International Journal of EXERCISE SCIENCE

Original Research

Effects of Acute Exercise on Affect in Females with Substance Use Disorder

VICTORIA A. TOROK†1, CHRISTI B. BREWER‡1, and HAYLEY N. LAKE‡2

[1]Wellness and Movement Sciences, Eastern Washington University, Cheney, WA, USA;
[2]Addiction Studies, Eastern Washington University, Cheney, WA, USA

†Denotes graduate student author, ‡Denotes professional author

ABSTRACT

International Journal of Exercise Science 16(5): 95-108, 2023. Negative mood states experienced during the withdrawal stage of substance dependence have been associated with relapse in persons suffering from substance use disorder (SUD). Exercise is gaining attention as an adjunct therapy for SUD due to its ability to alleviate negative mood states experienced during withdrawal. The purpose of this study was to investigate the effects of acute, controlled bouts of aerobic and resistance exercise versus sedentary control (quiet reading) on positive affect (PA) and negative affect (NA) in females undergoing SUD treatment at inpatient facilities. Females (n=11; 34 $\pm$ 8 yrs) were randomly assigned to each condition in counterbalanced fashion. Aerobic exercise (AE) consisted of 20 minutes of steady-state moderate intensity (40-60% HRR) treadmill walking. Resistance exercise (RE) consisted of 20 minutes of standardized circuit weight training (1:1 work to rest ratio). The Positive and Negative Affect Scale (PANAS) was used to assess PA and NA pre- and post-interventions. Repeated measures ANOVAs indicated AE and RE significantly increased PA ($p < 0.05$) versus control, with no significant difference between AE and RE. Friedman's test revealed AE and RE significantly reduced NA ($p < 0.05$) versus control. Results indicate short bouts of aerobic and resistance exercise are equally effective for acute mood regulation and superior to a sedentary control in females undergoing inpatient SUD treatment.

KEY WORDS: Aerobic exercise, circuit training, positive affect, negative affect, polysubstance use

INTRODUCTION

Data from the Substance Abuse and Mental Health Services Administration (SAMHSA) indicate 20.4 million people aged >12 years in the U.S. had a substance use disorder (SUD) in 2019 (41). Polysubstance use (poly-SUD) has been reported to be prevalent among persons with SUD (24), with data indicating 2.4 million diagnoses for both alcohol use and illicit drug use disorders. Polysubstance use has been noted to be a predictor of poorer treatment outcomes (55) and a determinant of relapse risk perceptions among SUD patients (52). Recent research has called for increased attention on this patient population (14). Research dating back nearly four decades has consistently estimated the risk of relapse to be 50-90% within the first year of recovery (9,

11, 26). Given that relapse has been associated with withdrawal symptoms (6, 28, 35, 43, 56), many approaches to prevent relapse are aimed at reducing these symptoms. Withdrawal, in general, encompasses physical symptoms, urges/cravings, and negative affective states (4). While physical symptoms vary by addictive substance, there are similarities in the negative affective states induced by withdrawal. Strong associations between indices of withdrawal and affect have been reported (4).

Affect is typically conceptualized as a two-dimensional construct consisting of negative affect (NA) and positive affect (PA), and each dimension may be high or low. High NA indicates anger and irritability, while low NA indicates peace and calm. High PA indicates energy and enthusiasm, while low PA indicates fatigue and sadness. These constructs operate independently of one another, such that a decrease in one does not necessarily confer an increase in the other (54). Affective processes are regarded as central in the evolution of substance dependence (13). Once dependence develops, continued use or relapse occur due to the motivation to avoid negative affective states induced by withdrawal (4, 12, 13, 30). High NA has been reported to be the strongest predictor of relapse to a variety of substances (13, 33), including cigarettes (18, 22, 28, 43) and alcohol (56), and to lead to increased approach behaviors in response to cigarette and alcohol cues among patients in SUD detoxification programs (42). Low PA, experienced during withdrawal, motivates continued use in persons with SUD. Studies of approach and avoidance behaviors in response to alcohol and cigarette cues have shown high levels of PA during withdrawal result in greater avoidance behaviors and lower approach behaviors (42). Thus, interventions that can decrease NA and/or increase PA are useful in mitigating emotional aspects of withdrawal in SUD.

