon, Vidrine, and Litvin 2007). Emerging as a supplementary approach for SUD treatment, exercise garners interest due to its potential to prevent relapse (Marlatt and Donovan 2005). Despite lower adherence to physical activity guidelines among illicit substance users (Linke and Ussher 2015; Smith and Lynch 2012), there is a growing inclination toward regular exercise (Furzer et al. 2021; Ramadas et al. 2021). Various facets of physical fitness, including cardiorespiratory fitness and muscular strength, influence overall health (Garber et al. 2011; Teixeira et al. 2012) and may mitigate mental and physical health issues (Sujkowski et al. 2022). The theoretical grounding for this relationship posits that exercise impacts similar brain receptors as psychoactive drugs, potentially leading to a reduction in the severity of dependence on substances by providing an alternative means of influencing those receptors (Lynch et al. 2013).

While there are different types of SUDs corresponding to specific substances, such as alcohol, cannabis, opioids, and others, there are shared underlying mechanisms in addiction that cut across all substances (Volkow et al. 2009). Sherman (2017) suggests that a typical process in the brain involves the release, reuptake and reentry of neurotransmitters, which helps maintain their levels in the synaptic space. Similarly, a substantial body of evidence has shown that exercise has an impact on brain receptors that are also affected by psychoactive drugs (Basso and Suzuki 2017; Heijnen et al. 2016; Lynch et al. 2013; Saanijoki et al. 2018). Research has demonstrated that physical exercise triggers the release of endogenous opioids (endorphins) in the frontolimbic brain regions,

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which is associated with the perceived euphoria often experienced by runners (Boecker et al. 2008; Desai et al. 2022). Exercise such as cycling (Sparling et al., 2003) and running (Raichlen et al. 2012) significantly increase the release of endocannabinoids. As a result of these interactions, other studies have suggested that exercise may prevent dependency formation (Buchowski et al. 2011; Roessler 2010; Vidot et al. 2019; Zhu et al. 2018). Specifically, engaging in regular exercise may act as a protective factor against the development of substance use dependency and, consequently, a lack of physical activity might elevate the vulnerability to engage in illicit substance use, potentially contributing to an increased risk of disorders (Buchowski et al. 2011; Roessler 2010; Vidot et al. 2019; Zhu et al. 2018).

Exercise, which falls under the umbrella of physical activity, comprises structured actions aimed at improving or sustaining physical fitness (Wasfy and Baggish 2016). It is often grouped into aerobic/endurance (e.g., running, walking) and resistance (e.g., weight lifting) activities, although various sports combine these physiological aspects (Wasfy and Baggish 2016). Each facet of physical fitness, encompassing elements such as cardiorespiratory fitness, muscular strength and endurance (muscular fitness), body composition, flexibility, and neuromotor fitness, has the potential to impact various facets of health (Garber et al. 2011; Teixeira et al. 2012). As a result, exercise offers a range of benefits to both the mind and body, serving as a protective factor against illnesses (Sujkowski et al. 2022). This pattern of protection often extends to other health behaviors, with individuals who engage in exercise also tending to adopt habits and abstaining from substance use (Leasure et al. 2015). Most recently, engaging in enjoyable and structured exercise has been associated with improved health indicators and reduced likelihood of relapse among individuals undergoing SUD treatment (Furzer et al. 2021). Drawing these findings together, we underscore the potential significance of incorporating enjoyable exercise as a crucial component in effectively meeting illicit substance use dependency. Engaging in exercise can serve as a protective factor against craving and relapse by exposing individuals to novel environments, thus reducing exposure to cues associated with substance use (Ehrman et al. 1992; Ramadas et al. 2021). Participation in meaningful and structured activities, including exercise, is a crucial element in overcoming SUDs, as it offers opportunities for establishing new routines, fostering social connections, and facilitating identity transformation (Piatkowski et al. 2020; Ramadas et al. 2021). Notably, research findings indicate that individuals who undertake exercise (possibly as a coping mechanism) are less inclined to resort to alcohol consumption for dealing with negative emotions (Weinstock et al. 2017).

