Exercise Capacity and Acute Effect of Exercise on Affect in a Substance Use Disorder Population

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ABSTRACT

Background: It is known that exercise is beneficial to people with substance use disorder, however little evidence exists regarding their exercise capacity. This pilot study investigates the exercise capacity of patients with substance use disorder and effects of an acute bout of exercise on affect.

Methods: Twenty-nine participants admitted to a withdrawal management facility were recruited to complete a health and exercise assessment (18 females, 11 males; 41 ± 11 years old). Mood was measured before and after exercise assessments using the subjective experience to exercise scale. Data was grouped by sex, and descriptive analyses were performed against age-matched normative data. Within group, before and after subjective experience to exercise scale measures were analyzed using 2-way ANOVA with sex as a between subject factor.

Results: Participants ranged from having 2 to 6 modifiable cardiovascular risk factors. Participants performed below average compared to age-matched and sex-matched normative data for the 6-minute walk test (females: 539 ± 54 m, males: 606 ± 89 m); and push-up test (females: 22% good, males: 36% good). Of the 29 participants, 29% failed to achieve the average range for sex-matched norms in the sit-to-stand test. However, all participants achieved above average for curl-ups, and 72% achieved an average or above score in the step-up test. Exercise significantly increased wellbeing ($P < 0.001$, effect size = 1.12) and decreased psychological distress ($P = 0.045$, effect size = 1.03) and fatigue ($P < 0.001$, effect size = 1.32).

Conclusion: Exercise is both feasible and beneficial in a withdrawal management setting. Capacity to perform exercise was generally poor with high individual variance. Design of future interventions will need tailored prescription for patients in this population. *Journal of Clinical Exercise Physiology*. 2021;10(4):142–149.

Keywords: mood, physical activity, cardiovascular risk

INTRODUCTION

Substance use disorder (SUD) is a major public health concern and is associated with elevated rates of comorbidities including diabetes, cardiovascular disease (CVD) (1,2), and psychological disorders (3). Within Australia, 6.5% of the population have an alcohol use disorder and 2.2% have other forms of SUD (4). SUD is a major global health issue, with close to 30 million people suffering worldwide (5).

Structured exercise and physical activity are widely accepted to have positive effects on multiple parameters of psychological health and the well-known effects of increasing capacity to perform exercise to reduce risk of metabolic

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disease. Engagement with exercise-related activities is reported across numerous studies to increase periods of abstinence during treatment for SUD (6) and improve psychological outcomes such as depression and anxiety (7). The role of physical activity in the management of SUD is not well elucidated, however it has been an area of increasing research in the past years (8,9).

A particular challenge for this area of growing interest is a lack of a clear understanding of the capacity of people with SUD to perform exercise, or the impact of a single bout of exercise on acute mood state. These are vital first steps before prescribing interventions to aid recovery in clinical practice. As such, the aim of this pilot study was to investigate the fitness of people with SUD and effects of an acute bout of fitness testing on psychological state, while undergoing acute withdrawal management within an inpatient setting. Regarding this latter aim, we hypothesized that the acute bout of exercise would improve psychological outcome.

METHODS

The protocol described below was approved by Sydney Local Health District Human Research Ethics Committee – Concord Repatriation General Hospital (EC00118). Potential participants underwent an initial medical screen with all testing conducted under the supervision of an accredited exercise physiologist following informed consent. A full description of the exercise testing procedures was previously published (10) and as such only a brief summary is provided below. Assessments not previously described elsewhere are provided in full below.

Setting

This cross-sectional study was conducted at Concord Drug Health Department within the Concord Repatriation General Hospital, NSW Australia. This department is a 12-bed inpatient withdrawal management unit with a typical length of stay of 5 to 7 days for people aged 18 and over.

Participants

Participants were recruited within the first 3 days of admission. Participants were required to have a voluntary admission to the facility for assistance with SUD and be deemed to have the capacity to provide consent by their treating doctor. Where participants had multiple admissions during the period, only their 1 admission was eligible for inclusion.