The positive effects of aerobic exercise on mood are well established in a range of populations, with improvements attained through both reductions in NA and elevations in PA (57). Within the SUD literature, single studies, comprehensive reviews, and meta-analyses have concluded that acute bouts of primarily aerobic activity of varying intensities and durations reduce NA in smokers during voluntary abstention (20, 38, 45, 49). Among persons with alcohol use disorder (AUD), studies have produced conflicting results. Studies lacking a control group have reported short bouts (10 minutes) of low- and moderate-intensity cycling did not improve mood in a sample of patients in hospital-based alcohol rehabilitation clinic (50); however, other research reported 12 minutes of moderate-to-vigorous intensity cycling did improve mood in a sample of non-treatment seeking adults with AUD (23). While there are sample differences between these aforementioned studies, it has also been suggested the effect of exercise on symptoms of withdrawal may vary by addictive substance (53). Most studies have examined the effects of aerobic exercise on mood in single substance SUD (single-SUD), primarily nicotine and alcohol, and have done so in samples comprised solely or primarily of males. Less is known about the effects of an acute bout of aerobic exercise on mood in females with poly-SUD and how it might compare to an acute equivalent-duration bout of resistance exercise.

In contrast to aerobic exercise, the affective response to resistance exercise is equivocal and believed to be influenced by a number of factors that may act both separately and synergistically.

In substance-dependent samples, an acute bout of dynamic, moderate intensity resistance exercise was not shown to reduce withdrawal symptoms in sedentary, college-aged male smokers (25); however, an acute 5-minute bout of isometric muscle actions was shown to reduce cigarette withdrawal symptoms in a community-based sample of adults (51), with participants in both studies undergoing a 24-hour period of voluntary abstention. To date, one study has examined the effect of a single bout of group circuit training on overall mood in a coed sample of poly-SUD patients across multiple inpatient treatment centers, reporting significant improvements in overall mood post-exercise (16). While there are training studies that have assessed the effects of resistance exercise on mood, these studies implemented resistance exercise either as part of a multi-component exercise intervention of a relatively long duration (60 minutes) (21, 39), in comparison to a control treatment which included supervised sport and game activities (47), confounding the interpretation of the effects of physical activity/exercise. To the authors' knowledge, there are no studies that have explored the effects of an isolated bout of resistance exercise on mood in females with poly-SUD and in comparison to an equivalent-duration bout of aerobic exercise.

While it is generally accepted that exercise is helpful in recovery, the majority of studies have investigated the effects of aerobic exercise in ameliorating symptoms of withdrawal from individual substances of abuse, namely nicotine or alcohol, and have been comprised of predominantly male samples. Several of these studies implemented group aerobic exercise interventions (2, 9, 10) or included recreational games as part of the exercise intervention (16, 17, 32), making it difficult to distinguish the effects of exercise from those of social interaction. The few studies to examine the acute effect of resistance exercise on mood on persons with SUD have reported conflicting findings and have been largely limited to persons with nicotine dependence (25, 48, 51). Training studies that have examined the influence of resistance exercise on emotional aspects of withdrawal have implemented the resistance exercise as part of a program that also included aerobic training (21, 39), making it difficult to discern if one mode of exercise is more effective for mood enhancement. There appear to be no randomized controlled trials comparing the effect of isolated bouts of aerobic and resistance exercise on mood in females with poly-SUD undergoing inpatient treatment. Given the role of negative mood states in spurring relapse and the known benefits of exercise on mood, the purpose of this study was to investigate the effects of acute equivalent-duration bouts of moderate intensity aerobic and resistance exercise versus sedentary control on positive affect and negative affect in females with poly-SUD undergoing inpatient treatment.

METHODS

Participants

Participants were verbally recruited from two local female-only inpatient SUD treatment facilities. An a priori power calculation was not performed due to the limited research reporting effect size values for the measures used in this study. A combination of a limited number of female-only inpatient treatment centers locally and low responsiveness from the existing pool worked to limit the sample size. In addition to the required residency at the treatment facility,

other inclusion criteria consisted of being between the ages of 18-55 years, being enrolled in treatment for at least four weeks during the anticipated study timeline, and being cleared to perform moderate intensity aerobic and resistance exercise. Exclusion criteria consisted of current pregnancy, current postpartum depression, use of HR-altering prescription medications, and/or responses on the Physical Activity Readiness Questionnaire (PAR-Q+) that would preclude safe participation in moderate intensity exercise. Abstinence was checked both randomly and at regularly scheduled times by the treatment center; however, it was not checked specifically as part of this study. The study was approved by the university's Institutional Review Board, and all participants provided written informed consent in accordance with the Declaration of Helsinki. This multi-center randomized controlled trial was carried out fully in accordance to the ethical standards of the International Journal of Exercise Science (36).

