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The feasibility and acceptability of high-intensity interval training for adults with mental illness: A pilot study

Running title: HIIT for adults with mental illness

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ABSTRACT

Introduction: Adults with mental illness have increased risk of cardiovascular disease. High-intensity interval training (HIIT) is more efficacious than moderate-intensity continuous training (MICT) for improving cardiorespiratory fitness (CRF); however, the utility of HIIT for this group is unclear. The aim of this study was to compare the feasibility and acceptability of HIIT and MICT in adults with mental illness. A secondary aim was to compare the efficacy of HIIT and MICT on mental health and fitness. **Method:** Inactive adults with self-reported mental illness participated in aerobic exercise three times/week over 12 weeks. Participants were randomised to HIIT (3x4-min bouts at 85–95% maximum heart rate [HR_{max}] interspersed with 3-min recovery bouts) or MICT (1x30-min at 65–75% HR_{max}). Feasibility was assessed using attendance and withdrawal rates. Acceptability and mental health was assessed using self-administered questionnaires. Fitness was measured using indirect calorimetry during a graded fitness test to exhaustion. **Results:** 24 participants consented and 16 participants began the intervention (HIIT, n=8; MICT, n=8). Completion rates (HIIT, n=4; MICT, n=5) and median attendances were similar (HIIT=81%, MICT=86%). Most participants were satisfied with their allocation (88% MICT; 100% HIIT), and found the exercise enjoyable (63% MICT; 100% HIIT). Equal numbers reported that they would like to continue the exercise (63%), and that they would feel confident doing so without supervision (75%). No significant differences were found between groups on mental health and fitness. **Conclusion:** This preliminary evidence suggests that HIIT was as acceptable and feasible as MICT for adults with mental illness.

Key words: HIIT; Aerobic exercise; Exercise intervention; Mental health; Pilot study; Randomised controlled trial

INTRODUCTION

Adults with mental illnesses have a mortality rate more than double that of the general population, and a 10-20 year lower life expectancy (Lawrence, Hancock, & Kisely, 2013). Evidence suggests that this mortality gap has increased in recent decades, and is largely attributable to preventable chronic conditions, such as cardiovascular disease (Lawrence et al., 2013). Exercise protects against chronic disease, decreases mortality risk(Barry et al., 2014), and can reduce symptoms of depression (Schuch et al., 2016), anxiety (Stonerock, Hoffman, Smith, & Blumenthal, 2015), and schizophrenia (Dauwan, Begemann, Heringa, & Sommer, 2015). Regular exercise also improves cardiorespiratory fitness (CRF), which is inversely related to cardiovascular and all-cause mortality (Blair et al., 1996).

High-intensity interval training (HIIT) involves alternating short bursts of high intensity exercise with recovery periods of rest or light exercise. HIIT can lead to greater improvements in CRF than moderate-intensity continuous training (MICT) in healthy individuals and cardiometabolic patients (Weston, Wisløff, & Coombes, 2013; Wisløff, Ellingsen, & Kemi, 2009). HIIT is also more effective than MICT at improving known cardiometabolic risk factors, such as insulin sensitivity, total and low-density lipoproteins, and endothelial function (Kilpatrick, Jung, & Little, 2014). In addition to the physical health benefits, HIIT may also improve mental health. Studies of HIIT in clinical groups with physical conditions (e.g. cardiac patients) have reported greater, or similar, improvements in quality of life compared with MICT (Fu et al., 2013; Moholdt et al., 2009; Molmen-Hansen et al., 2012; Wisløff et al., 2007), as well as similar reductions in symptoms of depression and anxiety (Freyssin et al., 2012).

Initial work has shown promise for the use of HIIT with adults with mental illness. Two controlled trials with inpatients with schizophrenia (Heggelund, Nilsberg, Hoff, Morken, & Helgerud, 2011), or substance use disorder (Flemmen, Unhjem, & Wang, 2014), reported that

8-weeks of HIIT for three sessions/week, using a 4x4 minute interval protocol, significantly improved fitness, but not mental illness symptoms. Another pre-post study used a 14-week HIIT protocol with 10x20-sec intervals and 90-sec recovery periods with patients with first episode psychosis; global functioning and severity, and social/occupational functioning remained similar, but waist circumference and VO_2max significantly improved (Abdel-Baki, Brazzini-Poisson, Marois, Letendre, & Karelis, 2013). One study on the acute effects of HIIT, reported that adults with depression or schizophrenia experienced improved mental health for up to 3-hours after a single session of 4x4 minute interval training (Heggelund, Kleppe, Morken, & Vedul-Kjelsås, 2014). These studies used conventional aerobic equipment (e.g. treadmill) to achieve the desired heart rate training ranges. One pre-post study with outpatients with schizophrenia used "body weight exercises" to achieve age-predicted heart rate ranges, and found that an 8-week, three sessions/week intervention, involving 15 minute sessions (4 sets of 3.75-minute intervals which included 5x15-s circuit intervals) significantly improved depression, anxiety, and negative symptoms of schizophrenia (Wu, Lee, Hsu, Chang, & Chen, 2015).

Preliminary evidence suggests that HIIT is a feasible exercise protocol for adults with mental illness: Mean attendance rates in the aforementioned studies ranged from 68%-92%, and attrition ranged from 10%-36% (Abdel-Baki et al., 2013; Flemmen et al., 2014; Heggelund et al., 2011; Wu et al., 2015). However, no studies have specifically compared the feasibility or acceptability of HIIT and MICT for adults with mental illness across a range of diagnoses. From a patient perspective, HIIT may be more appealing than MICT, because a similar health benefit can be achieved in a shorter time. Additionally, the short bursts of activity involved in HIIT may be more enjoyable than traditional endurance training (Tjønna et al., 2008). Conversely, some patients may find the higher intensity exercise uncomfortable (Blanchard, Rodgers, Spence, & Courneya, 2001).

The primary aim of this pilot study was to compare the feasibility and acceptability of HIIT with MICT, for adults with mental illness. The hypothesis was that HIIT would have better feasibility and acceptability than MICT, consistent with preliminary evidence from studies with other patient groups (Fu et al., 2013; Moholdt et al., 2009; Molmen-Hansen et al., 2012; Wisløff et al., 2007). The secondary aim was to compare the efficacy of HIIT and MICT on mental health and fitness.

METHODS

This was a two-group randomised study. Ethical approval was obtained from The University of Queensland Behavioural and Social Sciences Ethical Review Committee (2014000644), and the Princess Alexandra Hospital Metro South Human Ethical Review Committee (HREC/14/QPAH/202). Data were collected between October 2014 and July 2015 in Brisbane, Australia.