Therefore, this study examined the associations among exercise frequency, illicit substance use, and severity of dependence in a sample of people who use drugs from the Global Drug Survey (GDS). We hypothesized, firstly, that individuals who report engaging in a higher frequency of exercise would attain lower scores on the Severity of Dependence Scale (SDS) for nine illicit substances (cannabis, MDMA, cocaine, amphetamine (powder and paste), methamphetamine, ketamine, GHB and mephedrone). Secondly, we proposed that this relationship would remain significant for those participants who exclusively used a single illicit substance in the last 12 months out of the nine substances for which SDS scores were obtained. This proposition is rooted in the idea that the distinct effects of exercise on substance use dependency might be more pronounced and discernible among those who have engaged in a singular pattern of substance use. As a result, SDS for a single drug provides a more accurate comparison of SDS scores across different drugs within the specific one-drug group, as SDS scores for multiple drugs may influence each other's interpretations.

Methods

Participants

This study used data from the (Global Drug Survey 2018). The GDS is an annual online anonymous drug survey that has been conducted since 2011 (Winstock et al. 2022) Details about the GDS's methodology, including survey design, recruitment and representativeness have been previously described (Barratt et al. 2017; Winstock et al. 2022). Participants are eligible to complete the GDS if they are at least 16 years old and have used at least one drug (including alcohol) in the past 12 months. GDS2018 was open for completion between November 6, 2017, and January 10, 2018, and was completed by 130,761 participants from 206 countries. The survey was translated into 18 languages; English, German, Serbian, Czech, Georgian, Azerbaijani, Hebrew, Polish, French, Italian, Spanish (South American Spanish), Portuguese, Flemish, Hungarian, Turkish, Finnish and Danish). For this study, the analysis was restricted to participants who provided responses to at least one of the nine drug categories included in the survey (see below), who answered all five SDS questions for the particular drug and provided a valid response with respects to their age, gender and exercise frequency ($N = 57{,}110$). Additionally, we partitioned this sample into two distinct groups. The first group comprises individuals who indicated use of only one of the nine substances in the last 12 months, which forms the primary focus of our analytical models. The second group includes participants who indicated use of one of the nine substances and at least one additional substance (of the nine). Approval for this study was granted by the University College London Research Ethics Committee (11671/001) and ratified by The University of Queensland (No: 2017001452) and the University of New South Wales (HREC HC17769) ethics committees.

Measures

Substance

The substances included in this study are cannabis, MDMA, cocaine, amphetamine (powder and paste), ketamine, methamphetamine, GHB and mephedrone. These were the substances in the GDS2018 survey with associated questions for the Severity of Dependence Scale (SDS).

Severity of dependence scale (SDS)

The SDS is a brief five-item scale that has been shown to effectively measure dependency across various drug types (Gossop et al. 1995), demonstrating good test-retest reliability (0.89; Gossop et al. 1997). The scale comprised five questions:

(1) Did you ever think your use of [named drug] was out of control?
(2) Did the prospect of not using [named drug] make you very anxious or worried?
(3) Did you ever worry about your use of [named drug]?
(4) Did you ever wish you could stop using [named drug]?
(5) How difficult would you find it to stop or go without [named drug]?

The questions were slightly modified such that stigmatizing language originally used in question 2 "missing a fix (or dose) or not chasing" was changed to "not using." Each question is rated on a 4-point scale. For questions 1, 2 and 3 the scoring and wording are 0 "Never or almost never," 1 "Sometimes," 2 "Often" 3 "Always or nearly always." For question 3, response options are 0 "Not at all," 1 "A little," 2 "Quite a lot," 3 "A great deal." For question 5, response options include 0 "Not difficult," 1 "Quite difficult," 2 "Very difficult," 3 "Impossible." The higher the score, the higher the level of dependency, ranging from 0–15 (Gossop et al. 1995).

Exercise frequency

Participants were asked: "How often in the last year did you exercise (i.e., play sport, run, gym, yoga, etc.)?" Seven response options were provided: Never, less than once every 3 months, once a month, once every fortnight, once or twice a week, 3 to 4 times a week, or more than 4 times a week. These responses were reclassified into three categories, in order to simplify the interpretation and conform broadly with previous research (Vina et al. 2012) and physical activity recommendations (Wasfy and Baggish 2016).