Exclusion criteria were pregnancy, chronic noncancer pain, mental health disorders including eating disorders, and cognitive impairment. Participants were also excluded if, in the opinion of the screening doctor, they were too physically unwell to participate in exercise.

Measures

Baseline Characteristics and Clinical Measures

Demographic data including age, sex, ethnicity, smoking status, medical, substance use, and social history were obtained from medical records. The severity of dependence scale was administered to measure participants' level of dependence on their primary substance of abuse (11).

Exercise Assessments for Physical Capacity

Participants completed five brief exercise tests in the following sequence: 3-minute step test; push-up test; 30 second chair stand test; curl-up test; and 6-minute walk test under the supervision of an accredited exercise physiologist. Full description of the procedures and implementation have been provided previously (10).

Participants completed a subjective exercise experience scale (SEES) prior to commencing the 3-minute step test and immediately following the 6-minute walk test to assess change in psychological states from completing exercise. The SEES is a validated tool to measure the effects of exercise on psychological state using 12 items to measure positive wellbeing, psychological distress, and fatigue on a scale of 1 to 7 (12).

Nutritional Status

The nutritional status of the participants was determined using the subjective global assessment tool, which scores participants as (a) well nourished, (b) mild or moderately malnourished, or (c) severely malnourished (13). Height and weight were measured in light clothes with shoes off, using a stadiometer and a calibrated standing scale to calculate body mass index. Weight was measured again within 24 hours prior to discharge.

CVD Risk

CVD risk was determined by the number of risk factors that a participant reported. Cardiovascular risk-related biomarkers including nonfasting blood lipids and glycated hemoglobin (HbA1C) were retrieved from medical records. All testing was carried out as part of usual care by the hospital pathology service.

Abdominal obesity was determined by waist-to-height ratio. Waist circumference was measured at the narrowest point of the participant's back. Participants were classified as having abdominal obesity if the waist-to-height ratio was greater than 0.55 for males or 0.50 for females (14).

Adherence to the Mediterranean diet was assessed using a 14-item Mediterranean diet score tool administered at admission and discharge (15). Previous findings showed a score of $\geq$ 9 points was inversely associated with cardiovascular risk factors (16). Question 8 regarding wine intake on the tool was excluded as some participants were alcohol dependent.

Discharge Assessments

Participants who remained at the hospital for 10 or more days following their admission exercise assessment were asked to complete the exercise assessments, SEES, and Mediterranean diet questionnaire, and undergo anthropometry assessments immediately prior to discharge.

Statistical Analysis

Participant characteristics are presented as mean ± SD for all participants and grouped by sex. Unpaired student *t* tests