Procedure

Participants were recruited via general community advertisements (radio, local paper, online social media news articles), and clinician referral from private practice psychology clinics, and a local mental health outpatient unit. Individuals were eligible for the study if they: i) self-reported having a psychiatric diagnosis (any diagnosis not specified in the exclusion criteria), or were experiencing high psychological distress defined as a score >15 on the Kessler-6 scale (Kessler et al., 2002); ii) were currently receiving mental health treatment from a psychologist or psychiatrist; iii) were ambulatory; iv) were able to understand English, and v) were over 18 years of age. Exclusion criteria were: i) currently pregnant; ii) having acute symptoms of psychosis and considered insufficiently stable to participate (determined by the referring clinician); iii) having an eating disorder (e.g. anorexia nervosa, bulimia nervosa) characterised by excessive exercise; iv) having a mental illness secondary to a

diagnosed medical condition, and v) participating in more than 30 minutes per week of self-reported exercise. Participant information is shown in Table 1.

The lead researcher (JJC) met eligible individuals in person at an agreed location (often at their residence) to: i) obtain written informed consent for study participation; ii) obtain consent to contact their medical doctor for information related to their suitability to exercise; iii) administer the Adult Pre-exercise Screening System (APSS) (Norton et al., 2012); iv) administer a sociodemographic questionnaire (e.g. self-reported psychiatric diagnosis, education, employment; shown in Table 1); and v) provide accelerometers to measure baseline physical activity levels. Participants were asked to wear the accelerometer on a waist belt on the right hip, 24 hours/day (except when in water) for seven consecutive days, and note times to bed and out of bed each day in a log book.

After the initial meeting, participants were assigned a unique code that was sent to a biostatistician (AK) for randomisation. Participants were randomised in 1:1 ratio to HIIT or MICT conditions using block randomisation (block size of four). Participants were notified of their allocation at their first intervention exercise session, which was after completing all assessments.

After completing the accelerometry, participants were asked to attend an individualised baseline testing session. Participants were asked to refrain from vigorous activity and consuming alcohol for 24 hours, and from smoking for 2 hours, prior to the testing session. At the testing, participants completed self-administered mental health questionnaires, followed by anthropometric measures and a maximal fitness test. The lead researcher assisted an Exercise Physiologist with the assessments.

Assessments were completed at baseline and post-intervention (12 weeks). Participants were offered an AUD$20 gift card at completion of the baseline assessments, and an AUD$100 gift

card at completion of the post-intervention assessments. Participants were asked to complete the post-intervention assessments even if they withdrew from the study; however, those who withdrew because of exercise-related pain were not asked to complete the post-intervention fitness test.

Outcomes

Feasibility was assessed using recruitment numbers, attendance, completion rates, and reasons for withdrawal; completion of unsupervised sessions were assessed via self-report. Acceptability was assessed at post-intervention using ten questionnaire items developed for this study; responses were on a 5-point Likert scale (*strongly disagree*, *disagree*, *neither agree nor disagree*, *agree*, and *strongly agree*). Questionnaire items are shown in Table 2.

Symptoms of poor mental health were assessed using the Depression Anxiety Stress Scale (DASS21) (Lovibond & Lovibond, 1995), and the Psychological General Wellbeing Index (PGWBI) (Chassany, Dimenas, Dubois, & Wu, 2004). The DASS21 is a 21-item questionnaire to assess depression, anxiety and stress. Each subscale includes seven questions, with possible scores ranging from 0 to 21; the subscales have high internal reliability in adults across a range of mental illnesses (Cronbach's $\alpha = 0.94$, 0.87 and 0.91 for depression, anxiety, and stress respectively) (Antony, Bieling, Cox, Enns, & Swinson, 1998). The PGWBI consists of 22 items to assess six dimensions of wellbeing: anxiety, depressed mood, positive wellbeing, self-control, general health and vitality; possible scores range from 0 to 110 to form an overall index of general wellbeing (Chassany et al., 2004). The PGWBI has been shown to have satisfactory internal construct validity for patients with exhaustion related disorders (Lundgren-Nilsson, Jonsdottir, Ahlborg, & Tennant, 2013).

Body composition (percent fat mass, and fat free mass) was measured using bioelectric impedance. Height was measured to the nearest 0.1 cm using a stadiometer and waist was measured to the nearest 0.1 cm using a tape measure. Each was measured twice, and the

average taken as the point estimate. If there was more than a 1-cm difference between the two measurements, a third measurement was taken, and the average of the two closest values reported. Weight was measured to the nearest 0.01 kg using electronic scales.

Cardiorespiratory fitness (CRF) was assessed using a graded exercise test to exhaustion. Participants chose either treadmill or stationary bike; the modified Bruce protocol was used for the treadmill, and a ramping protocol was used for the stationary bike (Bruce, Kusumi, & Hosmer, 1973). Expired air was analysed using a standard metabolic system (Vmax, SensorMedics, Yorba Linda, CA), and electrocardiogram (ECG) was measured with a 12-lead ECG (GE Healthcare Case Machine, V6.51). Rate of perceived exertion was measured using the Borg scale, and blood pressure was manually measured using a stethoscope, every three minutes. The 20-second averaged rate of oxygen consumption during the final minute was used to calculate VO_2max. The maximum heart rate (HR_{max}) achieved during the test was used to calculate the HR training range.

Intervention protocol

Both HIIT and MICT conditions involved three sessions per week for 12 weeks (36 sessions total). Supervision was provided by the lead researcher (JJC), who is a qualified personal trainer. During supervised sessions, participants could use a treadmill or stationary bike, and were encouraged to use the same machine they used for the fitness test. Supervised exercise sessions were scheduled per participant availability, and were conducted in groups of up to five at the School of Human Movement and Nutrition Sciences Exercise Physiology research laboratory. Supervision was tapered over the program: three sessions/week were supervised for the first eight weeks; two sessions/week were supervised in the final four weeks, and participants were asked to complete one self-directed session/week at home. Exercise type for self-directed sessions was jogging or cycling.

HIIT: Three 4-minute (3x4-minute) intervals at 85-95% of HR_{max}, interspersed by 3-minute recovery periods at 60-70% HR_{max}. Training ranges had to be achieved within the first two minutes of each interval. Each session began with a 4-minute warm-up, and finished with a 3-minute warm-down at 60-70% of HR_{max}. The total session duration was 25 minutes.

