



# Barriers, perceived benefits and preferences to exercise in adults with an opioid use disorder in the U.S

Nora L. Nock<sup>a,b,\*</sup>, Estefania Hernandez<sup>c</sup>, Dallas Robinson<sup>d</sup>, Lee Hoffer<sup>c</sup>, Amy Wachholtz<sup>d</sup>

<sup>a</sup> Departments of Population and Quantitative Health Sciences, Case Western Reserve University, Cleveland, OH, USA

<sup>b</sup> Case Comprehensive Cancer Center, Cleveland, OH, USA

<sup>c</sup> Anthropology, Case Western Reserve University, Cleveland, OH, USA

<sup>d</sup> Department of Psychology, University of Colorado at Denver, Denver, CO, USA

## ARTICLE INFO

### Keywords:

Opioid use disorders  
 OUD  
 Exercise  
 Barriers  
 Facilitators

## ABSTRACT

**Introduction:** Over 10 million Americans misuse opioids and more than 5 million have been diagnosed with an opioid use disorder (OUD). In 2021, over 100,000 Americans died of a drug overdose and more than 75% of these deaths involved an opioid. Exercise has been shown to increase abstinence and decrease anxiety and depression in people with a substance use disorder. However, only a few small trials have focused on persons with OUD who often experience additional challenges including chronic pain, mental health disorders and cardio-metabolic abnormalities.

**Methods:** We aimed to describe the barriers, perceived benefits and preferences to exercise in adults with OUD in residential treatment in the U.S. as part of a larger study. We conducted 33 individually administered, semi-structured interviews and transcribed audiotapes verbatim, conducted coding and thematic analysis using NVivo v12 software (QSR International Inc.).

**Results:** Our sample had nearly equal representation of males and females and, was predominantly Caucasian (88%) with a mean of age of 34.5 (s.d. 7.5) years old. Participants stated that exercise helps to reduce drug cravings, anxiety, depression and pain and improve mood, physical health and build “normalcy”. Barriers included lack of time, access to resources, fear of poor health and triggering pain. Participants preferred moderate intensity exercise 3 times/week and 30–60 min sessions.

**Conclusions:** Our findings indicate that adults with OUD believe exercise is a valuable tool to use in their recovery but they encounter several barriers. Many barriers, however, could be overcome with structured programs offered by residential treatment centers.

## 1. Introduction

Approximately 10 million adults in the U.S. misuse opioids and 5.6 million have been diagnosed with an opioid use disorder (OUD), while overdose deaths involving an opioid, particularly fentanyl, continue to drive the opioid epidemic (National Academy of Sciences, 2017; SAMHSA, 2022). A record number of Americans, 107,622, died of a drug overdose in 2021, which represents a 40% increase over 2019 rates, with more than 75% of the deaths involving an opioid (Ahmad FB, 2021; CDC, 2022). Furthermore, over 43% of Americans with a substance use disorder (SUD) have a co-occurring mental illness (SAMHSA, 2017) and, about 40–60% of people with an OUD also report chronic pain (Cicero et al., 2008; National Academy of Sciences, 2017). In addition, the

percentage of people who do not complete drug treatment is high among persons with SUD, with drop-out rates of 50–60% common (Bronson et al., 2019; Njoroge, 2018; Stahler et al., 2016). Moreover, people with OUD and chronic pain are three to five times more likely to relapse than those with OUD but without pain (Cicero et al., 2008; Larson et al., 2007).

Several randomized trials have shown that exercise increases drug abstinence and decreases anxiety and depression scores in people with SUD (Wang et al., 2014); however, most of these trials have been smaller pilot studies and have not specifically focused on people with OUD. The STRIDE trial, which is the largest randomized exercise trial conducted to date in persons with SUD involving stimulants was conducted at 9 drug treatment centers and found that participants in the exercise arm ( $n =$

\* Corresponding author at: Case Western Reserve University, 10900 Euclid Avenue, Cleveland, OH 44106, USA.

E-mail address: [nln@case.edu](mailto:nln@case.edu) (N.L. Nock).

<https://doi.org/10.1016/j.pmedr.2023.102393>

Received 15 January 2023; Received in revised form 7 August 2023; Accepted 28 August 2023

Available online 29 August 2023

2211-3355/© 2023 The Authors. Published by Elsevier Inc. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

152) had a significantly higher drug abstinence rates compared to those in the health education arm ( $n = 150$ ; 78.7% vs. 73.9%; 4.8% difference between arms) (Trivedi et al., 2017). Although several exercise trials have included some people with OUD, only a couple of small pilot trials have focused on people with an OUD (Colledge et al., 2017; Huang et al., 2000; Wang et al., 2014). In the most recent pilot trial, patients receiving heroin-assisted treatment at an outpatient clinic in Switzerland were randomized to a 12-week program involving exercise ( $n = 13$ ) or a comparative condition ( $n = 11$ ) of the 50 patients invited to participate, nearly half ( $n = 22$ ) were not willing to commit to a 12 week program; however, 92.3% of patients in the exercise condition were considered “compliant” (missed fewer than 5 of 23 sessions; 78% attendance) (Colledge et al., 2017).