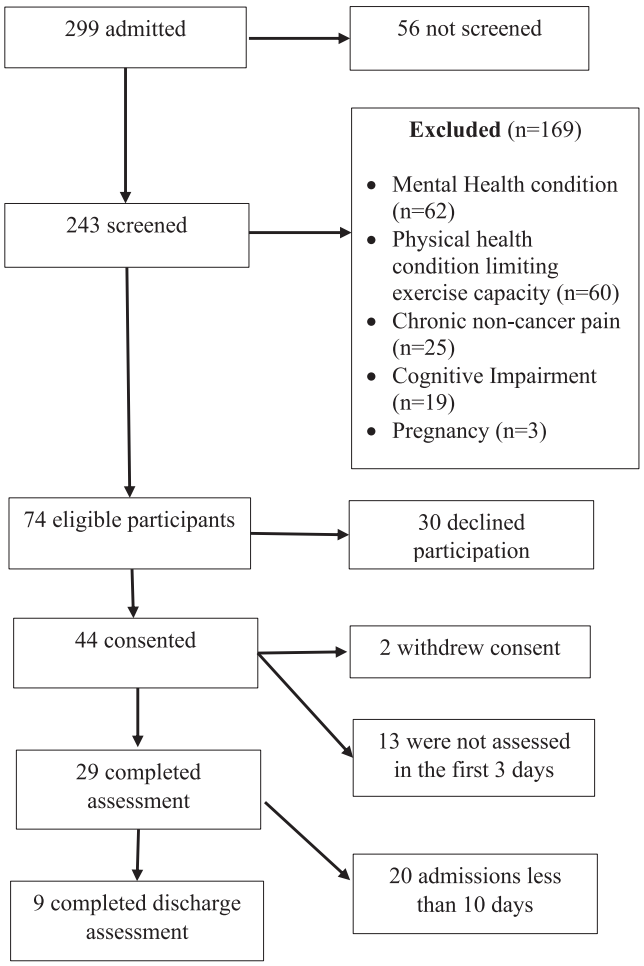

FIGURE 1. Consort diagram of participant inclusion and exclusion.

with Bonferroni corrections were conducted for standard characteristics including age, sex, weight, body mass index, waist-to-height ratio, and blood biochemistry. Mediterranean diet score is presented as median and range.

Given that our aim was to describe the population recruited for the purposes of determining exercise capacity, and the potential for variability in individual performance to skew means because of a low sample size, fitness testing outcomes are presented as medians and range for all participants at admission. A descriptive comparison of admission data to age-matched and sex-matched normative data is presented with no statistical analyses performed.

For the 9 participants who returned for a second assessment at discharge, performance was compared to baseline data using paired *t* tests. Changes in 7 variables were assessed: body weight, push-ups, curl-ups, chair stand rises, heart rate before and after the step test, and 6-min walk distance. Given these 7 measures are closely related, we applied a Bonferroni correction such that the alpha value for rejection of the null hypothesis was 0.05 / 7 = 0.00714 (17).

The acute effect of exercise on psychological state for all participants at admission was analyzed using (2) x 2 ANOVAs with sex as a between-subjects factor. Additionally, pre-exercise and postexercise scores on the SEES subscales were compared between tests for the 9 participants who completed a second assessment at discharge. To do this we analyzed raw SEES scores in (2) x (2) x 2 mixed-ANOVAs, with factors of *test* (initial vs. discharge), *exercise* (before vs. after), and *sex* (6 females, 3 males).

RESULTS

Participant Demographics

During the 6 month time period, 299 participants were admitted, and 243 were screened for eligibility. The remaining 56 were not able to be screened within their first 3 days of admission and therefore excluded. Of these, 169 met one or more of the exclusion criteria with more details available in Figure 1. Twenty-nine patients (11 males, 18 females) took part in the admission assessment, and 9 participants were available for discharge assessments 10 days following admission tests. All baseline characteristics are presented in Table 1. The 29 patients reported in this manuscript represents 10% of all admissions to the ward during our recruitment period. Further, these 29 participants represent 39% of

TABLE 1. Baseline characteristics of the participants, stratified by sex.

	All (N = 29)	Males (n = 11)	Females (n = 18)
Age, Mean, SD, years	40.6 ± 10.7	40.0 ± 11.9	41.0 ± 10.2
SDS Score, Mean, SD	11.5 ± 2.4	11.7 ± 1.8	11.4 ± 2.7
Weight, Mean, SD, kg	70.8 ± 18.1	79.4 ± 14.0	65.5 ± 18.6*
BMI, Mean, SD, $kg \cdot m^{-2}$	24.4 ± 4.6	25.0 ± 4.4	24.0 ± 4.8
WHtR, Mean, SD	0.51 ± 0.06	0.50 ± 0.07	0.52 ± 0.06
SGA Score			
SGA –A, n	18	6	12
SGA –B, n	8	4	4

BMI = body mass index; SD = standard deviation; SDS = severity of dependence scale; SGA = subjective global assessment; WHtR = waist-to-height ratio

*P = 0.03 uncorrected females vs. males

TABLE 2. Prevalence of modifiable cardiovascular risk factors.