MICT: 30 minutes at 65-75% of the HR_{max}. Each session began with a 3-minute warm-up, and finished with a 2-minute warm-down at 60-70% of HR_{max}. The total session duration was 35 minutes.

HR ranges during supervised sessions were achieved by adjusting ergometer resistance, and treadmill speed and/or incline. Polar FT1 heart rate monitors (Polar Electro, Finland) were used to monitor compliance with target heart rates. HR was recorded at the end of each interval for HIIT participants, and at 20 minutes and 30 minutes for MICT participants. Blood pressure was measured before and after each session; participants with hypertension (140/90 mm Hg) were required to rest until blood pressure returned to baseline. Participants were given a HR monitor to use for self-directed sessions, and the researcher met with participants at their residence to assist with planning an exercise route. There were no restrictions from engaging in additional exercise outside the study requirements.

Data management

Responses to the acceptability questionnaire were collapsed into three categories (*disagree*, *neutral*, *agree*) to generate summary statistics. These were then collapsed to two categories (*disagree/neutral*, *agree*) for analysis. Accelerometer data recorded during participants' waking hours defined by their self-reported time to bed and out of bed, were analysed to determine baseline activity levels. Consecutive zero counts of 60 minutes or longer were defined as non-wear and removed; data were considered valid if the accelerometer was worn for at least 80% of waking hours (J. J. Chapman, Brown, W.J., and Burton, N.W., 2015) on at least three days. Data from the accelerometer's vertical axis were converted to counts per

minute (cpm) and used to define sedentary behaviour (SB; ≤100 cpm), light activity (101–2,019 cpm), and moderate-to-vigorous activity (MVPA; >2,019 cpm).

Analysis

As an indicator of feasibility, attendance for all participants who did not withdraw were compared between HIIT and MICT conditions using Mann-Whitney U tests. Acceptability questionnaire items were compared for all HIIT and MICT participants who completed at least one exercise session, using Chi-square Fisher's exact tests. Participants were asked to complete the post-intervention outcome assessments even if they withdrew from the study; all participants who provided post-intervention data were included in the analyses of outcome variables (depression, anxiety, stress, wellbeing, VO_2max). *Per protocol* analyses included participants who completed at least 70% of the exercise sessions. Wilcoxon sign rank tests were used to compare within-group pre-post scores for HIIT and MICT groups, and Mann-Whitney U tests were used to compare the *percent change* in between groups. Participant baseline characteristics for HIIT and MICT conditions were compared using Mann-Whitney U tests for continuous variables (age, BMI, scores of depression, anxiety, stress and wellbeing, and time spent in SB, light activity, and MVPA), and Fisher's exact test for categorical variables (sex). Analyses were performed using SPSS version 23. Statistical significance was set at $p<0.05$.

RESULTS

Participants

A participant flow diagram is shown in Figure 1. Fifty-four individuals were screened for study entry: 32 (59%) made contact after finding out about the study from community advertisements, 21 (39%) were referred from the outpatient clinic, and one (2%) was referred by a psychologist in private practice. Of those screened, 24 (44%) met the eligibility criteria. The most common reasons for ineligibility were already doing more than 30 minutes per

week of self-reported exercise (43%), and not receiving mental health treatment from a psychologist or psychiatrist (20%). Participant health and demographic characteristics at baseline are presented in Table 1.

Of the 24 participants who received accelerometers at baseline, 21 completed the accelerometer protocol, and of those 19 (90%) provided valid accelerometry data (HIIT=9, MICT=10). Participants in each group had similar accelerometer-derived SB (U=61.0, p=0.211), light activity (U=44.0, p=0.968), and MVPA (U=38.0, p=0.604), and were of similar age (U=68.5, p=0.880), BMI (U=32, p=0.069), and gender (Fisher's exact test, p=0.414). Participants also had similar scores for baseline depression (U=59.5, p=0.974), anxiety (U=66.0, p=0.722), stress (U=74.5, p=0.346), and wellbeing (U=35.0, p=0.107). Participants who withdrew but still provided post-intervention data were similar to those who completed the exercise program on all baseline measures (p>0.05).

Feasibility

Withdrawals

Two participants withdrew after completing the baseline accelerometry, but prior to completing the fitness test, or being told their group allocation. These participants had schizophrenia (n=1) and bipolar disorder (n=1), and withdrew due to personal concerns about inability to attend due to poor mental health (e.g. disorganisation, or having regular "bad days"). Twenty-two participants (92% of those randomised) completed all baseline assessments, six of whom (27%) withdrew prior to being told their group allocation. Reasons for withdrawal were: "Too much going on in their life" (n=1), recent surgery (n=1), psychiatric admission (n=1), and self-consciousness (n=1). Two people did not provide reasons for withdrawal.

Of the 16 participants who began the exercise program, equal numbers were allocated to HIIT (n=8) and MICT (n=8). Seven participants (44% of total) withdrew before completing the 12-week program (HIIT=4; MICT=3), after a median of three weeks (range=2-7). The most common reason for withdrawal was exacerbation of a pre-existing musculoskeletal condition (n=4): back/hip pain (HIIT=2) and shin/ankle pain (MICT=2). Two participants withdrew due to transport difficulties (HIIT=1, MICT=1): one because of fuel costs, and one because of an inability to organise public transport. One HIIT participant withdrew because the exercise was perceived as too difficult.

Completion and attendance

Median attendance for the five participants who completed the MICT program was 86% (IQR=59-90%), or 31 of 36 sessions (IQR=20-33). Median attendance for the four participants who completed the HIIT program was 81% (IQR=43-95%), or 29 of 36 sessions (IQR=16-34). Attendance was similar in the two groups (U=10.0, p=1.0). Nine participants (50% of those who began the program) completed the exercise program (HIIT=4, MICT=5). Three HIIT participants, and four MICT participants completed at least 70% of sessions (78% of those who completed). The numbers of participants who completed each assessment are shown in

FIGURE **CAPTIONS**

Figure 1: Participant flow diagram

HIIT: high-intensity interval training; MICT: moderate-intensity continuous training.

[a] Withdrew before completing mental and physical health baseline assessments, but after providing written informed consent, completing a demographics questionnaire, and wearing an accelerometer for 7 days.

[b] Withdrew after completing the baseline assessments (including the fitness test) but before receiving their group allocation.

[c] Participants who withdrew were invited to complete the post-intervention assessments; those who withdrew to exercise-related pain were not asked to complete the post-intervention fitness test.