People with OUD may face additional challenges in adhering and complying to an exercise program. Although people with SUD in general have been shown to have lower cardiorespiratory fitness than those without SUD of similar age and biological sex (Flemmen & Wang, 2015; Stoutenberg et al., 2017), people with OUD may have even lower fitness levels due to higher rates of smoking (Gubner et al., 2018) and cardio-metabolic complications from long-term heroin and other opioid misuse (Greenwald et al., 2021). In addition, although exercise has been shown to induce a hypoalgesic response and is an approved frontline, non-pharmacological treatment for chronic pain (Dowell et al., 2016), chronic pain in people with OUD has been associated with a heightened sensitivity to pain and a fear that pain may be exacerbated by movement such as exercise (Luque-Suarez et al., 2019; Martel et al., 2013; Wachholtz & Gonzalez, 2014). Moreover, having co-occurring OUD and mental health issues such as depression and anxiety may be associated with worse treatment outcomes including retention in drug treatment programs and relapse (Zorick et al., 2010), making it potentially more difficult to achieve high adherence rates to exercise programs. Furthermore, although Food and Drug Administration (FDA) approved pharmaceutical medications to treat OUD (MOUD) including methadone, naltrexone and buprenorphine are highly effective in helping to reduce overdoses and maintain abstinence (Mattick et al., 2014; Wakeman et al., 2020), some MOUD may have undesired side effects. Methadone has been associated with an increased risk of cardiovascular disease (Thylstrup et al., 2015) and increase weight gain, fatigue, disrupted sleep and may increase cravings for sweets (Gahr et al., 2017; Parvaresh et al., 2015; Peles et al., 2016). Medications used to treat depression (e.g., Paxil, Prozac) are associated with weight gain (Fenn et al., 2015; Gartlehner et al., 2011; Serretti & Mandelli, 2010) and weight gain may make exercise more challenging.

Prior qualitative studies have reported that people with SUD are interested in engaging in exercise as part of their treatment to help reduce cravings and boredom and, improve their overall physical and mental health (Abrantes et al., 2011; Gimenez-Meseguer et al., 2015). However, very little is known about the barriers and facilitators to exercise in people with OUD who may have additional challenges from co-occurring pain, mental health disorders and other cardiopulmonary and metabolic abnormalities (Krantz et al., 2021). Only one prior qualitative study has focused on interviewing adults with OUD exclusively where they interviewed individuals in treatment for heroin and reported on participation in sports (Neale et al., 2012). Thus, we aimed to describe the barriers, perceived benefits and preferences to exercise more generally in people with OUD in residential drug treatment centers as part of the initial phase of a larger multi-site trial in the U.S.

## 2. Methods

### 2.1. Study population

The study population consisted of a purposive sample of adults 18 years of age and older from both biological sexes (male, female) with an OUD of any race/ethnicity enrolled in collaborating residential drug treatment center programs in the Northeast Ohio (3 centers) and

Denver, Colorado (1 center) regions as part of a larger multi-site study involving a subsequent pilot trial (NCT04736550). Participants were referred to researchers by residential treatment center directors and counselors. The protocol was approved by the Institutional Review Board (IRB) of Case Western Reserve University and the Colorado Multiple IRB and met the corresponding IRB guidelines for protection of human subjects concerning safety and privacy. All participants provided informed written consent.

### 2.2. Interviewing Procedures

The participants completed individually administered, open-ended, semi-structured interviews that lasted approximately 60 to 90 min. Interviews were conducted in a private office or conference room. Interviews were conducted by trained research staff using a phenomenological approach with a standardized interview guide that was adapted from our prior work (Owusu et al., 2018) and Im et al. (Im et al., 2008) modified to explore relevant themes on substance use, facilitators and barriers to participation in exercise as well as preferences to the frequency, duration, intensity and length of an exercise program. We did not formally define exercise or physical activity for participants.

### 2.3. Data acquisition and analysis

Interviews were audio-recorded and professionally transcribed verbatim. Transcribed data were imported into NVivo v12 software (QSR International Inc., Americas: Burlington, MA, USA) for data storage, organization, and analysis. Thematic analysis of the data was employed using a constant comparative analysis method through the use of *a priori* and emergent coding with a study devised codebook [19]. Members of the research team were engaged at key junctures of data collection and analysis to review and discuss raw data and emergent themes and resolve any discrepancies in coding. Interviews were conducted until data saturation was achieved.

## 3. Results

Characteristics of the study population are shown in Table 1. Individually administered interviews were conducted in 33 adults with OUD being treated at collaborating residential drug treatment centers. The study population consisted of 52% males and 48% females. The majority of participants were Non-Hispanic White (90%) with a mean age of  $34.5 \pm 7.5$  years old (range: 23 – 58 years old). The average BMI calculated using self-reported height and weight in our study population was  $28.8 \pm 5.2$  kg/m<sup>2</sup> in males and  $27.6 \pm 6.3$  kg/m<sup>2</sup> in females. All participants reported being either current (75.8%) or former (24.2%) smokers. Most (81.8%) participants were receiving MOUD with nearly half receiving suboxone (46%). When asked about their drug of choice, most participants reported “heroin” (51.5%) or “opiates” more generally (39.4%) and a few (9.1%) reported “meth and heroin”. Some participants were also on prescribed medications for depression (36%), anxiety (21%) and pain (18%).

### 3.1. Attitudes and perceived benefits to exercise

The thematic analysis revealed that adults with OUD believe that exercise helps with reducing depression, anxiety and stress as well as drug cravings. Exemplar quotes related to attitudes and facilitators to exercise are provided in Table 2. Several participants noted that exercise helped with their mental health and overall mood with one participant stating: “It [exercise] helps in my depression, anxiety. It [exercise] helps with stress. I’m able to handle the day a lot better and I’m a lot more cheerful. I’m more alert.” (31 yrs, Male). Participants mentioned how incorporating exercise helps them “build structure” (34 yrs, Female) and live a “normal life” (38 yrs, Female). Regarding cravings, one participant stated: “I’ve experienced the craving completely go away, especially

**Table 1**  
 Characteristics of the Study Population of Adults with an Opioid Use Disorder in Residential Treatment in the U.S. (n = 33).