Protocol

In addition to the PAR-Q+, participants also completed a Health History Questionnaire in which they self-reported any previous or current diagnosis of mental health conditions (e.g., depression, anxiety, bipolar disorder), substance use history, prior treatment history, current time in treatment facility, and current physical activity habits. Participants completed a familiarization session during which height (m), body mass (kg), and resting heart rate were measured by way of palpation. At this time, exercise technique was demonstrated and practiced; and a schedule for the three experimental conditions was determined, allowing for a minimum of one week between conditions. Interventions were scheduled during each participant's designated free time to avoid interference with any other elements of their inpatient treatment regimen. In this within-subject design, participants were randomized to aerobic exercise (AE), resistance exercise (RE), and control (C) conditions. Randomization was attained by having participants draw from a random assortment of papers upon arrival for testing. This was done for the first and second interventions, while the third intervention was the only remaining intervention by default. AE began with a 5-minute low intensity (<40% HRR, heart rate reserve) general aerobic warm-up performed on a motorized treadmill (pending treatment center, Weslo Cadence DX12 or Matrix T7xe). After this, treadmill speed or incline were increased until the participant reached moderate intensity. Moderate intensity was calculated using the HRR method using an estimate of maximal HR based on age (220-age) and defined as 40-60% HRR. Participants were informed that rest was permitted but to do their best to complete the 20 minutes continuously. Heart rate was monitored continuously (Polar Electro FT1, Kempele, Finland) to ensure it remained within the moderate intensity range. This was followed by a 5-minute active cool-down on the treadmill. RE began with a 5-minute general aerobic warm up performed on a motorized treadmill. This was followed by a 20-minute circuit training program consisting of eight bodyweight exercises. The exercises included squats, sumo squats, standard push-ups, wide push-ups, gluteal bridges, back extensions, planks, and wall sits. All participants were able to modify positions if necessary to achieve proper technique (e.g., modified push-up). Repetitions were performed continuously for 30 seconds with 30 seconds rest between sets (1:1 ratio). After 20 minutes of RE, participants completed five minutes of static stretching. For the control condition, participants sat in a quiet, private room and read self-selected materials allowed by their treatment facility for 30 minutes. A master's

level exercise physiologist, not the primary investigator, supervised each exercise session with the aim of reducing bias. To minimize the effect of social interaction, the physiologist provided verbal cues on technique and monitored intensity but did not engage in additional conversation. Music was not allowed during the interventions, and all interventions were administered individually in a private setting.

The Positive Affect and Negative Affect (PANS) was used to assess mood. The PANAS is a validated 20-item questionnaire used to identify moods related to PA and NA (54). The items are evenly split between PA- and NA-related items, which are all rated on a 5-point Likert scale (1 = not at all, to 5 = extremely). PA and NA are summed separately, and scores can range from 10-50 for each construct, with higher scores reflecting higher dimensional affect. The PANAS has been used to measure mood states in patients with SUD (2, 8, 42). The PANAS was administered immediately pre- and post- each experimental condition, and participants were instructed to complete the PANAS on the basis of how they felt 'at that moment.'

Statistical Analysis

Descriptive statistics were calculated for all variables. Dependent variables (PA, NA) were examined to ensure assumptions for parametric statistics were met. If parametric assumptions were met, a 2 (time) x 3 (condition) repeated measures ANOVA was used to test for significant differences pre- to post-treatment in each dependent variable across conditions with Bonferroni post hoc tests if necessary. If parametric assumptions were not met, Friedman's test was used to assess significant differences across conditions with Wilcoxon's signed rank tests post hoc if necessary. Alpha was set at $p<0.05$ a priori, and SPSS (version 24, IBM, Armonk, NY) was used for data analysis.

RESULTS

Thirty females were recruited in a total of six recruitment sessions conducted between the two treatment facilities. Seventeen females completed the familiarization session; however, only 11 completed the entire study. Six females withdrew at different time points: two withdrew after the familiarization session, two withdrew after the control session, and an additional two withdrew due to early discharge. Statistical analyses were conducted only on those who completed all three conditions. Participant anthropometrics are provided in Table 1. Among participants, eight were Caucasian, two were Hispanic, and one was African American. Based on information collected in the Health History Questionnaire, 10 participants were sedentary, or performing <150 minutes per week of moderate intensity physical activity. The majority (72%) reported a previous or current diagnosis of two or more mental health disorders, with both depression and anxiety reported by 82% of participants. An examination of patients' substance use history revealed all had used five or more addictive substances in their lifetime; however, their polysubstance use history differed individually. Among these, alcohol (91%), marijuana (91%), methamphetamine (82%), tobacco/nicotine/e-cigs (82%), and heroin (64%) were the most commonly used addictive substances. Each participant was at a different stage in their treatment, with days of enrollment in the current facility ranging from 17-180 days. The

number of times participants had previously sought treatment ranged from 1-14 times. Despite being sedentary, all participants were able to complete 20 continuous minutes of moderate intensity AE and two complete circuits of the RE intervention (± 1-2 exercises) within 20 minutes. Approximately 5-10 minutes were required to complete the PANAS immediately before and after each condition.