Figure 2: Baseline and post-intervention mental health scores of participants completing at least 70% of the program

Median pre-intervention (black bars) and post-intervention (shaded bars) scores on mental health outcomes are shown for participants who completed at least 70% of exercise sessions; individual data are plotted as solid lines. Possible depression, anxiety and stress scores range from 0 to 21, higher scores represent higher severity. Possible wellbeing scores range from 0 to 110, higher scores represent better wellbeing. HIIT: High intensity interval training; MICT: Moderate intensity continuous training.

281 **Table 1: Health and demographic characteristics of participants at baseline**

	HIIT (n=12)	MICT (n=12)	All (n=24)
	Mean (SD)	**Mean (SD)**	**Mean (SD)**
Age (years)	37.4 (10.4)	38.6 (11.7)	38.0 (10.8)
Female n (%)	7 (58%)	4 (33%)	11 (92%)
Psychological distress [a]	15.3 (6.6)	17.5 (3.6)	16.3 (5.4)
Self-reported diagnosis	**n (%)**	**n (%)**	**n (%)**
Psychoses	3 (25%)	3 (25%)	6 (25%)
Depression	1 (8%)	3 (25%)	4 (17%)
Bipolar disorder	3 (25%)	1 (8%)	4 (17%)
Anxiety	0 (0%)	1 (8%)	1 (4%)
Delusional disorder	1 (8%)	0 (0%)	1 (%)
Depression and anxiety [b]	2 (17%)	1 (8%)	3 (12%)
Depression, anxiety and *other* [c]	1 (8%)	2 (17%)	3 (12%)
Depression and BPD	1 (8%)	0 (0%)	1 (4%)
Bipolar and BPD	0 (0%)	1 (8%)	1 (4%)
Education			
Did not finish high school	1 (8%)	4 (33%)	5 (21%)
High school	2 (17%)	5 (42%)	7 (29%)
Certificate/diploma (college)	6 (50%)	2 (17%)	8 (33%)
Tertiary degree (university)	3 (25%)	1 (8%)	4 (17%)
Employment			
Full-time/part-time	1 (8%)	1 (8%)	2 (8%)
Student	2 (17%)	0 (0%)	2 (8%)
Unemployed / looking for work	3 (25%)	7 (58%)	10 (42%)
Unable to work	6 (50%)	4 (33%)	10 (42%)
Smoker status			
Never/ex-smoker	6 (50%)	4 (33%)	10 (42%)
Daily/occasionally	6 (50%)	8 (67%)	14 (58%)
BMI (kg/m^2) [d]			
<18.5	0 (0%)	1 (10%)	1 (4%)
18.5 – 24.9	1 (8%)	1 (10%)	2 (8%)
25 – 29.9	4 (33%)	6 (60%)	10 (42%)

>30	7 (58%)	2 (20%)	9 (38%)

HIIT: high-intensity interval training; MICT: moderate-intensity continuous training; BPD: borderline personality disorder; BMI: Body Mass Index.

[a] Psychological distress was measured using the Kessler-6 scale; scores range from 6 to 30, scores over 15 indicate high distress.

[b] The participant allocated to MICT had a diagnosis of postnatal depression.

[c] *Other* here refers to i) alcohol dependence, ii) binge-eating disorder, and iii) borderline personality disorder.

[d] BMI calculated as weight (kg) / height $(m)^2$. Height and weight were measured for participants who completed the baseline fitness test, BMI was therefore available for 22 participants (HIIT, n=12; MICT, n=10).

293 **Table 2: Acceptability of the exercise condition (n=16)**

Questionnaire item	Group	Disagree n (%)	Neutral n (%)	Agree n (%)
I feel satisfied with the exercise condition that I was allocated to	HIIT	0 (0%)	1 (13%)	7 (88%)
	MICT	0 (0%)	0 (0%)	8 (100%)
I would have preferred to be in the other exercise condition	HIIT	4 (50%)	3 (38%)	1 (13%)
	MICT	6 (75%)	2 (25%)	0 (0%)
I found the exercise enjoyable	HIIT	0 (0%)	0 (0%)	8 (100%)
	MICT	1 (13%)	2 (25%)	5 (63%)
I found the exercise too hard	HIIT	4 (50%)	2 (25%)	2 (25%)
	MICT	6 (75%)	2 (25%)	0 (0%)
I found the exercise boring	HIIT	4 (50%)	4 (50%)	0 (0%)
	MICT	4 (50%)	3 (38%)	1 (13%)
I would have preferred group-based exercise	HIIT	4 (50%)	2 (25%)	2 (25%)
	MICT	6 (75%)	0 (0%)	2 (25%)
I looked forward to the exercise sessions	HIIT	2 (25%)	3 (38%)	3 (38%)
	MICT	2 (25%)	2 (25%)	4 (50%)
I would like to continue doing this kind of exercise outside of the study	HIIT	2 (25%)	1 (13%)	5 (63%)
	MICT	1 (13%)	2 (25%)	5 (63%)
I would feel confident doing this kind of exercise without assistance	HIIT	1 (13%)	1 (13%)	6 (75%)
	MICT	0 (0%)	2 (25%)	6 (75%)
I would feel confident being able to do this kind of exercise when having a bad day	HIIT	4 (50%)	2 (25%)	2 (25%)
	MICT	3 (38%)	5 (63%)	0 (0%)

294 HIIT: High-intensity interval training; MICT: Moderate intensity continuous training.

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296 **Table 3: Study outcomes for all participants who completed post-intervention**
297 **assessment**

	HIIT		MICT	
	Baseline	**12-weeks**	**Baseline**	**12-weeks**
Mental health		**(n=9)**		**(n=10)**
DASS21 [a]				
Depression	14 (5, 16)	9 (3, 13)	7 (9, 10)	9 (4, 13)
% change		-25 (-50, 29)		-20 (-50, 50)
Anxiety	7 (2, 12)	1 (0, 7)	6 (4, 9)	6 (3, 7)
% change		-43 (-100, 0)		5 (-50, 4)
Stress	12 (3, 14)	6 (3, 10)	12 (10, 14)	8 (5, 12)
% change		0 (-45, 29)		-22 (-58, 0)
PGWBI total score [b]	61 (43, 76)	68 (54, 75)	50 (45, 58)	52 (47, 73)
% change		13 (-9, 22)		20 (-5, 44)
Physical health		**(n=7)**		**(n=9)**
Weight (kg)	85 (79, 106)	83 (81, 105)	87 (72, 96)	84 (73, 93)
BMI (kg/m^2)	31 (27, 33)	31 (27, 32)	27 (24, 29)	28 (25, 28)
Waist circumference (cm)	100 (93, 110)	103 (89, 119)	90 (81, 101)	92 (85, 101)
% fat mass	30 (25, 41)	32 (24, 35)	28 (24, 40)	27 (16, 32)
VO_2 max (ml/kg/min) [c]	21 (20, 28)	23 (18, 29)	24 (21, 32)	22 (21, 33)