Characteristic	Mean / No. (%)
Age (years)	34.5 ± 7.5
Biological Sex	
Male	17 (51.5)
Female	16 (48.5)
Race/Ethnicity	
Non-Hispanic White	30 (90.9)
Black/African-American	2 (6.1)
Hispanic White	1 (3.0)
Body Mass Index (BMI; kg/m <sup>2</sup> )	28.2 ± 5.7
Smoker	
Current	25 (75.8)
Former	8 (24.2)
Education	
Completed Less than High School	5 (15.2)
High School Diploma or GED	12 (36.4)
Bachelor's Degree or Some College	16 (48.5)
Age at First Substance Use (years)	14.3 ± 3.0
Prior Formal Attempts at Recovery	2.6 ± 2.4
Medication Assisted Treatment/MOUD	27 (81.8)
Methadone	5 (18.5)
Suboxone, Buprenorphine with Naloxone	16 (59.2)
Subutex, Buprenorphine	4 (14.8)
Vivitrol, Naltrexone	2 (7.4)
Drug of Choice	
Opiates	13 (39.4)
Heroin	17 (51.5)
Heroin & Methamphetamines	3 (9.1)
Depression Prescription Medication	12 (36.4%)
Anxiety Prescription Medication	7 (21.2%)
Pain Prescription Medication	6 (18.2%)

**Table 2**  
 Facilitators and Preferences to Exercise in Adults with an Opioid Use Disorder in Residential Treatment in the U.S.: Illustrative Quotes.

Themes	Illustrative Quotes
Improves Mental Health (Depression, Anxiety, Stress, Mood, Self-esteem)	“It [exercise] helps with my depression and anxiety. It [exercise] helps with stress. I’m able to handle the day a lot better and I’m a lot more cheerful. I’m more alert.” [31 yrs, Male]
	“It [exercise] just makes me feel better about myself. It’ll give me something to work on, once I get out of here.” [39 yrs, Male]
	“The chemical imbalance that we cause from our drug use, the psychological effect, things are put back into place and the brain heals faster from exercise.” [31yrs, Male]
	“It [exercise] really helps you improve your self-esteem. It’s a great way to get aggression out... It’s a great way to release negative tension in a positive way without having any bad repercussions.” [35 yrs, Male]
	“When I’m done [exercising], I feel like I accomplished something, and then it releases endorphins, so it generally makes me happier.” [34 yrs, Female]
	“It’s a mind-clearer...it helps me stay alert.” [29 yrs, Female]
Improves Physical Health & Body Image (Healthy Weight Loss)	“It [exercise] helps me looking and feeling good. It [exercise] just helps me feel better about myself knowing that I’m able to be physical, that I’m fit and that there are a lot of people that aren’t.” [35 yrs, Male]
	“When you’re exercising and losing weight your fit, it’ll help with the trigger of using, because a lot of people will use certain drugs so they can lose weight.” [33 yrs, Female]
Improves Social Health	“Sometimes you might not feel like it [exercise], but your buddies pick you up when you don’t want to.” [35 yrs, Male]
	“Just shooting [basketball] around with the guys...it’s kind of nice, ‘cause it brings us somewhat closer together. It’s something that we can do together to keep our minds off of drugs.” [27 yrs, Male]
	“It helps a lot to have someone...It’s [exercise] better when you have someone.” [24 yrs, Female]
Reduces Triggers & Cravings	“I’ve experienced the [drug] cravings completely go away, especially when I can go ride my bike for a couple of miles and just get tired out.” [29 yrs, Male]
	“I mean I feel happy after I exercise. When I feel good, it’ll help the cravings more. I’ll feel better. The cravings are worse when you’re depressed.” [31 yrs, Female]
	“It [exercise] kind of like creates that balance in my brain... If I am feeling stressful or anxious, it [exercise] would just replace that... it [exercise] is good for triggers.” [37 yrs, Female]
	“It [exercise] keeps my mind off of it, ‘cause I still get cravings sometimes, even when I’m on the Suboxone.” [39 yrs, Male]

(continued on next page)

when I ride my bike for a couple of miles and just get tired out.” (29 yrs, Male). Another participant stated: “I feel happy after I exercise. If I feel good, it’ll help the cravings more. I’ll feel better. The cravings are worse when you’re depressed.” (31 yrs, Female). One participant mentioned how exercise creates balance and decreases triggers: “[Exercise] kind of like creates that balance in my brain... If I am feeling stressful or anxious, it [exercise] would just replace that... it is good for triggers.” (37 yrs, Female). Other facilitators mentioned include that exercise helps to improve body image, socialization and can serve as a distraction to “keep our minds off of drugs” (27 yrs, Male). Exercise was cited as providing relief from pain with quotes from participants as follows: 1) “...the first couple of sessions was pretty rough ‘cause of my weight – I’m a big boy – but I started liking it ‘cause I could feel relief from my pain.” (39 yrs, Male); and, 2) “I need to keep a good core because of my back [pain]... if I have a good core that the pain will go away...physically, mentally, everything.” (35 yrs, Female).