Table 1. Participant Anthropometrics

	Minimum	Maximum	M ± SD
Age (yrs)	26	46	34.18 ± 7.12
Height (m)	1.55	1.75	1.64 ± 0.07
Weight (kg)	63.50	101.15	78.80 ± 14.01
BMI (kg/m^2)	23.05	35.51	29.12 ± 3.95

M ± SD - mean ± standard deviation

Positive Affect: The Shapiro-Wilk test statistic indicated all pre- and post-treatment PA data were normally distributed. Descriptive statistics are provided in Table 2. Mauchly's test indicated the assumption of sphericity was met. A 2 x 3 repeated measures ANOVA indicated a significant time by condition interaction ($F(1, 2) = 9.51$, $p = 0.001$, $\eta_p^2 = 0.49$). Pairwise comparisons of the difference (pre- to post-treatment) between means revealed a significant increase in PA for AE (10.36 + 2.31, M + SEM, mean + standard error of mean, $p = 0.001$) and RE (9.82 + 2.11 M + SEM, $p = 0.001$) but not C (0.27 + 1.70 M ± SEM, $p > 0.05$) (Figure 1), with no significant difference between AE and RE.

Table 2. Positive Affect

			95% Confidence Interval	
Condition	Time	M ± SD	Lower Bound	Upper Bound
AE	Pre	23.00 ± 7.66	17.86	28.14
	Post	33.36 ± 9.41	27.05	39.68
RE	Pre	23.55 ± 9.99	16.83	30.26
	Post	33.36 ± 11.07	25.93	40.80
C	Pre	23.00 ± 9.32	16.74	29.26
	Post	23.27 ± 11.82	15.33	31.22

AE - aerobic exercise, RE - resistance exercise, C – control, M ± SD - mean ± standard deviation

Negative Affect: The Shapiro-Wilk test statistic indicated all NA variables were not normally distributed. Application of a log10 transformation did not yield a normal distribution; therefore, Friedman's test of differences between repeated measures was conducted with post hoc Wilcoxon signed ranks tests.

Descriptive statistics are presented in Table 3. Friedman's test indicated a significant difference in NA pre- to post-treatment between conditions ($\chi^2_{(5)} = 31.55$, $p < 0.001$). Wilcoxon signed rank tests revealed a significant decrease for AE (difference in mean ranks 2.86, $p = 0.005$) and RE (difference in mean ranks 2.63, $p = 0.005$) but not C (difference in mean ranks 0.96, $p = 0.55$).

Table 3. Negative Affect

Condition	Time	M ± SD	Median	95% Confidence Interval	
				Lower Bound	Upper Bound
AE	Pre	17. 0 ± 8.53	14.0	11.27	22.73
	Post	12.36 ± 5.55	10.0	8.63	16.10
RE	Pre	17.18 ± 9.65	13.0	10.70	23.67
	Post	10.91 ± 2.39	10.0	9.31	12.51
C	Pre	13.82 ± 4.81	12.0	10.58	17.05
	Post	12.73 ± 3.80	11.0	10.18	15.28

M ± SD - mean ± standard deviation

DISCUSSION

The purpose of this study was to determine if acute bouts of aerobic or resistance exercise would elicit positive changes in mood in females enrolled for SUD at inpatient treatment centers. The results indicate that a 20-minute of both aerobic and resistance exercise significantly increase positive affect and decrease negative affect versus a control, with no difference between the exercise treatments. To the authors' knowledge, this is the first study to compare the effects of acute controlled bouts of aerobic exercise and bodyweight circuit training to a sedentary control on positive affect and negative affect in females with poly-SUD undergoing treatment at inpatient centers.

Our results indicate that an acute bout of moderate intensity, steady-state aerobic exercise leads to a significant increase in PA. PA increased in all females, with an average increase of 10.4 points. Given that low positive affect is believed to contribute to relapse (13), the increase in PA is important to note. Prior research did not report an increase in PANAS-assessed PA following an acute bout of aerobic exercise in females attempting to quit smoking (8); however, this study employed a longer duration (40-50 minutes) of a more vigorous intensity (60-85% HRR) exercise. In addition to sample differences (i.e., single- v poly-SUD), it is likely the relatively more challenging exercise parameters contributed to fatigue, which negatively impacted mood, a phenomenon fairly well accepted in the literature (15). Aerobic exercise also significantly decreased NA, with a median reduction of 3.0. While research in nicotine-dependent samples has reported decreases in NA with longer durations of more vigorous intensity aerobic exercise (8), our results suggest a reduction in NA can be attained more easily in a SUD sample. Given

that time is the most frequently cited barrier to exercise participation, the attainment of improved mood with a shorter duration of exercise is practically important. Although a direct comparison is difficult given the different instrument used to assess withdrawal symptoms, our results also corroborate studies that have reported decreases in Mood and Physical Symptom Scale (MPSS)-derived tobacco withdrawal symptoms (e.g. urge/craving, mood, physical symptoms) with 5-, 10- and 20-minutes of mild-to-moderate intensity aerobic exercise (38, 46, 49) and extend this finding to females with poly-SUD undergoing inpatient treatment. Our results add to the extensive body of research demonstrating improvements in mood with aerobic exercise and support the use of relatively short duration, moderate intensity bouts as a self-regulatory strategy to improve mood among females suffering from SUD (46). The concomitant increase in PA and decrease in NA attained with aerobic exercise is similar to that seen with an equivalent duration bout of resistance exercise but significantly different from quiet reading.