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299 DASS21=Depression Anxiety Stress Scale; PGWBI=Psychological General Wellbeing Index.
300 [a] Possible depression, anxiety and stress scores range from 0 to 21, higher scores represent
301 greater severity of symptoms (i.e. a negative change indicates improved mental health).
302 [b] Possible wellbeing scores range from 0 to 110, higher scores represent greater wellbeing.
303 [c] A total of 12 participants (HIIT n=6, MICT n=6) completed the post-intervention maximal
304 fitness tests. One HIIT participant's VO_2max results were excluded due to a technical error.

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Acceptability

Responses to acceptability items are presented in Table 2; only participants who began their first exercise session were included in the acceptability analyses (MICT=8, HIIT=8). Most participants were satisfied with their allocation (MICT=8, HIIT=7). Few reported that the exercise was boring (MICT=1, HIIT=0), or too hard (MICT=0, HIIT=2), and there was a suggestion that more HIIT than MICT participants found the exercise enjoyable (MICT=5, HIIT=8). Equal numbers reported that they'd like to continue that kind of exercise after the study (63%), and that they'd feel confident doing so without supervision (75%). Chi-square Fisher's exact tests did not reveal any significant differences between conditions for any of the acceptability items ($p>0.1$).

Mental and physical health outcomes

Aggregated baseline and post-intervention scores are presented in Figure 2, and Table 3. There were no statistically significant within-group differences between pre- and post-intervention mental health outcomes or fitness, for either HIIT (depression: $p=0.09$, anxiety: $p=0.06$, stress: $p=0.27$, wellbeing: $p=0.48$, VO_2max: $p=0.89$) or MICT (depression: $p=0.77$, anxiety: $p=0.12$, stress: $p=0.09$, wellbeing: $p=0.13$, VO_2max: $p=0.92$). There were no statistically significant differences between HIIT and MICT participants in the percent change in mental health outcomes or fitness, for all who provided post-intervention data (MICT n=10, HIIT n=9; depression: $p=0.83$, anxiety: $p=0.12$, stress: $p=0.52$, wellbeing: $p=0.50$, VO_2max: $p=1.0$) or the per protocol sample (depression: $p=0.86$, anxiety: $p=0.06$, stress: $p=0.63$, wellbeing: $p=0.40$, VO_2max: $p=1.0$).

Additional observations

There was great diversity among participants and in their responses to the exercise program. For example, two participants had complex presentations of mental illness (e.g. multiple comorbidities, hospital admission during the program etc.), but still completed the program

with high attendance (>70%), and showed marked improvements in mental health. In contrast, three other participants cited poor mental health as the reason for low attendance, and reported poorer mental health at post-intervention; for example, one participant withdrew and re-enrolled three times before beginning the exercise, finally withdrawing due to disorganisation and antipsychotic medication side-effects. Some participants had strong support for attending the exercise sessions; for example, one participant's partner drove her to exercise sessions, bought an activity monitor (Fitbit) for her, and actively encouraged her to reach walking goals. Other participants had strong motivation to improve their health, and began additional exercise (e.g. began participating in fun runs). Two participants who withdrew before completing four weeks of the intervention reported better mental health at follow-up due to improvements in other life circumstances (e.g. housing situation resolved).

DISCUSSION

The primary aim of this study was to compare the feasibility and acceptability of HIIT with MICT for adults with mental illness. Contrary to our hypothesis, HIIT and MICT had similar feasibility and acceptability; attendance and withdrawal rates, and responses on acceptability questionnaire items were similar. Most HIIT and MICT participants found the exercise enjoyable, and said they would like to continue the exercise after the study. A secondary aim was to evaluate the efficacy of each exercise condition on mental health and fitness. Although there was some suggestion of a greater anxiolytic effect in HIIT, there were no significant differences in the outcomes because of limited statistical power.

In terms of feasibility, it is notable that study attrition was high *overall*: 63% (n=15) of randomised participants withdrew. This is higher than attrition rates reported in most previous exercise training studies with adults with mental illness: meta-analyses reported pooled attrition of 18% (95%CI=15–22%) for adults with major depression (Stubbs et al., 2016), and 27% (95%CI=20%–35%) for adults with schizophrenia (Vancampfort et al., 2016). In this

study about half of those who withdrew (n=8; 53% of withdrawals) did so after completing the baseline assessments, but before receiving their group allocation. This may indicate that the context of the exercise (exercise laboratory at a university), rather than the type of exercise, negatively influenced participation for these individuals. Further, all participants stated that the VO_2max test (which involved wearing a head piece and nose-clip, breathing through a mouthpiece, and being monitored with a 12-lead ECG) was an unpleasant experience, which may have influenced their decision to withdraw. Future research into the feasibility of exercise interventions for adults with mental illness could use less invasive approaches to assess cardiorespiratory fitness (e.g. submaximal testing) or an indirect measure of exercise capacity e.g. six-minute walk test (Vancampfort et al., 2015).

Attrition after commencing the exercise program was also high: 44% (n=7) of those who began the exercise program withdrew. Withdrawal rates were similar for HIIT and MICT conditions (HIIT=4; MICT=3), and may therefore have been independent of exercise intensity. The most common reason for withdrawal was the exacerbation of a pre-existing musculoskeletal injury. Although participants could switch to a different aerobic machine to minimise further exacerbation (e.g. stationary cycling instead of treadmill), this did not resolve the pain issues in some cases. As we only included inactive individuals in the study, low conditioning may have made them more susceptible to exercise-related pain. The feasibility of HIIT and MICT programs could be improved by incorporating a lower-intensity pre-conditioning phase, including rehabilitation exercises to minimise exacerbation or injury (e.g. core stability exercise for participants with low back pain), or including other aerobic machines to reduce impact (e.g. upper body ergometer). Other reasons for withdrawal included transport related issues (fuel costs, unable to organise regular attendance), and self-consciousness about attending a busy university. Accessibility could be improved by offering

transport assistance, or conducting exercise programs at community exercise facilities or within the local neighbourhood (e.g. outdoor walking groups).