### 3.2. Barriers to exercise

Common barriers to exercise including a lack of time and limited access to resources were mentioned (Table 3). The intense schedule in residential treatment was mentioned frequently with one participant stating: “schedule wise, you’ve got group twice a day...you’ve just got to figure out a time ‘cause everything is mandatory. So I would say scheduling restrictions stop me from doing it [exercise]” (35 yrs, Female). The lack of exercise equipment (bikes, weights, DVDs) and places to walk/run were highlighted by several participants with one stating: “we have no equipment for any kind of exercise” (34 yrs, Female). Pain was also described as a barrier with participants stating: 1) “my pain, I’ve got neuropathy on one leg and I have lower back pain, which limits me a lot...I haven’t been able to [exercise] because my back spazzes up and I can’t do it” (39 yrs, Male); and, 2) “...pain, of course – using drugs

Table 2 (continued)

Themes	Illustrative Quotes
Reduces & Alleviates Pain	<p>“After trying it [yoga] for a while, the first couple of sessions was pretty rough ‘cause of my weight –I’m a big boy –but I started liking it ‘cause I could feel relief from my pain.” [39 yrs, Male]</p> <p>“I need to keep a good core because of my back... when I have a good core the pain will go away...physically, mentally, everything.” [35 yrs, Female]</p> <p>“Physically it [exercise] helps with pain. It helps you feel good, stand straight. It gives you confidence.” [37 yrs, Female]</p> <p>“It [exercise] helps alleviate the pain to where it’s not crucial.” [58 yrs, Female]</p>
Builds Structure & Normalcy	<p>“It’ll [exercise] take up some time in my day that I wouldn’t be thinking about the drugs, because I’ll be working out” [39 yrs, Male]</p> <p>“It [exercise] is healthy... it helps me to realize that’s normal, trying to live a new way of life, doing things different, things that I didn’t used to do, like exercise.” [38 yrs, Female]</p> <p>“It helps build structure in your day. It gives you a tool to use in your recovery that you can use all the time. And it helps fill certain time slots of your day.” [34 yrs, Female]</p>

as soon as you’re not using, you feel every ache there is in you, so I’m not moving.” (34 yrs, Female). Participants also expressed concerned about their overall health and ability to be able to exercise after sometimes decades of using drugs with one patient stating: “drug use leads to breathing problems, and that might prevent me [from exercising]” (58 yrs, Female). Several patients expressed the desire to have a health screen before commencing an exercise program and to have the exercise supervised. One participant stated: “if there was someone to actually see where I’m at in my health and then help me start from there” (44 yrs, Male) while another said “it would be nice to talk to a doctor about it and even more important to talk to a fitness specialist” (50 yrs, Female).

3.3. Preferences to exercise

All participants interviewed all patients reported being willing to participate in exercise during their stay in residential drug treatment. More than half of participants (n = 17; 51.5%) stated they would prefer a program that was offered 3 days/week and most (n = 20; 60.6%)

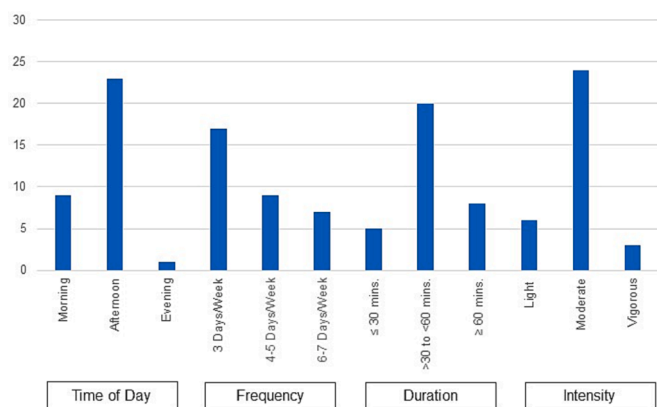
preferred a duration of 30–60 min per session. The majority of participants (n = 24; 72.2%) expressed that they would prefer exercise of moderate intensity (Fig. 1). In terms of program length, participants stated they would like to have an exercise program offered during their time in residential drug treatment (e.g., 60–90 days). Many participants stated that they might not have time for exercise once they are in subsequent outpatient treatment programs because of numerous other commitments. However, a few participants did express a desire to have an exercise program that was initiated during residential treatment and which would continue. into outpatient treatment.

4. Discussion

Our study is among the first to present the barriers, perceived benefits and preferences to exercise specifically in people with OUD. Our findings indicate that adults with an OUD believe exercise is a valuable tool to use in their recovery and, stated that exercise helps to reduce their drug cravings, anxiety, depression and pain. They also stated that

Table 3  
Barriers to Exercise in Adults with an Opioid Use Disorder in Residential Treatment in the U.S.: Illustrative Quotes.

Themes	Illustrative Quotes
Lack of Time During Residential Drug Treatment & Recovery	<p>“No time. You’re spending so much time at meetings, and again with the addict traits, I take everything to the extreme. If I’m going to meetings, I’m going to meetings 100%, so no time for exercise.” [31 yrs, Male]</p> <p>“Here, timing wise, schedule wise, you’ve got group twice a day...you’ve just got to figure out a time ‘cause everything is mandatory. So I would say scheduling restrictions stop me from doing it [exercise].” [35 yrs, Female]</p> <p>“I want to work out, and then I’ve got to have so many meetings and then I have to go to a job. No time.” [41 yrs, Male]</p> <p>“I’m about to be starting GED classes, and I’m gonna have a baby here, so that [exercise] would interfere a lot.” [31 yrs, Female]</p>
Lack of Time When Actively Using	<p>“Well my using kind of took all of my time, chasing the drug, chasing the money to get the drug, chasing the dope boy around. It was very time-consuming...I didn’t have time for nothing. I just didn’t want to do nothing. The drugs brought on depression, anxiety, so that was another things I had to deal with...” [39 yrs, Male]</p> <p>“For like the last two years, I was just coping, jut chasing it. I wasn’t even really getting high. I was spending all my time just getting normal.” [32 yrs, Male]</p>
Lack of Resources	<p>“Not having the equipment or something in the places. Like in here or in prison, you can’t go biking and there’s no weights.” [37 yrs, Male]</p> <p>“It’s kind of difficult to get in a groove. We have no equipment for any kind of exercise.” [34 yrs, Female]</p> <p>“...There’s no videotapes or DVDs or anything to do and there’s just limited area. We can’t go outside and walking the halls, there’s only a certain amount you can do.” [37 yrs, Female]</p>
Fear Exercise May Trigger or Exacerbate Pain	<p>“My pain, I’ve got neuropathy on one leg and I have lower back pain, which limits me a lot...I haven’t been able to [exercise] because my back spazzes up and I can’t do it...Lifting weights, certain poses, certain positions I can’t do nothing.” [39 yrs, Male]</p> <p>“I have to watch how I move a lot of times because of my pain. Some days are better than others. Some days, I’ll just go to tie my shoe and throw my back out.” [30 yrs, Male]</p> <p>“My pain, of course using drugs as soon as you’re not using, you feel every ache there is in you, so I’m not moving.” [ 34 yrs, Female]</p>