Participants who indicated never exercising, exercising less frequently than once every 3 months, or on a monthly basis were coded as "None or low." Those reporting exercising either once a fortnight or once or twice a week were coded as "moderate, and those exercising 3–4 times per week or more were coded ("High.."

Data analysis

The analysis employed negative binomial regression to investigate the association between exercise and SDS scores within each drug category; analysis was stratified across the two sample subsets. To compare differences in exercise frequency and SDS scores for each particular drug across the two groups a third model was undertaken including an interaction term between exercise frequency and sample subset (0 for 2 or more drugs; 1 for one drug only). This approach tested whether the pattern of exercise frequency on SDS scores differs by drug relative to respondents reporting using the drug exclusively or using the drug in the presence of other drugs (where we have asked the SDS items).' For each drug category, the typical $\alpha = 0.05$ has been applied to test for significance.

Results

The study sample comprises 57,110 participants who indicated using at least one of the nine drugs in the last year and answered the corresponding SDS questions. The majority of respondents identified as men/male (70.5%), followed by women/female (28.4%); approximately 1.1% identified as non-binary or a different identity. The sample's mean age was 25.3 years ($SD = 8.8$), ranging from 16 to 85 years (median 23; interquartile range 19–29). Among the entire sample, exercise frequency over the last 12

Table 1. Demographic characteristics and exercise frequency distribution ($N = 57{,}110$).

Categories	Whole sample (57,110) *n*	%	Only one drug (31,862) *n*	%
Exercise frequency (last 12 months)				
Low (or none)	19,088	33.4	10,006	31.4
Moderate	24,936	43.7	14,087	44.2
High	13,086	22.9	7,769	24.4
Gender				
Male	40,214	70.5	22,445	70.4
Female	16,240	28.4	9,075	28.5
Non-binary	411	0.7	205	0.7
Different identity	245	0.4	137	0.4
Age groups				
16–24	33,915	59.4	18,838	59.1
25–34	15,964	28.0	8,212	25.8
35–44	4,657	8.1	2,885	9.0
45–54	1,725	3.0	1,208	3.8
55–85	849	1.5	719	2.3
Education				
No formal schooling	254	0.6	161	0.7
Primary school	1,182	2.9	658	3.0
Lower secondary school	5,612	13.7	3,460	15.7
Technical or trade certificate	3,737	9.2	2,033	9.2
Higher secondary school/HSC/VCE/ Leaving Certificate	8,785	21.5	4,556	20.6
College certificate/diploma	9,285	22.7	4,997	22.6
Undergraduate degree	9,134	22.4	4,698	21.3
Postgraduate degree	2,437	6.0	1,320	6.0
Don't know	391	1.0	196	0.9
Missing	[16,293]		[9,783]	
Employment status				
Yes (full time)	15,146	38.0	7,973	37.0
Yes (part time <35 hours a week)	8,117	20.4	4,101	19.0
No (non-working students)	12,571	31.6	7,290	33.9
No (looking for work)	2,638	6.6	1,282	6.0
No (retired)	287	0.7	242	1.1
No (undertaking home duties)	474	1.2	284	1.3
No (permanently ill or unable to work)	608	1.5	372	1.7
Missing	[17,269]		[10,318]	

months varied, with 33.4% indicating low or no exercise, 43.7% reporting moderate exercise, and 22.9% engaging in high exercise frequency (see Table 1).

Table 1 presents socio-demographic characteristics for the sample of respondents who provided SDS information to only one of the nine drugs listed. This subsample (see "Only one drug" in Table 1) consisted primarily of respondents who reported moderate to high frequency of exercise in the past 12 months (68.6%), identified as male (70.4%) with a mean age 25.7 years ($SD = 9.8$), ranging from 16 to 85 years. Almost 60% of the sample were aged 16–24 years; 6.1% were 45 years of age or older. When considering only those respondents who reported using a single illicit substance ($n = 31{,}862$), the distribution was similar, with 31.4% indicating low exercise, 44.2% reporting moderate exercise, and 24.4% engaging in high exercise frequency.