Our results also indicate an acute bout of bodyweight circuit training also leads to a significant increase in PA. Like that seen with AE, PA increased in all females, with an average increase of 9.8 points. Given that high PA has been associated with greater avoidance and lower approach behaviors, this increase is important to note. This increase in PA supports the results of some (48, 51) but not all (25) studies of smokers. Our results support recent research that has reported improved mood after a 45-minute bodyweight circuit training intervention in a coed sample with poly-SUD undergoing inpatient treatment (16). In this recent study, however, circuit training was performed in a group, and mood was assessed with a single-item instrument (16). With both exercise interventions in the current study administered in a private, one-on-one setting and with a more comprehensive mood assessment, our study provides a more comprehensive understanding of the separate changes in PA and NA, reflecting the independent nature of these constructs, and also allows the affective response to resistance exercise to be disentangled from that of social interaction. Additionally, our results also indicate mood can be improved with a shorter duration of circuit training in females with SUD. The concomitant increase in PA and decrease in NA attained with resistance exercise is similar to that seen with an equivalent duration of aerobic exercise but significantly different from quiet reading.

Circuit training is an approach to resistance exercise that entails the performance of a relatively high number repetitions with a relatively light resistance, creating an exercise stimulus that elicits noticeable cardiorespiratory responses. Perhaps this similarity with aerobic exercise explains the lack of a significant difference between the two exercise interventions. While studies in non-SUD samples indicate effects may depend on intensity (3) and inter-set rest duration (7), our results indicate a simple bodyweight circuit with balanced work and recovery intervals effectively increases PA and reduces NA. Our circuit training intervention also included dynamic and static muscle actions, an important detail since dynamic muscle actions were not shown to reduce withdrawal symptoms (25) but isometric muscle actions were (51). Our results broaden the types of resistance exercise that may improve mood in persons with SUD and supports research which contends both continuous, rhythmic exercise (e.g., walking)

and intermittent exercise (e.g., resistance exercise) are effective for acute mood regulation (5, 44, 57).

The finding that 30 minutes of quiet reading, a cognitive activity which served as a control, did not result in significant improvements in PA or NA is in line with others to report no effect of other passive interventions (e.g., quiet sitting, listening to an audio book, lecture) on aspects of tobacco withdrawal (16, 48, 51). While some have suggested an acute bout of exercise may exert its positive influences on mood through distraction from the psychological distress that results from withdrawal (17), our results suggest that physical activity is more beneficial for mood enhancement than a sedentary intervention such as quiet reading. This then would suggest there is more at play than a mere distraction from stress. Given that one of the elemental differences between a physical and cognitive activity is the expenditure of energy, these results may lend support to the thermogenic model of mood enhancement. However, the authors acknowledge this is entirely speculative, and there are several other mechanisms through which exercise may enhance mood, ranging from psychological to neurophysiological (10, 32, 37).

There were several aspects of this study that make unique contributions to the field. To the authors' knowledge, this is the first time the acute effects of aerobic and circuit resistance exercise on mood have been compared to a passive control in females with poly-SUD undergoing inpatient treatment. Most studies have utilized samples consisting primarily of males, and the overwhelming majority have examined samples with single-SUD. Given the prevalence and consequences of polysubstance use, researchers have urged exploration of treatment effects in this population to increase translatability and treatment efficacy (14). Furthermore, this study is one of the few that have administered the exercise intervention in a private, one-on-one setting, eliminating the influence of social interaction on affect. There are limitations to the current study, notably its small sample size. Due to recruitment difficulties early in the study, small, non-monetary incentives were offered for participation; however, it was ineffective in increasing interest or participation. Due to equipment and logistical constraints, body weight exercises were performed for the resistance exercise condition. Without baseline strength testing, the relative intensity of the resistance exercise condition is not known, making it difficult to compare our study directly with others that have used a fixed relative intensity. However, the fact that RE intervention was completed without equipment could be viewed as a strength of the study, in that it enables exercise to be an immediately rewarding and easily accessible intervention (31) that may prevent SUD relapse when triggers arise (e.g., environmental cues, psychological responses). In light of the fact that two women withdrew after an initial control session, we encourage future studies to implement a block randomization, making sure an exercise session is performed first rather than a passive control. It is possible an initial control session decreased interest for continued participation.