**Fig. 1.** Preferences to Exercise Relative to Time of Day, Frequency, Duration and Intensity in Adults with an Opioid Use Disorder in Residential Treatment in the U.S. The number of participants in each sub-group is shown on the y-axis.

exercise helps to improve their as well as to improve their overall mood and physical health as well as help build structure and “normalcy”. Several common barriers were mentioned including lack of time and limited access to resources (equipment, supervision). Barriers identified by this specific sample included concerns with their poor overall health and fear of triggering or exacerbating pain.

We believe many of these barriers could be addressed by integrating structured exercise supervised by qualified exercise professionals into residential drug treatment. Barriers related to lack of time and access to resources could be overcome by incorporating exercise and education on the benefits of exercise into standard OUD treatment programming. Further, concerns regarding poor overall health in people with OUD could be overcome by conducting comprehensive exercise screening with a resting electrocardiogram (ECG) and cardiopulmonary exercise testing prior to initiating the exercise program. Moreover, employing certified exercise professionals and providing a complementary pain management program led by clinical health psychologists could help address concerns related to triggering or exacerbating pain as well as help address anxiety, depression and other mental health disorders in people with OUD. However, integrating these additional services would not be trivial and would require funding potentially provided by governmental agencies (e.g., SAMSHA), foundations and/or other philanthropic organizations. Under resourced treatment centers could potentially explore offering structured exercise using existing staff and donated equipment.

Our results, which included people whose drug of choice was “heroin”, “opiates” or “meth and heroin”, are generally consistent with prior studies in people with SUD more generally and in the one prior study that focused on people with OUD that misused heroin (Neale et al., 2012). In a recent review, Simonton et al. (Simonton et al., 2018a) found 5 small studies that examined the preferences and attitudes for physical activity among adults with a SUD mostly in residential or intensive outpatient treatment settings. Four of these studies used quantitative methods (surveys) with two studies focused on people with alcohol use disorders (AUD) (Read et al., 2001; Stoutenberg et al., 2015) and two studies with about 50% or more people with AUD (Abrantes et al., 2011; Linke et al., 2015). Only one study used qualitative methods (interviews), which is the same study previously mentioned that focused on people with OUD involving heroin (Neale et al., 2012). Simonton et al. (Simonton et al., 2018b) found that adults with SUD are interested in physical activity programs with the percentage of those strongly interested in participating in or receiving counseling regarding an exercise program ranging from 54.6% to 84.4% (Abrantes et al., 2011; Linke et al., 2015; Read et al., 2001; Stoutenberg et al., 2015). In our study, all of the adults with OUD in residential treatment that we interviewed were interested in participating in an exercise program.

Most of our population of adults with OUD in residential treatment preferred an exercise program that was offered 3 times per week with 30–60 min sessions of moderate intensity. Moderate intensity exercise most commonly received the highest preference in prior studies in people with a SUD, mostly AUD (Abrantes et al., 2011; Stoutenberg et al., 2015); however, a study in an older population (mean age:  $52.7 \pm 12.8$  years) of veterans predominantly (59%) preferred low intensity exercise (Linke et al., 2015). The prior study in people with OUD did not ask specifically about preferences regarding intensity, frequency or duration (Neale et al., 2012).

Simonton et al. (Simonton et al., 2018b) reported that the most frequently cited facilitators for exercise in people with a SUD were improvements in physical health, gaining a sense of accomplishment and (self) confidence and increasing confidence to stay sober. Our population of adults with OUD stated exercise helps with building self-esteem as well as building structure and “normalcy”. Our participants also stated that exercise helps to improve their mental health by reducing anxiety, depression and “creating balance in the brain” and improving their overall mood and happiness. A few individuals in our study and in the prior study in OUD stated exercise helps to reduce their drug cravings and tapped into the concept of “exercise related reward” citing that exercise “releases endorphins” and induces a “buzz” or “adrenalin rush” that may serve as a substitute for drugs (Neale et al., 2012).

In addition, our participants stated exercise would improve their physical health by increasing their strength and function and exercise helps with weight loss and body image. Although weight was not mentioned as a concern in the prior studies with AUD (Simonton et al., 2018b), weight gain and concerns with body image were mentioned, particularly among men, in the prior study in OUD (heroin) (Neale et al., 2012). People with OUD, particularly those using heroin, may gain substantive weight during residential treatment once they discontinue their drug use and are eating three meals per day. This weight gain, which can be exacerbated by some MOUD (e.g., methadone (Fenn et al., 2015)), was cited as a motivator to exercise but also was described as a source of anxiety and stress in both men and women in our study. We found that the average BMI among men ( $28.8$  vs.  $27.1$   $\text{kg/m}^2$ ) and women ( $27.6$  vs.  $26.5$   $\text{kg/m}^2$ ) in our study was slightly higher than that self-reported in the general population in the U.S. (Flegal et al., 2019); however, larger prospective studies are needed to better understand weight changes in people with OUD during recovery. Exercise also helped to improve the social health of our participants.