Modifiable Cardiovascular Risk Factor	n	% of Sample
Smoking	18	62%
Overweight or Obese	10	34%
Abdominal Obesity	12	41%
Hypertension	2	7%
Poor Diet	27	93%
Insufficient Exercise	17	59%
Abnormal Blood Lipid Profile	22	76%

all admissions during the time period that were eligible for exercise testing.

Participants reported alcohol dependence (n = 8), combination of alcohol and other drugs dependence (n = 8), Cannabis (n = 2), Opioid (n = 2) and poly drug dependence (n = 9). Five patients were Aboriginal and Torres Strait Islanders. The mean age of the group was 40.6 ± 10.7 years, ranging from 20 to 64 years old (Table 1). The mean severity of dependence scale score was 11.5 ± 2.4, which indicated participants exhibited a high level of dependence on substance. There were no significant differences in age and severity of dependence scale score between sex groups.

Participants had a median score of 4 (range: 0-10) points on the Mediterranean diet tool, and only 2 participants obtained a score of ≥9 points, indicating high adherence to Mediterranean diet. For the 9 participants for whom admission and discharge data is available, scores were comparable following inpatient stay with a median score of 4 (range 3-8).

CVD Risk

All participants had at least 2 modifiable cardiovascular risk factors: 2 risk factors (n = 3), 3 risk factors (n = 12), 4 risk factors (n = 9), 5 risk factors (n = 3), 6 or more risk factors (n = 2). A detailed breakdown of these risk factors in available in Table 2.

Fitness Testing

Push-Up Test

Performance was compared against age-matched and sex-matched normative values published by the American College of Sports Medicine (18), which categorized performance as *good*, *fair*, or *needs improvement*. At admission, 9 participants a score of *good* or higher; 5 achieved a score of *fair*, 1 achieved a score of *needs improvement*, and 14 did not achieve the minimum standard. A general trend toward improved performance can be observed from admission to discharge with increases in medians for males and females. Compared to admission, a significant improvement in push-ups completed was observed (P = 0.007). Medians and ranges for admission and discharge assessments are available in Table 3.

Curl-Up Test

Performance was compared against age-matched and sex-matched normative values published by the American College of Sports Medicine (18), which categorized performance as either *excellent*, *very good*, *good*, *fair*, or *poor*.

TABLE 3. Median and (range) for exercise testing outcomes.

Time	Test	All (N = 29)	Males (n = 11)	Females (n = 18)
Admission (All)	Push-Up Test	6 (0-20)	13 (1-20)	4 (0-15)
	Curl-Up Test	25 (11-25)	25 (20-25)	25 (11-25)
	Chair Stand Rises	14 (8-21)	15 (9-21)	13.5 (8-17
	Step Test HR (bpm)	102 (83-133)	102 (88-132)	101 (83-132)
	6-Min Walk Distance (m)	560 (440-720)	645 (440-720)	538 (450-640)
		All (N = 9)	**Males (n = 3)**	**Females (n = 6)**
Admission (Completers)	Push-Up Test	9 (1-17)	9 (5-17)	7 (1-14)
	Curl-Up Test	25 (11-25)	25 (25)	20 (11-25)
	Chair Stand Rises	14 (9-21)	15 (9-21)	14 (10-17)
	Step Test HR (bpm)	110.5 (91-124)	108 (100-113)	115 (91-124)
	6-Min Walk Distance (m)	580 (450-675)	660 (525-675)	560 (450-610)
Discharge	Push-Up Test	13 (4-21)*	14 (5-21)	10.5 (4-18)
	Curl-Up Test	25 (13-25)	25 (25)	25 (13-25)
	Chair Stand Rises	18 (12-26)*	14 (13-26)	18 (12-25)
	Step Test HR (bpm)	100 (91-115)	95 (91-110)	101 (96-115)
	6-Min Walk Distance (m)	620 (515-710)*	660 (560-710)	615 (515-655)

*$P < 0.005$

TABLE 4. Summary of subjective experience to exercise results.