Useful anecdotal information was volunteered by participants at the conclusion of the study. First, participants self-reported a desire to continue to engage in exercise at the conclusion of the study. This is a practically important finding that has also been reported by others (1, 40); however, there is likely an inherent bias in our sample as they volunteered to participate in the

study. Many in our sample cited a specific goal of improving body composition. Indeed, descriptive statistics revealed the mean BMI for this sample was on the cusp of overweight. Participants cited weight gain as a relapse-provoking trigger and weight loss as a positive outcome expectancy resulting from exercise. Participants cited lack of time and/or knowledge as barriers to exercise. A comprehensive fitness program that includes not only resources for exercise (e.g., equipment, trained personnel) but also dietary counseling may support females in weight management, and in doing so, increase self-efficacy for exercise after leaving the treatment center.

It has been argued that SUD should be considered a chronic disease (34). As an approach to lifestyle modification, one of the three pillars of relapse prevention, exercise holds particular promise for recovery (9, 33). With regard to SUD relapse prevention, exercise is thought to assist by reducing the general mental distress associated with withdrawal (32), increasing self-efficacy, and providing positive alternatives to substance use (10). In addition to the substance use disorder and commonly co-occurring mental illnesses (41), physical comorbidities are prevalent in persons with SUD (27). Among drug- and alcohol- dependent patients, 76% reported having at least one physical health problem, 51% reported having two, and 31%reported having three or more physical health problems (29). Leading organizations support exercise as a beneficial treatment for numerous conditions including cardiovascular, respiratory, metabolic, and gastrointestinal disease, all of which are physical comorbidities associated with SUD (19). The fact that exercise is a low-cost intervention that can simultaneously address the physiological and psychological comorbidities that are often present in persons afflicted by SUD support the logic for its inclusion into SUD recovery. While we acknowledge the effects of an exercise session on mood and affect are transient, we agree with others who have argued for the inclusion of exercise into holistic treatment programs. If exercise adherence can be achieved, it could potentially become a life-long means to manage recovery and maintain sobriety.

REFERENCES

1. Abrantes AM, Battle CL, Strong DR, Ing E, Dubreuil ME, Gordon A, Brown RA. Exercise preferences of patients in substance abuse treatment. Ment Health Phys Act 4(2):79-87, 2011.

2. Abrantes AM, Bloom EL, Strong DR, Riebe D, Marcus BH, Desaulniers J, Fokas K, Brown RA. A preliminary randomized controlled trial of a behavioral exercise intervention for smoking cessation. Nicotine Tob Res 16(8):1094-1103, 2014.

3. Arent SM, Landers DM, Matt KS, Etnier JL. Dose-response and mechanistic issues in the resistance training and affect relationship. J Sport Exerc Psychol 27(1):92-110, 2005.

4. Baker TB, Japuntich SJ, Hogle JM, McCarthy DE, Curtin JJ. Pharmacologic and behavioral withdrawal from addictive drugs. Curr Dir Psychol Sci 15(5):232-236, 2006.

5. Bartholomew JB, Moore J, Todd J, Todd T, Elrod CC. Psychological states following resistance exercise of different workloads. J Appl Sport Psychol 13(4):399-410, 2001.

6. Becker HC. Alcohol dependence, withdrawal, and relapse. Alcohol Res 2008.

7. Bibeau WS, Moore JB, Mitchell NG, Vargas-Tonsing T, Bartholomew JB. Effects of acute resistance training of different intensities and rest periods on anxiety and affect. J Strength Cond Res 24(8):2184-2191, 2010.

8. Bock BC, Marcus BH, King TK, Borrelli B, Roberts MR. Exercise effects on withdrawal and mood among women attempting smoking cessation. Addict Behav 24(3):399-410, 1999.

9. Brown RA, Abrantes AM, Minami H, Read JP, Marcus BH, Jakicic JM, Strong DR, Dubreuil ME, Gordon AA, Ramsey SE. A preliminary, randomized trial of aerobic exercise for alcohol dependence. J Subst Abuse Treat 47(1):1-9, 2014.

10. Brown RA, Abrantes AM, Read JP, Marcus BH, Jakicic J, Strong DR, Oakley JR, Ramsey SE, Kahler CW, Stuart G. Aerobic exercise for alcohol recovery: Rationale, program description, and preliminary findings. Behav Modif 33(2):220-249, 2009.

11. Brownell KD, Marlatt GA, Lichtenstein E, Wilson GT. Understanding and preventing relapse. Am Psychol 41(7):765, 1986.

12. Carpenter KM, Hasin DS. Drinking to cope with negative affect and DSM-IV alcohol use disorders: A test of three alternative explanations. J Stud Alcohol 60(5):694-704, 1999.