Importantly, our population of adults with an OUD stated that exercise helps to alleviate or reduce their pain. However, some participants stated that their pain was a barrier to exercise with fears that exercise may trigger or exacerbate their pain. Several participants cited having back pain while another participant stated that just coming off of opioids induces pain (“...as soon as you’re not using, you feel every ache there is in you, so I’m not moving.”).

Overall, male and female participants reported similarly on preferences, barriers and facilitators to exercise. This is generally consistent with the prior study in people with OUD (Neale et al., 2012) and in the recent review in people with SUD (Simonton et al., 2018b). Both male and female participants in our study stated that they did not participate in exercise because of concerns with their poor overall health and the damage that drug use for many years may have done to their bodies. Only a few studies have measured fitness in people with SUD and found that cardiopulmonary fitness levels appear to be at least 15–30% lower in men and 25–40% lower in women with a SUD compared to normative values in people without a SUD of similar age (Flemmen & Wang, 2015; Stoutenberg et al., 2017). Although the underlying mechanisms for decreased fitness are not well known, they likely involve damage to cardiac and pulmonary tissue from smoking and misusing other substances. Opioids, in particular, may exhibit a myriad of cardiovascular complications including hypotension, bradycardia, peripheral vasodilatory flushing and syncope; and, opioid withdrawal may trigger hypertension, tachycardia, stress cardiomyopathy, and other acute

coronary syndromes (Greenwald et al., 2021; Krantz et al., 2021).

Our study has several strengths including the depth of information we obtained when conducting individual interviews. However, we had a small sample of adults (17 men, 16 women) with OUD in residential treatment and our study population was predominantly Non-Hispanic White, which decreases the generalizability of results. In addition, we did not specifically address barriers related to adhering to an exercise program. We did not specifically define exercise or physical activity. We did not ask about a clinical diagnosis of mental illness or chronic pain or about the preferred route of drug administration in our study and, therefore, are not able to assess how these aspects might potentially affect the results.

In summary, our findings indicate that adults with OUD believe exercise is a valuable tool to use in their recovery. Many barriers could be overcome by providing structured exercise programs during residential drug treatment.

## Funding

This work was supported by the National Institutes of Health (NIH) National Center for Complementary and Integrative Health (NCCIH) and National Institute of Neurological Disorders and Stroke (NINDS) grant no. R61/R33-AT010806 (awarded to NLN & AW). The content is solely the responsibility of the authors and does not necessarily represent the official views of the NIH.

## CRedit authorship contribution statement

**Nora L. Nock:** Conceptualization, Methodology, Formal analysis, Writing – original draft, Data curation, Supervision, Writing – review & editing. **Estefania Hernandez:** Writing – review & editing, Formal analysis, Writing – original draft, Data curation. **Dallas Robinson:** Writing – review & editing, Data curation. **Lee Hoffer:** Methodology, Writing – review & editing, Formal analysis, Supervision. **Amy Wachholtz:** Supervision, Conceptualization, Data curation, Methodology, Writing – review & editing.

## Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

## Data availability

The data that has been used is confidential.

## References

- Abrantes, A.M., Battle, C.L., Strong, D.R., Ing, E., Dubreuil, M.E., Gordon, A., Brown, R. A., 2011. Exercise preferences of patients in substance abuse treatment. *Ment. Health Phys. Act.* 4 (2), 79–87. <https://doi.org/10.1016/j.mhpa.2011.08.002> [doi] (Not in File).
- Ahmad FB, R. L., Sutton P. (2021). Provisional drug overdose death counts. Retrieved from [https://www.cdc.gov/nchs/nvss/vsrr/drug-overdose-data.htm#drug\\_specificity](https://www.cdc.gov/nchs/nvss/vsrr/drug-overdose-data.htm#drug_specificity).
- Brorson, H.H., Arnevik, E.A., Rand, K., 2019. Predicting dropout from inpatient substance use disorder treatment: a prospective validation study of the OQ-analyst. *Subst Abuse* 13. <https://doi.org/10.1177/1178221819866181>.
- CDC. (2022, May 11, 2022). *U.S. Overdose Deaths In 2021 Increased Half as Much as in 2020 – But Are Still Up 15%*. [https://www.cdc.gov/nchs/pressroom/nchs\\_press\\_releases/2022/202205.htm](https://www.cdc.gov/nchs/pressroom/nchs_press_releases/2022/202205.htm).
- Cicero, T. J., Lynskey, M., Todorov, A., Inciardi, J. A., & Surratt, H. L. (2008). Co-morbid pain and psychopathology in males and females admitted to treatment for opioid analgesic abuse. *Pain*, 139(1), 127-135. S0304-3959(08)00147-4 [pii];10.1016/j.pain.2008.03.021 [doi] (Not in File).
- Collidge, F., Vogel, M., Dursteler-Macfarland, K., Strom, J., Schoen, S., Puhse, U., Gerber, M., 2017. A pilot randomized trial of exercise as adjunct therapy in a heroin-assisted treatment setting. *J. Subst. Abuse Treat.* 76, 49–57. <https://doi.org/10.1016/j.jsat.2017.01.012>.