	Admission (All) (N = 29)	Admission (Completers) (n = 9)	Discharge (Completers) (n = 9)	Normative Values
Pre-Exercise				
Personal Wellbeing	13.97 ± 4.94	13.2 ± 4.8	19.33 ± 5.96	19.55 ± 4.73
Psychological Distress	13.07 ± 4.62	14.2 ± 4.5	9.00 ± 5.39	6.63 ± 2.45
Fatigue	16.62 ± 5.05	20 ± 6	11.67 ± 6.56	8.8 ± 5.09
Postexercise				
Personal Wellbeing	17.31 ± 5.61	18.2 ± 5.5	22.00 ± 4.18	20.37 ± 5.24
Psychological Distress	10.28 ± 4.61	10.9 ± 4.4	5.78 ± 1.92	5.39 ± 3.35
Fatigue	12.76 ± 5.26	17.1 ± 5.5	13.22 ± 7.00	9.98 ± 5.02

At admission, 20 participants achieved the maximum score, hence placing them in the *excellent* category, with 4 placing in the *very good* category. The remaining 5 participants placed within the *good* category.

In participants with both admission and discharge assessments, a general trend toward improved performance is seen in the female cohort with no change in the all or male cohorts as they had achieved maximum score at admission. Compared to admission, the changes in curl-up test did not reach statistical significance ($P = 0.07$). Medians and ranges for admission and discharge assessments are available in Table 3.

Chair Stand Test

Performance was compared to sex matched normative values from the senior fitness test 2013 (19) based on an age group of 60 to 64 years because of a lack of available age-matched norms. This categorizes participants as *below average*, *average*, or *above average*.

At admission, 1 male achieved a score in the *above average* category, 20 participants achieved the *average* range, and the remaining 8 participants were *below average*.

Compared to admission, a significant improvement in chair stands completed was observed ($P = 0.0046$), with increases of medians in the all and female cohorts, but not in the male cohort. Medians and ranges for admission and discharge assessments are available in Table 3.

Box Step Test

Performance was compared to normative data from the YMCA step test (20). This categorized participants as either *very poor*, *poor*, *below average*, *average*, *above average*, *good*, or *excellent*.

At admission, 4 participants achieved *above average*, 5 achieved *good*, and 1 female achieved *excellent*. A further 5 participants scored in the *average* range, 2 in the *below average* range, 6 in the *poor* range, and 2 in the *very poor* range. Two participants were unable to maintain the cadence of the test for 3 minutes, hence were unable to complete the test.

An improvement in performance can be generally observed at discharge with a decrease in the median post step test heart rate. Compared to admission, the changes in performance did not reach significance ($P = 0.31$). Medians and ranges for admission and discharge assessments are available in Table 3.

6-Minute Walk Test

Performance was compared to Australian normative values reported in Jenkins 2009 (21). Only 1 male achieved a distance above the average for the Australian population; 12 participants were within 1 SD below the norms for their respective sex, with 16 falling further than 1 SD below average.

At discharge an overall improvement in performance can be observed with an increase in medians for all cohorts. Compared to admission, a significant improvement in 6-minute walk distance was observed ($P = 0.0005$). Medians and ranges for admission and discharge assessments are available in Table 3.

SEES

Table 4 presents the mean score for the 3 SEES subscales for all participants and completers. Groups have not been presented by sex since this was included as a factor in the analysis. Table 4 also presents normative data extracted from (12) for comparison. Compared to normative values, the participants in this study reported personal wellbeing more than 1 SD below norms; psychological distress more than 2 SDs above norms; and fatigue over 1 SD above norms.

Effects of exercise on the 3 SEES subscales were analyzed in separate within-subject ANOVAs that included sex as a between-subjects factor. Exercise significantly increased self-reported wellbeing ($P < 0.001$) and significantly decreased psychological distress ($P = 0.045$) and fatigue ($P < 0.001$). A significant exercise x sex interaction was found for personal wellbeing ($P = 0.026$) but not psychological distress ($P = 0.23$) or fatigue ($P = 0.13$), and no main effects of sex were significant (all $P < 0.05$). To identify the source of the exercise x sex interaction on the wellbeing subscales,

scores were analyzed separately for men and women, revealing a significant effect of exercise in women ($P < 0.001$) but not in men ($P = 0.17$).