Drug use and SDS scores

Stratified by the two subsamples, Table 2 presents the prevalence of drug use for each of the nine drugs and a summary of the SDS score and SDS classification categories (mild, moderate and severe) associated with that drug. In the full sample, cannabis was used by 91.1% of respondents in the past year, while mephedrone had the lowest usage at 1.5%. SDS scores showed that for most drugs, the majority of respondents had no to mild dependence (upper-quartile SDS score ≤ 3), but 19.1% to 3.2% were moderate to severe. In the subgroup reporting only one drug, cannabis (91.3%), MDMA (4.0%), and cocaine (3.3%) were most commonly used. Stimulant drugs had higher rates of moderate to severe SDS (cocaine 12.4%, amphetamine powder 13.8%, amphetamine paste 24.1%, methamphetamine 32.8%). GHB (32.3%) and mephedrone (25.0%) also showed elevated rates.

Table 2. SDS scores and classification distribution for different substances.

		SDS Score	SDS Classification: N(%)		
	N (%)	Median (IQR)	Mild	Moderate	Severe
Whole sample (57,110*)					
Cannabis	52,025 (91.1)	1 (0–3)	44,812 (86.1)	6,333 (12.2)	880 (1.7)
MDMA	20,442 (35.8)	0 (0–1)	19,556 (95.7)	810 (4.0)	76 (0.3)
Cocaine	14,418 (25.2)	0 (0–2)	13,071 (90.7)	1,099 (7.6)	248 (1.7)
Amphetamine (powder)	8,929 (15.6)	0 (0–2)	8,059 (90.3)	753 (8.4)	117 (1.3)
Ketamine	4,635 (8.1)	0 (0–0)	4,486 (96.8)	128 (2.8)	21 (0.4)
Methamphetamine	1,770 (3.1)	0 (0–3)	1,432 (80.9)	250 (14.1)	88 (5.0)
Amphetamine (paste)	1,371 (2.4)	1 (0–3)	1,158 (84.5)	173 (12.6)	40 (2.9)
GHB	950 (1.7)	0 (0–1)	883 (93.0)	48 (5.0)	19 (2.0)
Mephedrone	867 (1.5)	0 (0–3)	732 (84.4)	120 (13.8)	15 (1.7)
Only one drug (31,862)					
Cannabis	29,086 (91.3)	1 (0–3)	25,714 (88.4)	2,952 (10.2)	420 (1.4)
MDMA	1,263 (4.0)	0 (0–1)	1,217 (96.4)	42 (3.3)	4 (0.3)
Cocaine	1,054 (3.3)	1 (0–3)	923 (87.6)	101 (9.6)	30 (2.8)
Amphetamine (powder)	283 (0.9)	0 (0–3)	244 (86.2)	32 (11.3)	7 (2.5)
Ketamine	62 (0.2)	0 (0–1)	60 (96.8)	1 (1.6)	1 (1.6)
Methamphetamine	64 (0.2)	3 (1–5)	43 (67.2)	19 (29.7)	2 (3.1)
Amphetamine (paste)	29 (0.1)	3 (0–4)	22 (75.9)	7 (24.1)	-
GHB	9 (0.03)	1 (0–8)	6 (66.7)	2 (22.2)	1 (11.1)
Mephedrone	12 (0.04)	3 (.5–4.5)	9 (75.0)	2 (16.7)	1 (8.3)

*The reported N exceeds 57,110 as respondents provided SDS responses for one or more drugs.

Table 3. Incident rate ratios (IRRs) and 95% confidence intervals (CI) for exercise categories.