- Dowell, D., Haegerich, T. M., & Chou, R. (2016). CDC Guideline for Prescribing Opioids for Chronic Pain—United States, 2016. *JAMA*, 315(15), 1624-1645. 2503508 [pii]; 10.1001/jama.2016.1464 [doi] (Not in File).
- Fenn, J.M., Laurent, J.S., Sigmon, S.C., 2015. Increases in body mass index following initiation of methadone treatment. *J. Subst. Abuse Treat.* 51, 59–63.
- Flegal, K.M., Ogden, C.L., Fryar, C., Afful, J., Klein, R., Huang, D.T., 2019. Comparisons of self-reported and measured height and weight, BMI, and obesity prevalence from national surveys: 1999–2016. *Obesity (Silver Spring)* 27 (10), 1711–1719. <https://doi.org/10.1002/oby.22591>.
- Flemmen, G., Wang, E., 2015. Impaired aerobic endurance and muscular strength in substance use disorder patients: implications for health and premature death. *Medicine (Baltimore)* 94 (44), e1914. <https://doi.org/10.1097/MD.0000000000001914>.
- Gahr, M., Eller, J., Cabanis, M., Hiemke, C., Freudenmann, R.W., Conemann, B.J., Lang, D., Schönfeldt-Lecuona, C., 2017. Drug safety and adverse drug reaction reporting behavior related to outpatient opioid replacement therapy: Results from a survey among physicians. *J. Subst. Abuse Treat.* 74, 7–15.
- Gartheiner, G., Hansen, R. A., Reichenpader, U., Kaminski, A., Kien, C., Strobelberger, M., Van Noord, M., Thieda, P., Thaler, K., & Gaynes, B. (2011). In *Drug Class Review: Second-Generation Antidepressants: Final Update 5 Report*. <https://www.ncbi.nlm.nih.gov/pubmed/21595099>.
- Gimenez-Meseguer, J., Tortosa-Martinez, J., Fernandez-Valenciano, D.I.R., 2015. Benefits of exercise for the quality of life of drug-dependent patients. *J. Psychoact. Drugs* 47 (5), 409–416. <https://doi.org/10.1080/02791072.2015.1102991> [doi] (Not in File).
- Greenwald, M.K., Lundahl, L.H., Shkokani, L.A., Syed, S., Roxas, R.S., Levy, P.D., 2021. Effects of cocaine and/or heroin use on resting cardiovascular function. *Int J Cardiol Cardiovasc Risk Prev* 11, 200123. <https://doi.org/10.1016/j.ijcrp.2021.200123>.
- Gubner, N.R., Williams, D.D., Pagano, A., Campbell, B.K., Guaydish, J., 2018. Menthol cigarette smoking among individuals in treatment for substance use disorders. *Addict. Behav.* 80, 135–141. <https://doi.org/10.1016/j.addbeh.2018.01.015>.
- Huang, H., Yang, F., Yang, S.S., 2000. Influence of aerobic training on recovery of heroin addicts. *Chinese Journal of Phys. Ther.* 23, 267–270. Not in File.
- Im, E.-O., Chee, W., Lim, H.-J., Liu, Y.-i., Kim, H.K., 2008. Midlife women's attitudes toward physical activity. *J. Obstet Gynecol Neonatal Nurs* 37 (2), 203–213.
- Krantz, M.J., Palmer, R.B., Haigney, M.C.P., 2021. Cardiovascular complications of opioid use: JACC state-of-the-art review. *J. Am. Coll. Cardiol.* 77 (2), 205–223. <https://doi.org/10.1016/j.jacc.2020.11.002>.
- Larson, M.J., Paasche-Orlow, M., Cheng, D.M., Lloyd-Travaglini, C., Saitz, R., Samet, J. H., 2007. Persistent pain is associated with substance use after detoxification: a prospective cohort analysis. *Addiction* 102 (5), 752–760. <https://doi.org/10.1111/j.1360-0443.2007.01759.x>.
- Linke, S.E., Noble, M., Hurst, S., Strong, D.R., Redwine, L., Norman, S.B., Lindamer, L.A., 2015. An exercise-based program for veterans with substance use disorders: formative research. *J. Psychoact. Drugs* 47 (3), 248–257. <https://doi.org/10.1080/02791072.2015.1047915>.
- Luque-Suarez, A., Martinez-Calderon, J., Falla, D., 2019. Role of kinesophobia on pain, disability and quality of life in people suffering from chronic musculoskeletal pain: a systematic review. *Br. J. Sports Med.* 53 (9), 554–559. <https://doi.org/10.1136/bjsports-2017-098673>.
- Martel, M.O., Wasan, A.D., Jamison, R.N., Edwards, R.R., 2013. Catastrophic thinking and increased risk for prescription opioid misuse in patients with chronic pain. *Drug Alcohol Depend.* 132 (1–2), 335–341. <https://doi.org/10.1016/j.drugalcdep.2013.02.034>.
- Mattick, R. P., Breen, C., Kimber, J., & Davoli, M. (2014). Buprenorphine maintenance versus placebo or methadone maintenance for opioid dependence. *Cochrane Database Syst Rev*(2), CD002207. 10.1002/14651858.CD002207.pub4.
- National Academy of Sciences, E. a. M. (2017). *Pain Management and Opioid Epidemic: Balancing Societal and Individual Benefits and Risks of Prescription Opioid Use*. N. A. Press. <http://nationalacademies.org/hmd/Reports/2017/pain-management-and-the-opioid-epidemic.aspx>.
- Neale, J., Nettleton, S., Pickering, L., 2012. Heroin users' views and experiences of physical activity, sport and exercise. *Int. J. Drug Policy* 23 (2), 120–127.
- Njoroge, M., 2018. Review on treatment of substance use disorders. *J. Addict. Res. Ther.* 9 (1) <https://doi.org/10.4172/2155-6105.1000353>.
- Owusu, C., Antognoli, E., Nock, N., Hergenroeder, P., Austin, K., Bennet, E., Berger, N.A., Cerne, S., Foraker, K., Heine, K., Heyman, E., Moore, H., Petkac, J., Schluchter, M., Schmitz, K.H., Whitson, A., Flocke, S., 2018. Perspective of older African-American and Non-Hispanic white breast cancer survivors from diverse socioeconomic backgrounds toward physical activity: a qualitative study. *J. Geriatr Oncol.* S1879-4068 (17), 30271. <https://doi.org/10.1016/j.jgo.2017.12.003>.
- Parvareh, N., Sabahi, A.R., Mazhari, S., Gilani, H., 2015. A Study of the Sexual Function, Sleep, and Weight Status of Patients after 6 Months of Methadone Maintenance Treatment. *Addict. Health.* 7 (1–2), 24–29. <http://www.ncbi.nlm.nih.gov/pubmed/26322207>.
- Peles, E., Schreiber, S., Sason, A., Adelson, M., 2016. Risk factors for weight gain during methadone maintenance treatment. *Subst. Abuse* 37 (4), 613–618. <https://doi.org/10.1080/0897077.2016.1179705> [doi] (Not in File).
- Read, J.P., Brown, R.A., Marcus, B.H., Kahler, C.W., Ramsey, S.E., Dubreuil, M.E., Jakicic, J.M., Francione, C., 2001. Exercise attitudes and behaviors among persons in treatment for alcohol use disorders. *J. Subst. Abuse Treat.* 21 (4), 199–206. [https://doi.org/10.1016/s0740-5472\(01\)00203-3](https://doi.org/10.1016/s0740-5472(01)00203-3).
- SAMHSA. (2022). Key substance use and mental health indicators in the United States: Results from the 2021 National Survey on Drug Use and Health. S. A. a. M. H. S. Center for Behavioral Health Statistics and Quality. <https://www.samhsa.gov/data/report/2021-nsduh-annual-national-report>.