Most (86%) participants who withdrew from the program did so in the first six weeks. This suggests that more focused support (e.g. transport assistance) during this initial period could assist participants to overcome PA barriers, and improve program feasibility. However, participants who completed the program did so with high attendance: median attendance was 81% and 86% for HIIT and MICT groups, respectively. Anecdotally, those with strong social support or motivation had highest attendance. Facilitating social support and increasing motivation during the first six weeks may improve overall adherence to an exercise intervention (Gross, Vancampfort, Stubbs, Gorczynski, & Soundy, 2016). Social support could be increased by encouraging participants to exercise with a friend or someone they know, or by facilitating a 'team' environment among exercise participants, e.g. by providing team t-shirts, or setting group challenges (e.g. cumulatively walk a certain distance every week). Motivation could be increased by including exercise counselling or motivational interviewing.

No statistically significant between- or within-group differences in mental health were found at post-intervention. The greatest improvement was in anxiety scores for HIIT participants (median reduction of 43%): The three participants who completed at least 70% of HIIT sessions demonstrated a complete remission of anxiety symptoms. However, this was not statistically significant ($p=0.06$), possibly due to small sample size. Anecdotally, participants with positive expectation and a commitment to the exercise benefitted the most. A diverse range of life circumstances (e.g. housing, medication etc.), however, may have influenced mental health outcomes, independent of potential exercise effects.

No significant between-group differences in fitness were found at post-intervention. Previous studies in patients with cardiometabolic disease have shown greater improvements in

405 VO_2max following HIIT interventions (19%, compared with 10% for MICT; mean difference
406 ~3 $mL \cdot kg^{-1} \cdot min^{-1}$) (Weston et al., 2013), and that HIIT protocols using a 4x4-minute intervals
407 were most efficacious (Weston et al., 2013). We used 3x4-minute intervals because we
408 believed that 4x4-minute intervals would be too demanding for inactive, sedentary patients
409 with a chronic mental illness, and this may have reduced potential fitness gains. Participants
410 were given heart rate monitors to use during their four unsupervised sessions; however,
411 compliance may have been lower in unsupervised settings (e.g. to the prescribed intensity,
412 duration, number of sets), which may also have reduced potential improvements in mental
413 health and fitness.

414 This is the first study to compare the feasibility and acceptability of HIIT and MICT for
415 adults with mental illness. A strength of this study is that our sample had a diverse range of
416 psychiatric diagnoses. Previous research into HIIT for adults with mental illness has focused
417 on patients with one specific diagnosis (e.g. schizophrenia, depression, substance use)
418 (Abdel-Baki et al., 2013; Flemmen et al., 2014; Heggelund et al., 2014; Heggelund et al.,
419 2011; Wu et al., 2015). Understanding the feasibility and acceptability of different exercise
420 approaches for heterogeneous patient groups may guide the implementation of exercise
421 programs in mental health services, where patient groups are likely to be diverse. A limitation
422 is that this study was underpowered due to the higher than expected attrition. Further, medical
423 comorbidities, or the type, dose, or changes to conventional mental health treatments (e.g.
424 medications, psychotherapy) were not assessed. Conventional treatments may confound
425 mental health outcomes via associated changes in mental health; medical comorbidities may
426 also influence mental health via pain and reduced mobility (Stubbs et al., 2015), and are
427 commonly reported as a barrier to physical activity, which may influence program feasibility
428 (J. J. Chapman, Fraser, Brown, & Burton, 2016).

In summary, this preliminary evidence suggests that both HIIT and MICT are acceptable and feasible forms of exercise for adults across a range of mental illnesses. Community-based exercise programs with tailoring of exercises to participant abilities, and support in the initial stages of training to overcome physical activity barriers and enhance motivation, may improve adherence and reduce withdrawal rates. Larger trials with more comprehensive assessment of potential confounders are necessary to compare the efficacy of HIIT and MICT on mental health and fitness for adults with mental illness.

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CONFLIST OF INTEREST

The authors declare that there are no conflicts of interest.

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FIGURE CAPTIONS

Figure 1: Participant flow diagram

HIIT: high-intensity interval training; MICT: moderate-intensity continuous training.

[a] Withdrew before completing mental and physical health baseline assessments, but after providing written informed consent, completing a demographics questionnaire, and wearing an accelerometer for 7 days.

[b] Withdrew after completing the baseline assessments (including the fitness test) but before receiving their group allocation.

[c] Participants who withdrew were invited to complete the post-intervention assessments; those who withdrew to exercise-related pain were not asked to complete the post-intervention fitness test.

Figure 2: Baseline and post-intervention mental health scores of participants completing at least 70% of the program

Median pre-intervention (black bars) and post-intervention (shaded bars) scores on mental health outcomes are shown for participants who completed at least 70% of exercise sessions; individual data are plotted as solid lines. Possible depression, anxiety and stress scores range from 0 to 21, higher scores represent higher severity. Possible wellbeing scores range from 0 to 110, higher scores represent better wellbeing. HIIT: High intensity interval training; MICT: Moderate intensity continuous training.

582 **Table 1: Health and demographic characteristics of participants at baseline**

	HIIT (n=12)	MICT (n=12)	All (n=24)
	Mean (SD)	**Mean (SD)**	**Mean (SD)**
Age (years)	37.4 (10.4)	38.6 (11.7)	38.0 (10.8)
Female n (%)	7 (58%)	4 (33%)	11 (92%)
Psychological distress [a]	15.3 (6.6)	17.5 (3.6)	16.3 (5.4)
Self-reported diagnosis	**n (%)**	**n (%)**	**n (%)**
Psychoses	3 (25%)	3 (25%)	6 (25%)
Depression	1 (8%)	3 (25%)	4 (17%)
Bipolar disorder	3 (25%)	1 (8%)	4 (17%)
Anxiety	0 (0%)	1 (8%)	1 (4%)
Delusional disorder	1 (8%)	0 (0%)	1 (%)
Depression and anxiety [b]	2 (17%)	1 (8%)	3 (12%)
Depression, anxiety and *other* [c]	1 (8%)	2 (17%)	3 (12%)
Depression and BPD	1 (8%)	0 (0%)	1 (4%)
Bipolar and BPD	0 (0%)	1 (8%)	1 (4%)
Education			
Did not finish high school	1 (8%)	4 (33%)	5 (21%)
High school	2 (17%)	5 (42%)	7 (29%)
Certificate/diploma (college)	6 (50%)	2 (17%)	8 (33%)
Tertiary degree (university)	3 (25%)	1 (8%)	4 (17%)
Employment			
Full-time/part-time	1 (8%)	1 (8%)	2 (8%)
Student	2 (17%)	0 (0%)	2 (8%)
Unemployed / looking for work	3 (25%)	7 (58%)	10 (42%)
Unable to work	6 (50%)	4 (33%)	10 (42%)
Smoker status			
Never/ex-smoker	6 (50%)	4 (33%)	10 (42%)
Daily/occasionally	6 (50%)	8 (67%)	14 (58%)
BMI (kg/m^2) [d]			
<18.5	0 (0%)	1 (10%)	1 (4%)
18.5 – 24.9	1 (8%)	1 (10%)	2 (8%)
25 – 29.9	4 (33%)	6 (60%)	10 (42%)