13. Cheetham A, Allen NB, Yücel M, Lubman DI. The role of affective dysregulation in drug addiction. Clin Psychol Rev 30(6):621-634, 2010.

14. Crummy EA, O'Neal TJ, Baskin BM, Ferguson SM. One is not enough: Understanding and modeling polysubstance use. Front Neurosci 14(569), 2020.

15. Ekkekakis P, Petruzzello SJ. Acute aerobic exercise and affect. Sports Med 28(5):337-347, 1999.

16. Ellingsen MM, Clausen T, Johannesen SL, Martinsen EW, Hallgren M. Effects of acute exercise on drug craving in adults with poly-substance use disorder. A randomized controlled trial. Ment Health Phys Act 21:100423, 2021.

17. Giménez-Meseguer J, Tortosa-Martínez J, Remedios Fernández-Valenciano M. Benefits of exercise for the quality of life of drug-dependent patients. J Psychoactive Drugs 47(5):409-416, 2015.

18. Glassman AH, Helzer JE, Covey LS, Cottler LB, Stetner F, Tipp JE, Johnson J. Smoking, smoking cessation, and major depression. JAMA 264(12):1546-1549, 1990.

19. Gossop M, Neto D, Radovanovic M, Batra A, Toteva S, Musalek M, Skutle A, Goos C. Clinical study: Physical health problems among patients seeking treatment for alcohol use disorders: A study in six European cities. Addict Biol 12(2):190-196, 2007.

20. Haasova M, Warren FC, Ussher M, Janse Van Rensburg K, Faulkner G, Cropley M, Byron-Daniel J, Everson-Hock ES, Oh H, Taylor AH. The acute effects of physical activity on cigarette cravings: Systematic review and meta-analysis with individual participant data. Addiction 108(1):26-37, 2013.

21. Haglund M, Ang A, Mooney L, Gonzales R, Chudzynski J, Cooper CB, Dolezal BA, Gitlin M, Rawson RA. Predictors of depression outcomes among abstinent methamphetamine-dependent individuals exposed to an exercise intervention. Am J Addict 24(3):246-251, 2015.

22. Hall SM, Muñoz RF, Reus VI, Sees KL. Nicotine, negative affect, and depression. J Consult Clin Psychol 61(5):761, 1993.

23. Hallgren M, Vancampfort D, Hoang MT, Andersson V, Ekblom Ö, Andreasson S, Herring MP. Effects of acute exercise on craving, mood and anxiety in non-treatment seeking adults with alcohol use disorder: An exploratory study. Drug Alcohol Depend 220:108506, 2021.

24. Hassan AN, Le Foll B. Polydrug use disorders in individuals with opioid use disorder. Drug Alcohol Depend 198:28-33, 2019.

25. Ho J-Y, Kraemer WJ, Volek JS, Vingren JL, Fragala MS, Flanagan SD, Maladouangdock J, Szivak TK, Hatfield DL, Comstock BA. Effects of resistance exercise on the hpa axis response to psychological stress during short-term smoking abstinence in men. Addict Behav 39(3):695-698, 2014.
26. Hunt WA, Barnett LW, Branch LG. Relapse rates in addiction programs. J Clin Psychol 1971.

27. Huỳnh C, Tremblay J, Fleury M-J. Typologies of individuals attending an addiction rehabilitation center based on diagnosis of mental disorders. J Subst Abuse Treat 71:68-78, 2016.

28. Kassel JD, Stroud LR, Paronis CA. Smoking, stress, and negative affect: Correlation, causation, and context across stages of smoking. Psychol Bull 129(2):270, 2003.

29. Keaney F, Gossop M, Dimech A, Guerrini I, Butterworth M, Al-Hassani H, Morinan A. Physical health problems among patients seeking treatment for substance use disorders: A comparison of drug dependent and alcohol dependent patients. J Subst Use 16(1):27-37, 2011.

30. Koob GF, Simon EJ. The neurobiology of addiction: Where we have been and where we are going. J Drug Issues 39(1):115-132, 2009.

31. Linke SE, Ussher M. Exercise-based treatments for substance use disorders: Evidence, theory, and practicality. Am J Drug Alcohol Abuse 41(1):7-15, 2015.

32. Mamen A, Pallesen S, Martinsen EW. Changes in mental distress following individualized physical training in patients suffering from chemical dependence. Eur J Sport Sci 11(4):269-276, 2011.

33. Marlatt GA, Donovan DM. Relapse prevention: Maintenance strategies in the treatment of addictive behaviors. Guilford press; 2005.

34. McLellan AT, Lewis DC, O'Brien CP, Kleber HD. Drug dependence, a chronic medical illness: Implications for treatment, insurance, and outcomes evaluation. JAMA 284(13):1689-1695, 2000.