- SAMHSA. (2017). *Key Substance Use and Mental Health Indicators in the United States: Results from the 2016 National Survey on Drug Use and Health*. S. A. a. M. H. S. A. (SAMHSA). <https://www.samsha.gov/data/>.
- Serretti, A., Mandelli, L., 2010. Antidepressants and body weight: a comprehensive review and meta-analysis. *J. Clin. Psychiatry* 71 (10), 1259–1272. <https://doi.org/10.4088/JCP.09r05346blu>.
- Simonton, A.J., Young, C.C., Brown, R.A., 2018a. Physical activity preferences and attitudes of individuals with substance use disorders: a review of the literature. *Issues Ment. Health Nurs.* 39 (8), 657–666. <https://doi.org/10.1080/01612840.2018.1429510>.
- Simonton, A.J., Young, C.C., Johnson, K.E., 2018b. Physical activity interventions to decrease substance use in youth: a review of the literature. *Subst. Use Misuse* 53 (12), 2052–2068. <https://doi.org/10.1080/10826084.2018.1452338>.
- Stahler, G.J., Mennis, J., DuCette, J.P., 2016. Residential and outpatient treatment completion for substance use disorders in the U.S.: moderation analysis by demographics and drug of choice. *Addict. Behav.* 58, 129–135. <https://doi.org/10.1016/j.addbeh.2016.02.030>.
- Stoutenberg, M., Warne, J., Vidot, D., Jimenez, E., Read, J.P., 2015. Attitudes and preferences towards exercise training in individuals with alcohol use disorders in a residential treatment setting. *J. Subst. Abuse Treat.* 49, 43–49. <https://doi.org/10.1016/j.jsat.2014.08.008>.
- Stoutenberg, M., Rethorst, C.D., Vidot, D.C., Greer, T.L., Trivedi, M.H., 2017. Cardiorespiratory fitness and body composition of stimulant users: a baseline analysis of the STRIDE cohort. *J. Subst. Abuse Treat.* 78, 74–79. <https://doi.org/10.1016/j.jsat.2017.05.005>.
- Thylstrup, B., Clausen, T., Hesse, M., 2015. Cardiovascular disease among people with drug use disorders. *Int. J. Public Health* 60 (6), 659–668. <https://doi.org/10.1007/s00038-015-0698-3> [doi] (Not in File).
- Trivedi, M.H., Greer, T.L., Rethorst, C.D., Carmody, T., Grannemann, B.D., Walker, R., Warden, D., Shores-Wilson, K., Stoutenberg, M., Oden, N., Silverstein, M., Hodgkins, C., Love, L., Seamans, C., Stotts, A., Causey, T., Szucs-Reed, R.P., Rinaldi, P., Myrick, H., Straus, M., Liu, D., Lindblad, R., Church, T., Blair, S.N., Nunes, E.V., 2017. Randomized Controlled Trial Comparing Exercise to Health Education for Stimulant Use Disorder: Results From the CTN-0037 Stimulant Reduction Intervention Using Dosed Exercise (STRIDE) Study. *J. Clin. Psychiatry* 78 (8), 1075–1082.
- Wachholtz, A., Gonzalez, G., 2014. Co-morbid pain and opioid addiction: Long term effect of opioid maintenance on acute pain. *Drug Alcohol Depend.* 145, 143–149.
- Wakeman, S.E., Larochelle, M.R., Ameli, O., Chaisson, C.E., McPheeters, J.T., Crown, W. H., Azocar, F., Sanghavi, D.M., 2020. Comparative effectiveness of different treatment pathways for opioid use disorder. *JAMA Netw. Open* 3 (2), e1920622.
- Wang, D., Wang, Y., Wang, Y., Li, R., Zhou, C., Raju, R., 2014. Impact of physical exercise on substance use disorders: a meta-analysis. *PLoSOne* 9 (10), e110728. <https://doi.org/10.1371/journal.pone.0110728>.
- Zorick, T., Nestor, L., Miotto, K., Sugar, C., Hellemann, G., Scanlon, G., Rawson, R., London, E.D., 2010. Withdrawal symptoms in abstinent methamphetamine-dependent subjects. *Addiction* 105 (10), 1809–1818. <https://doi.org/10.1111/j.1360-0443.2010.03066.x>.