>30	7 (58%)	2 (20%)	9 (38%)

HIIT: high-intensity interval training; MICT: moderate-intensity continuous training; BPD: borderline personality disorder; BMI: Body Mass Index.

[a] Psychological distress was measured using the Kessler-6 scale; scores range from 6 to 30, scores over 15 indicate high distress.

[b] The participant allocated to MICT had a diagnosis of postnatal depression.

[c] *Other* here refers to i) alcohol dependence, ii) binge-eating disorder, and iii) borderline personality disorder.

[d] BMI calculated as weight (kg) / height $(m)^2$. Height and weight were measured for participants who completed the baseline fitness test, BMI was therefore available for 22 participants (HIIT, n=12; MICT, n=10).

Table 2: Acceptability of the exercise condition (n=16)

Questionnaire item	Group	Disagree n (%)	Neutral n (%)	Agree n (%)
I feel satisfied with the exercise condition that I was allocated to	HIIT	0 (0%)	1 (13%)	7 (88%)
	MICT	0 (0%)	0 (0%)	8 (100%)
I would have preferred to be in the other exercise condition	HIIT	4 (50%)	3 (38%)	1 (13%)
	MICT	6 (75%)	2 (25%)	0 (0%)
I found the exercise enjoyable	HIIT	0 (0%)	0 (0%)	8 (100%)
	MICT	1 (13%)	2 (25%)	5 (63%)
I found the exercise too hard	HIIT	4 (50%)	2 (25%)	2 (25%)
	MICT	6 (75%)	2 (25%)	0 (0%)
I found the exercise boring	HIIT	4 (50%)	4 (50%)	0 (0%)
	MICT	4 (50%)	3 (38%)	1 (13%)
I would have preferred group-based exercise	HIIT	4 (50%)	2 (25%)	2 (25%)
	MICT	6 (75%)	0 (0%)	2 (25%)
I looked forward to the exercise sessions	HIIT	2 (25%)	3 (38%)	3 (38%)
	MICT	2 (25%)	2 (25%)	4 (50%)
I would like to continue doing this kind of exercise outside of the study	HIIT	2 (25%)	1 (13%)	5 (63%)
	MICT	1 (13%)	2 (25%)	5 (63%)
I would feel confident doing this kind of exercise without assistance	HIIT	1 (13%)	1 (13%)	6 (75%)
	MICT	0 (0%)	2 (25%)	6 (75%)
I would feel confident being able to do this kind of exercise when having a bad day	HIIT	4 (50%)	2 (25%)	2 (25%)
	MICT	3 (38%)	5 (63%)	0 (0%)

HIIT: High-intensity interval training; MICT: Moderate intensity continuous training.

Table 3: Study outcomes for all participants who completed post-intervention assessment

	HIIT		MICT	
	Baseline	**12-weeks**	**Baseline**	**12-weeks**
Mental health		**(n=9)**		**(n=10)**
DASS21 [a]				
Depression	14 (5, 16)	9 (3, 13)	7 (9, 10)	9 (4, 13)
% change		-25 (-50, 29)		-20 (-50, 50)
Anxiety	7 (2, 12)	1 (0, 7)	6 (4, 9)	6 (3, 7)
% change		-43 (-100, 0)		5 (-50, 4)
Stress	12 (3, 14)	6 (3, 10)	12 (10, 14)	8 (5, 12)
% change		0 (-45, 29)		-22 (-58, 0)
PGWBI total score [b]	61 (43, 76)	68 (54, 75)	50 (45, 58)	52 (47, 73)
% change		13 (-9, 22)		20 (-5, 44)
Physical health		**(n=7)**		**(n=9)**
Weight (kg)	85 (79, 106)	83 (81, 105)	87 (72, 96)	84 (73, 93)
BMI (kg/m^2)	31 (27, 33)	31 (27, 32)	27 (24, 29)	28 (25, 28)
Waist circumference (cm)	100 (93, 110)	103 (89, 119)	90 (81, 101)	92 (85, 101)
% fat mass	30 (25, 41)	32 (24, 35)	28 (24, 40)	27 (16, 32)
VO_2 max (ml/kg/min) [c]	21 (20, 28)	23 (18, 29)	24 (21, 32)	22 (21, 33)