	Providing SDS for the one drug and at least one other				Providing SDS for the one drug				Interaction
	N	Moderate	High	Wald test $\chi^2_{(2)}$; p-value	N	Moderate	High	Wald test $\chi^2_{(2)}$; p-value	Wald test $\chi^2_{(2)}$; p-value
Cannabis	22,939	0.850 (0.818–0.883)	0.734 (0.699–0.769)	171.63; <.001	29,086	0.781 (0.751–0.812)	0.739 (0.707–0.774)	216.19; <.001	12.37; .021
MDMA	19,179	0.946 (0.892–1.002)	0.917 (0.855–0.985)	6.55; .038	1,263	0.705 (0.567–0.875)	0.899 (0.707–1.145)	1.48; .005	7.03; .030
Cocaine	13,364	0.845 (0.780–0.915)	0.883 (0.802–0.973)	17.77; <.001	1,054	0.661 (0.536–0.815)	0.717 (0.562–0.913)	16.50; <.001	3.24; .198
Amphetamine (powder)	8,646	0.833 (0.763–0.910)	0.761 (0.680–0.851)	28.06; <.001	283	0.503 (0.323–0.783)	0.920 (0.559–1.514)	1.26; .006	6.51; .039
Ketamine	4,573	0.912 (0.771–1.079)	0.926 (0.751–1.143)	1.24; .537	62	0.150 (0.043–0.518)	0.395 (0.122–1.273)	9.51; .009	4.97; .083
Methamphetamine	1,706	0.772 (0.634–0.939)	0.821 (0.651–1.036)	7.21; .027	64	0.832 (0.522–1.327)	0.430 (0.205–0.903)	4.99; .082	1.10; .577
Amphetamine (paste)	1,342	0.766 (0.630–0.931)	0.742 (0.574–0.958)	9.30; .010	29	0.889 (0.410–1.926)	0.333 (0.056–2.002)	1.46; .481	.48; .787
GHB	941	0.877 (0.590–1.303)	1.121 (0.719–1.747)	1.21; .545	9	-	-	-	-
Mephedrone	855	0.829 (0.637–1.081)	1.058 (0.770–1.453)	3.01; .222	12	0.381 (0.075–1.926)	1.333 (0.331–5.369)	1.99; .370	.57; .753

***Formula 1**.
Log is the natural logarithm.
E[Y|X1, X2] is the expected count of Y given X1 andX2.
β0 is the intercept.
β1 represents the difference in the log count of Y for moderate compared to low exercise frequency.
β2 represents the difference in the log count of Y for level 2 of X1 compared to level 3.
β3 represents the difference in the log count of Y for level 1 of X2 compared to level 2 (reference category) when X1 is at its reference category.
β4 and β5 represent the interaction effects.

Exercise and SDS scores

Table 3 and Figure 1 presents results from the negative binomial regression model for each drug with the single independent categorical variable of exercise frequency. The analyses were stratified for the two samples: respondents who provided SDS responses for the listed drug and at least one other drug (first column series) and respondents who provided SDS responses for where