Pre-exercise and postexercise scores on the SEES subscales were compared between tests for the 9 participants who completed a second assessment at discharge. To do this we analyzed raw SEES scores in (2) x (2) x 2 mixed-ANOVAs, with factors of *test* (initial vs. discharge), *exercise* (before vs. after) and *sex* (6 female, 3 male). A significant test x exercise interaction effect would suggest that the effect of the exercise bout on SEES scores varied between the initial and discharge assessments.

For wellbeing, a main effect of exercise was observed ($P = 0.002$), reflecting higher scores postexercise at both tests. However, the test x exercise interaction and all other effects were not significant ($P = 0.10$).

For psychological distress, significant main effects of test ($P = 0.008$) and exercise ($P = 0.009$) were observed. Respectively, these results indicate that distress scores were significantly lower at discharge than at the initial assessment, on average (*test* effect), and significantly lower postexercise, on average (*exercise* effect). No other main or interaction effects were significant ($P = 0.44$).

For fatigue, a significant main effect of test was observed ($P = 0.006$), reflecting lower fatigue scores at discharge than at the initial assessment, on average. No other main or interaction effects were significant ($P = 0.14$).

DISCUSSION

This study offers insights on 3 key areas of SUD: cardiovascular risk factors, fitness, and affective response to exercise. High rates of cardiovascular risk factors were observed in this population, characterized by poor diet quality, high smoking rates, and low rates of physical activity. Exercise assessments revealed that physical capacity is generally below average, except for the curl-up test which was well performed. There was a significant mood response to exercise observed in this study. Notably, at admission, the observed improvement in affect following exercise was much greater than observed in general populations (12). This positive response in affect was observed again at follow-up testing, however, the magnitude of the effect was closer to the change expected in the general population. Although the sample size is small, particularly for our discharge data, these results support the potential benefits of exercise in a drug and alcohol dependent population.

People with SUD have elevated risks of CVD (22) and have the largest gap in life expectancy of all mental disorders (23). To date there is minimal literature describing the cardiovascular risk profile of SUD populations. The results of this study indicate that significantly more can be done to improve health outcomes in this population. Poor diet, low rates of exercise, and high rates of smoking were of the most common risk factors observed in this sample, and none of these factors are routinely addressed in SUD treatment. This highlights the need for physical health interventions to be imbedded into care for SUD.

Exercise is known to benefit SUD populations in numerous ways, such as increased quality of life (24) and not just decreasing CVD risk. Additionally, low physical capacity is considered a strong risk factor for CVD (25). Results of the exercise assessments completed show below average cardiovascular and muscular fitness. Participants performed below average for muscular endurance in the sit to stand and push-up tests, hence reflecting the significant cardiovascular risk of this population. However, the curl-up test, which also assessed muscular endurance was well performed. If aiming to distinguish between participants for the means of exercise prescription a more challenging test such as the 3-minute curl-up test (26) would be required.

The protocol for the 3-minute step-up test was a modified YMCA step test (20); with a change of cadence from 24 to 15 rises per minute as it was predicted participants would struggle to complete the standardized protocol (see reference 8 for full description). Participant results varied as would be expected in an average population, indicating that the modification of cadence was the appropriate intensity to assess cardiorespiratory function in a drug and alcohol population, despite the resulting difficulty in comparing to norms of healthy populations. The 6-minute walk test also assesses cardiorespiratory capacity and showed a below average result. It should be noted that in any of the timed tests (6-minute walk test and sit to stand motivation would have also influenced results, although participants were instructed to complete the assessment to their highest physical capacity. Furthermore, in all exercise assessments completed, a learning effect could have contributed to an improved score.