35. Miller WR, Walters ST, Bennett ME. How effective is alcoholism treatment in the united states? J Stud Alcohol 62(2):211-220, 2001.

36. Navalta JW, Stone WJ, Lyons TS. Ethical issues relating to scientific discovery in exercise science. Int J Exerc Sci 12(1):1, 2019.

37. Petruzzello SJ, Landers DM, Hatfield BD, Kubitz KA, Salazar W. A meta-analysis on the anxiety-reducing effects of acute and chronic exercise. Sports Med 11(3):143-182, 1991.

38. Prapavessis H, De Jesus S, Harper T, Cramp A, Fitzgeorge L, Mottola MF, Ussher M, Faulkner G, Selby P. The effects of acute exercise on tobacco cravings and withdrawal symptoms in temporary abstinent pregnant smokers. Addict Behav 39(3):703-708, 2014.

39. Rawson RA, Chudzynski J, Gonzales R, Mooney L, Dickerson D, Ang A, Dolezal B, Cooper CB. The impact of exercise on depression and anxiety symptoms among abstinent methamphetamine-dependent individuals in a residential treatment setting. J Subst Abuse Treat 57:36-40, 2015.

40. Read JP, Kahler CW, Stevenson JF. Bridging the gap between alcoholism treatment research and practice: Identifying what works and why. Prof Psychol Res Pr 32(3):227, 2001.

41. SAMHSA. Results from the 2018 national survey on drug use and health. Retrieved from: https://www.samhsa.gov/data/; 2019.

42. Schlauch RC, Gwynn-Shapiro D, Stasiewicz PR, Molnar DS, Lang AR. Affect and craving: Positive and negative affect are differentially associated with approach and avoidance inclinations. Addict Behav 38(4):1970-1979, 2013.
43. Shiffman S, Waters AJ. Negative affect and smoking lapses: A prospective analysis. J Consult Clin Psychol 72(2):192, 2004.

44. Silveira H, Moraes H, Oliveira N, Coutinho ESF, Laks J, Deslandes A. Physical exercise and clinically depressed patients: A systematic review and meta-analysis. Neuropsychobiology 67(2):61-68, 2013.

45. Taylor AH, Ussher MH, Faulkner G. The acute effects of exercise on cigarette cravings, withdrawal symptoms, affect and smoking behaviour: A systematic review. Addiction 102(4):534-543, 2007.

46. Thayer RE, Peters III DP, Takahashi PJ, Birkhead-Flight AM. Mood and behavior (smoking and sugar snacking) following moderate exercise: A partial test of self-regulation theory. Pers Individ Dif 14(1):97-104, 1993.

47. Unhjem R, Flemmen G, Hoff J, Wang E. Maximal strength training as physical rehabilitation for patients with substance use disorder; a randomized controlled trial. BMC Sports Sci Med Rehabil 8(1):7, 2016.

48. Ussher M, Cropley M, Playle S, Mohidin R, West R. Effect of isometric exercise and body scanning on cigarette cravings and withdrawal symptoms. Addiction 104(7):1251-1257, 2009.

49. Ussher M, Nunziata P, Cropley M, West R. Effect of a short bout of exercise on tobacco withdrawal symptoms and desire to smoke. Psychopharmacology (Berl) 158(1):66-72, 2001.

50. Ussher M, Sampuran AK, Doshi R, West R, Drummond DC. Acute effect of a brief bout of exercise on alcohol urges. Addiction 99(12):1542-1547, 2004.

51. Ussher M, West R, Doshi R, Sampuran AK. Acute effect of isometric exercise on desire to smoke and tobacco withdrawal symptoms. Hum Psychopharmacol 21(1):39-46, 2006.

52. Walton MA, Blow FC, Booth BM. A comparison of substance abuse patients' and counselors' perceptions of relapse risk: Relationship to actual relapse. J Subst Abuse Treat 19(2):161-169, 2000.

53. Wang D, Wang Y, Wang Y, Li R, Zhou C. Impact of physical exercise on substance use disorders: A meta-analysis. PloS One 9(10):e110728, 2014.

54. Watson D, Clark LA, Tellegen A. Development and validation of brief measures of positive and negative affect: The panas scales. J Pers Soc Psychol 54(6):1063, 1988.

55. Williamson A, Darke S, Ross J, Teesson M. The effect of persistence of cocaine use on 12-month outcomes for the treatment of heroin dependence. Drug Alcohol Depend 81(3):293-300, 2006.

56. Witkiewitz K, Villarroel NA. Dynamic association between negative affect and alcohol lapses following alcohol treatment. J Consult Clin Psychol 77(4):633, 2009.

57. Yeung RR. The acute effects of exercise on mood state. J Psychosom Res 40(2):123-141, 1996.