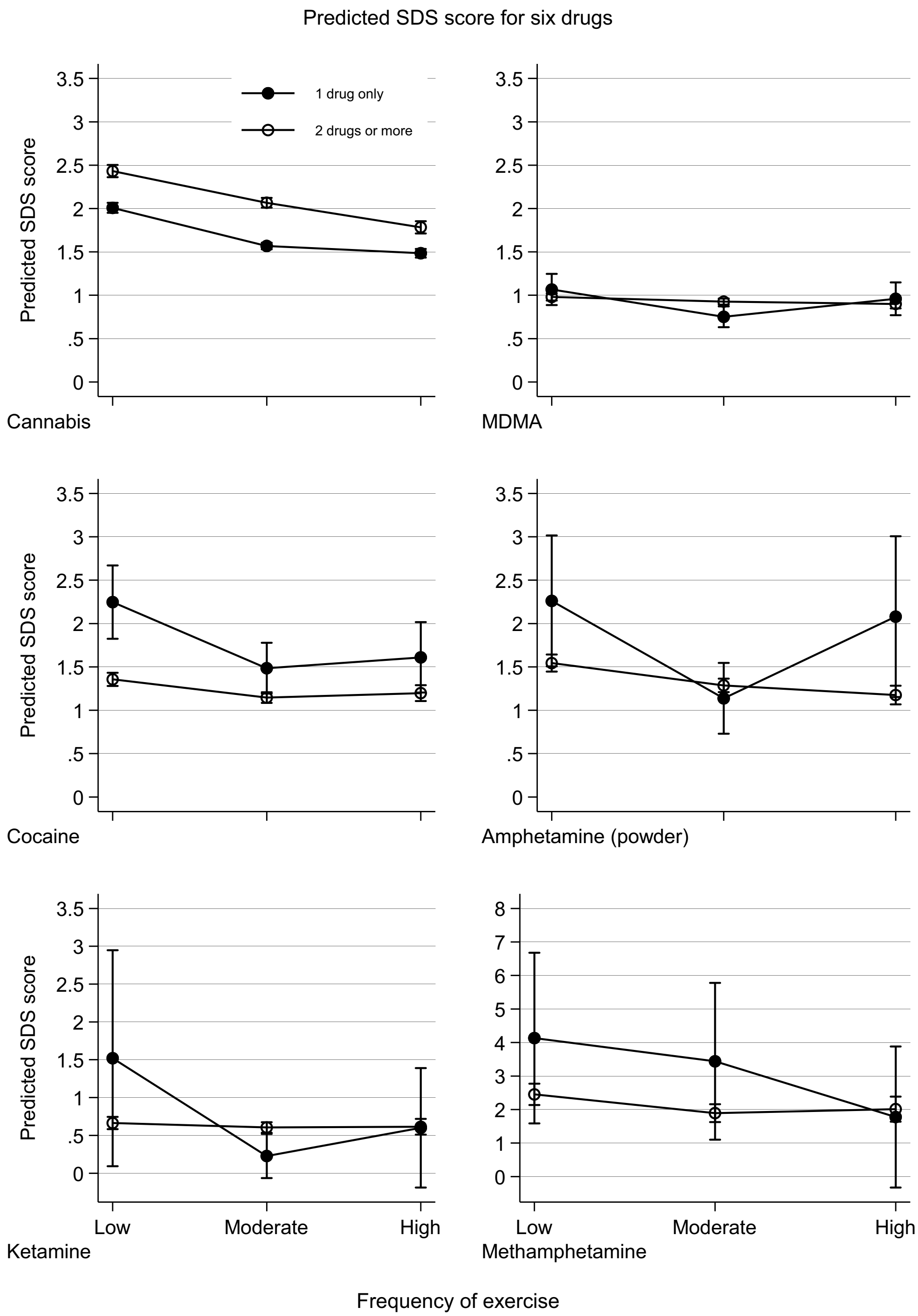

Figure 1. Predicted SDS scores by frequency of exercise for the whole sample (reporting SDS for 2 drugs or more) and the subsample (reporting SDS only for the one drug used). Note: results for Amphetamine (paste), GHB and mephedrone are not reported due to low numbers in the subsample.

they had only consumed the one listed drug in the past 12 months. The reference category is low exercise. To produce the results in Figure 1 and compare the overall effect of exercise on SDS responses the two groups of data were combined and an interaction term between exercise and group was generated (see Formula 1). Column 3 in Table 3 presents the χ^2 Wald test for the interaction effect of the exercise frequency and group.

$$Log(E[Y|X1, X2]) = \beta_0 + \beta_1 X_{(mod*)} + \beta_2 X_{(high)} + \beta_3 X_{(1drug)} + \beta_4 (D_{(mod*)} x D_{(1drug)} + \beta_5 \left(D_{(high)} x D_{(1drug)}\right) \quad (1)$$

Table 3, column 1, along with the hollow-circle lines in Figure 1, highlights the incident rate ratio (IRR; see Table 3) and the predicted SDS score (hollow-circle lines; Figure 1). A clear trend emerges for SDS scores when comparing one drug use to multiple drug use. For six of the nine drugs (cannabis, MDMA, cocaine, methamphetamine, amphetamine powder, and paste), exercise frequency significantly associates with lower SDS scores. Specifically, moderate to high exercise is linked to lower SDS scores. However, the impact varies; for example, with MDMA, moderate versus low exercise showed no significant difference (IRR 0.946; 95% CI 0.892–1.002). Conversely, for cocaine, high exercise correlated with higher SDS scores (IRR 1.216; 95% CI 1.069–1.382), and this difference was statistically significant. For ketamine, GHB, and mephedrone, exercise frequency did not significantly affect SDS scores.