The improvement in mood induced by exercise at initial assessment was significantly higher than that seen in general populations. A contributing factor to this could be the lower baseline mood of the population in this study increasing the potential response to exercise assessment. Discharge assessments showed that pre-exercise positive wellbeing scores were closer to that of the general population, however, this score increased in response to exercise to a similar degree in admission testing, exceeding the scores seen in general populations. This increase in feelings of wellbeing following a bout of exercise offers several potential benefits. The improved mood from a short bout of exercise offers the potential for exercise to be used as a way of self-management of mood and can be used to assist in the treatment or prevention of subsequent mood disorders that are common in SUD (27,28). Furthermore, improvements in perceptions of mood following exercise have been linked to improved longer term adherence to exercise programs (29,30), hence further research could investigate if this positive change in affect can be used to promote physical activity adherence in this population. At both assessments psychological distress was greatly reduced following exercise assessments. This is an important measure, as high psychological distress, is considered a risk factor for relapse (31). Psychological distress is linked to cravings, which are highest when going through withdrawal management (32,33). Based on the results of this study the provision of exercise throughout withdrawal

management has the potential to impact treatment outcomes. The reduction in psychological distress could lead to increased retention in withdrawal management programs, however needs to be researched further. Additionally, the reduction of craving symptoms through decreasing psychological distress is something that can benefit people with SUD through all phases of treatment and recovery, hence should be further explored.

Notably, scores on the fatigue subscale decreased in response to the initial exercise assessments, whereas it would be expected that sensations of fatigue would increase immediately following exercise. Sleep disturbance and fatigue are commonly reported withdrawal symptoms (34). It is possible that the observed reduction in fatigue is because of a reduction in symptoms of withdrawal, rather than true physical fatigue. At the discharge assessment the fatigue scores increased following exercise like that seen in general populations. At this point in treatment, participants were no longer experiencing high levels of symptoms from withdrawal, therefore were able to provide a measure of true physical fatigue. Further research is required to test this hypothesis.

In this study we chose to complete a battery of exercise assessments as the *acute bout of exercise* to gain additional information on the physical capacity of the population. However, it could be expected that similar results could be produced by other forms of physical activity. There is a wide body of literature that suggests that either aerobic or resistance exercise elicits acute improvements in psychological state (35). Hence either could be substituted for the exercise assessment battery completed here to improve affect.

A major limitation of our study is the small sample size. Participants with mental health diagnosis, cognitive impairment, and chronic noncancer pain were excluded either because of concerns about capacity to consent or that their comorbidity would complicate the assessments being undertaken. These populations in general benefit from exercise (36–38), and it would not be unreasonable to apply some of our findings, in particular exercise feasibility, to these groups. Another potential limitation is that all participants had a period of 1-to-1 interaction with the accredited exercise physiologist performing the assessments. This could limit the capacity to apply these results to group-based interventions. However, group exercise improves mood outcomes in other populations (39). Finally, the impact of exercise on other parameters such as withdrawal scores were not assessed, and this was a mixed SUD population, and the data is not stratified by problematic substance.

In future, it would be beneficial to assess if the positive findings of this study are observed in other settings of drug and alcohol treatment. This would offer insight into the role of exercise as an adjunct therapy in the greater scheme of drug and alcohol treatment. While the direct cost of consumables for the assessments completed in this manuscript are low, it is important to note that each participant test required approximately 1.5 hours of accredited exercise physiologist time that would need to be factored into the budget for treatment centers. Additionally, there would be considerable benefit in evaluating the mood response to regular exercise during withdrawal management rather than an acute bout. This would allow for a more comprehensive assessment into the impacts of exercise on not just mood but also cravings, quality of life, and self-esteem, which is less likely to change following an acute bout of exercise.

CONCLUSION

Exercise is feasible in an acute drug and alcohol in-patient rehabilitation setting. Exercise capacity and diet are poor in the present SUD population, with high rates of tobacco use. Exercise improves wellbeing and reduces psychological distress, with observed improvements on some parameters of exercise capacity over a brief in-patient stay.

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