In Table 3 and Figure 1's second column, IRR and predicted SDS scores demonstrate a consistent trend for individuals reporting single-drug use. Notably, exercise frequency significantly influences SDS scores for five of eight drugs (see Wald test, column 1). More exercise, particularly transitioning from low to moderate or moderate to high, consistently relates to lower SDS scores. This trend holds for cannabis and methamphetamine, with cannabis being statistically significant ($p < .001$). Similarly, respondents with moderate exercise frequency versus low exhibit decreased SDS scores for MDMA, cocaine, amphetamine (paste and powder), and ketamine. However, high exercise frequency is linked to higher SDS scores for these drugs, with statistical significance for MDMA, cocaine, amphetamine (paste and powder), and ketamine. For mephedrone, with no overall association between exercise frequency and SDS scores, further exploration was unwarranted.

The final column of Table 3 presents a Wald test comparing exercise frequency and SDS scores between two groups, indicating differences in SDS score patterns across exercise levels (Figure 1). Significant differences were found for cannabis, MDMA, and amphetamine (powder). For cannabis users, SDS scores were consistently higher across all exercise levels when compared to those using cannabis and at least one other drug, suggesting lower SDS scores for respondents exclusively using cannabis. MDMA ($p = .030$) and amphetamine (powder; $p = .039$) showed marginally significant overall Wald test results. Figure 1 illustrates less distinct differences in SDS scores across exercise frequency for MDMA users. No significant difference in SDS scores was observed for those solely using MDMA compared to those using both MDMA and another drug. A difference was observed for amphetamine (powder), with significantly larger predicted SDS scores for low and high exercise frequency users compared to those exclusively using amphetamine (powder) or using it with another drug.

Discussion

This study examined the associations among exercise frequency, substance use, and substance use severity in a large cohort of Global Drug Survey respondents. While the upper-quartile SDS scores for all nine drugs indicated no to mild substance use severity for most participants, the percentage classified as moderately or severely dependent ranged from 19.1% for methamphetamine to 3.2% for ketamine. Participants who reported exclusively using a single drug exhibited higher interquartile SDS score ranges for most substances, highlighting potentially divergent substance use patterns in this subgroup.

The hypotheses underpinning this study were twofold: firstly, we postulated that individuals engaging in more frequent exercise would yield lower SDS scores across the gamut of illicit substances; secondly, we anticipated that this association would persist even when examining participants who solely used one illicit substance from the nine considered. The hypotheses of this study were partially supported by the findings. Stratifying by respondents' use of multiple drugs versus those using only one, results demonstrated a significant inverse relationship between exercise frequency and SDS scores for five of the eight drugs studied among those who reported using a single drug in the past year. Notably, participants reporting moderate to high exercise frequency consistently exhibited lower SDS scores. This effect was statistically significant for cannabis, somewhat supporting the theoretical premise that the coactivation of shared receptors through exercise and endocannabinoid release could potentially reduce substance use severity (Lynch et al. 2013; Raichlen et al. 2012). In contrast, respondents using substances like MDMA, cocaine, amphetamine (paste and powder), and ketamine displayed differential dynamics: moderate exercise frequency corresponded to lower SDS scores but transitioning to high exercise frequency yielded higher SDS scores, with significance attained for MDMA and cocaine. Given that exercise may help reduce the use of cannabis and stimulants particularly (Buchowski et al. 2011; Vidot et al. 2019; Zhu et al. 2018) the current data partially fit with extant work.

Although prior research has consistently highlighted the positive impact of exercise on various substance use disorders (Barton and Pretty 2010; Daley 2008; Furzer et al. 2021; Pretty et al. 2007; Ramadas et al. 2021; Wegner et al. 2014), the results from this study provide more intricate and considered understanding. Specifically, the results for individuals using multiple drugs demonstrated more nuanced relationships than those from single drug participants. More specifically, exercise frequency showed a significant association with lower SDS scores for cannabis, MDMA, and amphetamine (powder). For MDMA, the difference in SDS scores was not significant when comparing moderate to low exercise frequency. Additionally, different patterns were evident in the dynamics between exercise frequency and SDS scores for different drugs. Notably, people reporting cannabis use reported consistently higher SDS scores across exercise frequency categories when used in conjunction with other drugs, hinting at potential synergistic effects. These findings suggest that exercise frequency may exert varying impacts on different substances in relation to disorder development and warrant further investigation.

Limitations

Given the cross-sectional nature of the study, causal inferences regarding this relationship cannot be drawn. The reliance on self-reporting in the data collection introduces potential biases, as seen in varying levels of truthfulness across substances (Hunt et al. 2015). Nevertheless, non-probability sampling through anonymous online surveys, like the GDS, serves as a practical and effective method to collect data on stigmatized behaviors among hard-to-reach populations, such as illicit substance users (Barratt et al. 2017) although we acknowledge limitations arising from the absence of data from all regions, such as Asia. Further, we did not fully capture the precise stage of respondents' substance use disorder severity, which could have implications for the relationship between exercise and substance use. Specifically, individuals in different states of substance use severity may exhibit varied exercise behaviors and mental health outcomes (Juel et al. 2017). Our study did not measure exercise intensity, a variable known to impact the positive benefits of exercise (Chan et al. 2019). Last, the analysis did not treat respondents' country of residence as a nested variable to address potential country-level variations in exercise patterns, culture, and drug use. Future research could explore country-level effects on substance use disorders, considering exercise profiles.

Implications

Recent prevalence estimates suggest there are over 200 million individuals who report cannabis use in the last year (UNODC 2022) and people who use cannabis are at risk of experiencing harms from high levels of use (Connor et al. 2021; Peacock et al. 2018). Therefore, it is important to consider interventions which may mitigate these harms. Given that limited research has been conducted specifically on exercise among populations using cannabis (Buchowski et al. 2011) the present findings contribute to an important gap. Although some studies (Brellenthin and Koltyn 2016; Buchowski et al. 2011) have observed reductions in craving among cannabis consumers engaging in exercise, these findings have not been tested in clinical trials. The only randomized controlled trial conducted on exercise for cannabis use focused on high-intensity interval training and found reductions in cue-induced craving, suggesting that time rather than exercise itself played a role in craving reduction (Wilson et al. 2018). The findings of this study provide insights into the potential application of exercise messaging as a public health strategy for harm reduction and substance use management. Incorporating exercise as a component of harm reduction initiatives and substance use treatment could offer additional benefits for individuals using cannabis.

Research conducted in populations with methamphetamine use disorders have reported non-statistically significant reductions in methamphetamine use among those in exercise conditions compared to control conditions involving health education or contact control (Rawson et al. 2015) to which our current data also add further substantiation. However, findings suggest a dose-response effect of the exercise intervention, with greater session attendance associated with greater reductions in methamphetamine use (Rawson et al. 2015). Furthermore, individuals with lower severity of methamphetamine use at baseline tend to maintain higher levels of physical activity post-treatment (Rawson et al. 2015). In individuals with cocaine use disorder, preliminary evidence from a randomized controlled trial comparing running, walking, and sitting indicates that exercise may play a role in reducing cocaine use compared to a sedentary condition (De La Garza et al. 2016). Additionally, exercise has been associated with significant improvements in cardiorespiratory fitness and mental health outcomes in individuals using methamphetamine (Morris et al. 2018). The current data extend on this previous evidence, directing public health messaging to be, potentially, tailored to illuminate the specific benefits of exercise in managing methamphetamine and stimulant use. Doing so provides an opportunity to elevate awareness regarding exercise's role in harm reduction among individuals navigating the challenges of risky stimulant use.

Conclusions

This study furthers understanding regarding the relationships which may exist between exercise and substance use severity. Transitioning from minimal to regular exercise emerges as a potential means to mitigate the risk of substance use disorders, especially in the context of stimulant drugs and cannabis. However, while the findings suggest potential benefits of exercise in relation to reduced substance use, other factors that may better explain the observed relationships. Therefore, the role of exercise interventions in mitigating substance use disorders requires further investigation through prospective designs and randomized controlled trials.

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Data availability statement

Data available from corresponding author on request.

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