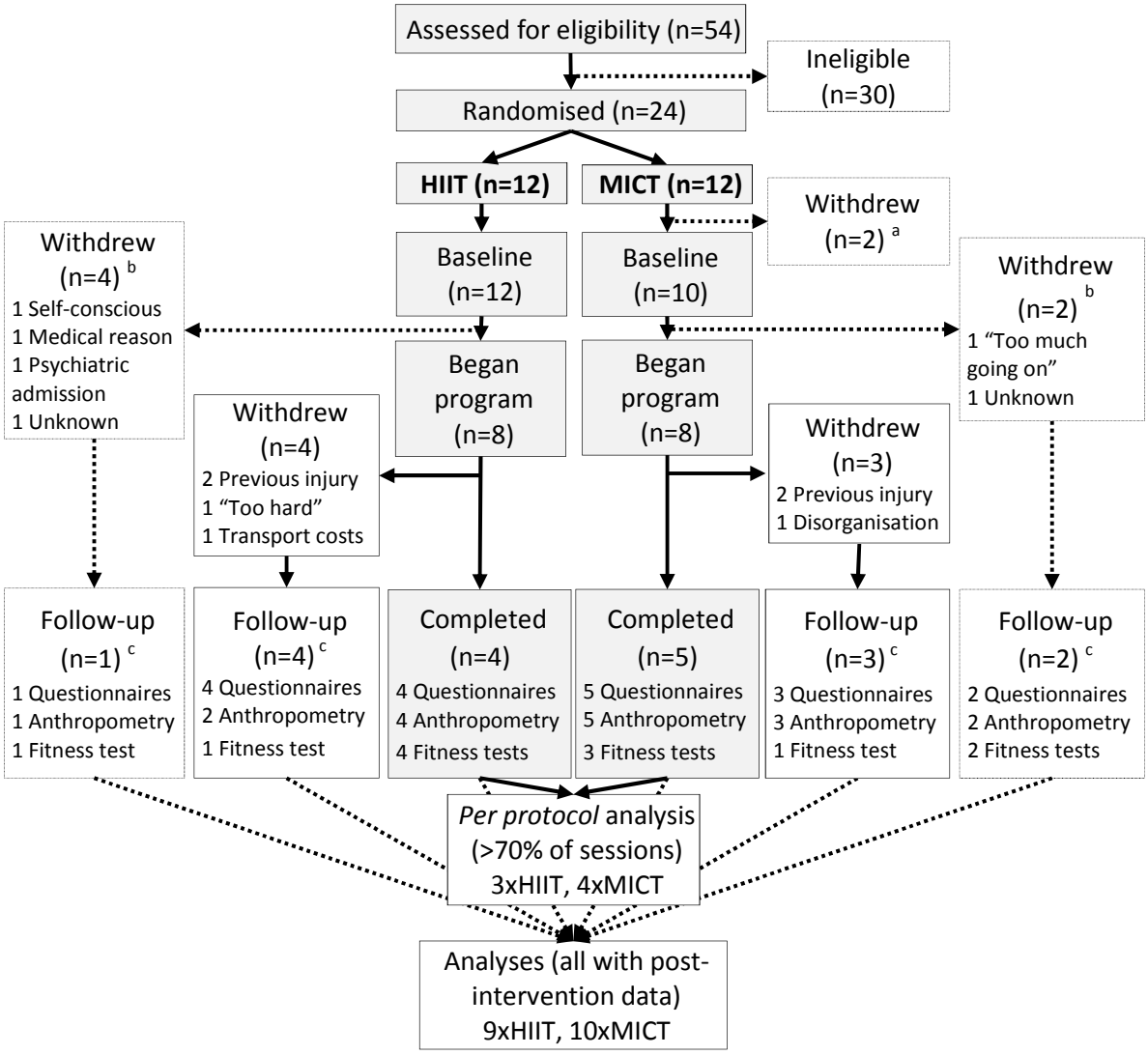
Note: all values quoted as median (25^{th} – 75^{th} percentile).

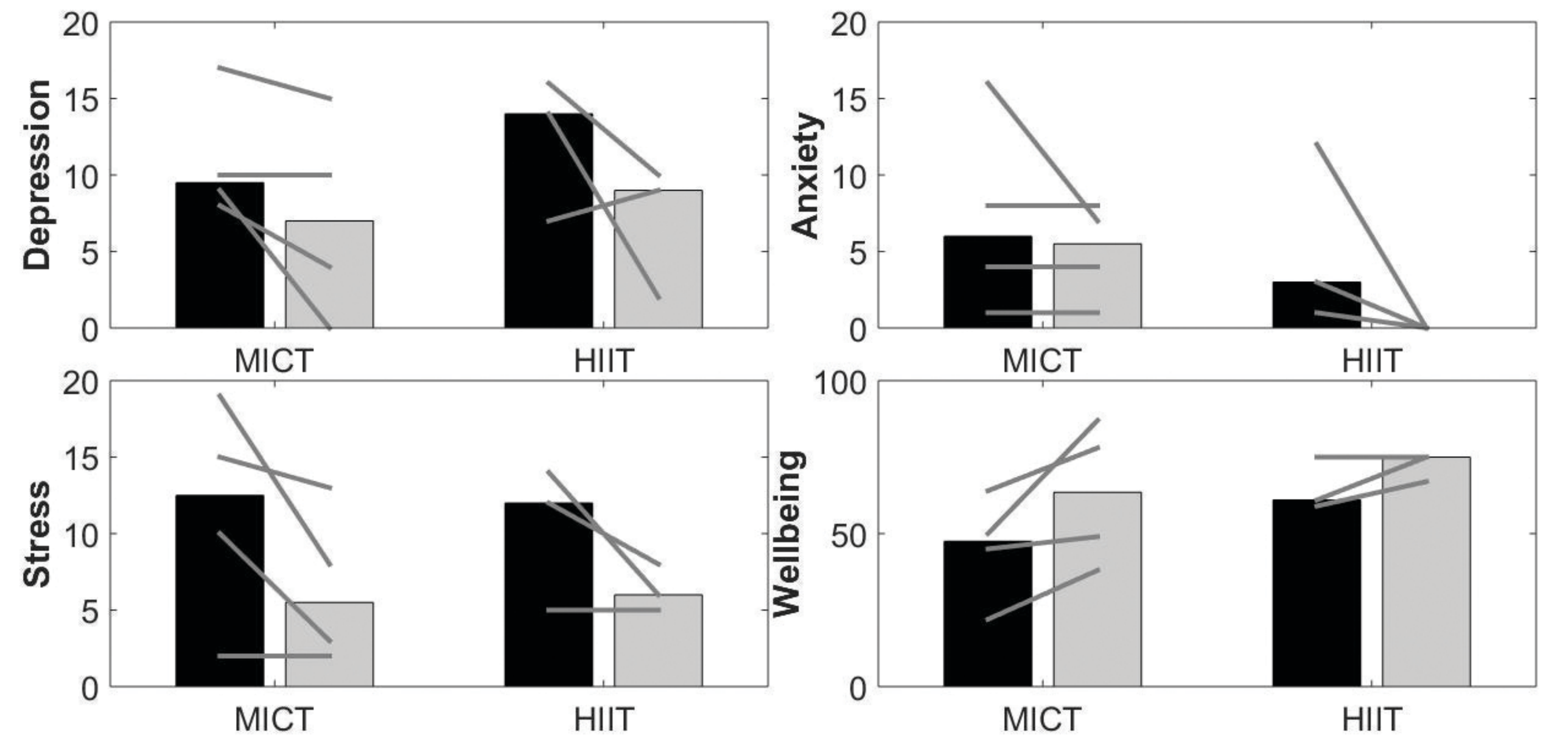
DASS21=Depression Anxiety Stress Scale; PGWBI=Psychological General Wellbeing Index.

[a] Possible depression, anxiety and stress scores range from 0 to 21, higher scores represent greater severity of symptoms (i.e. a negative change indicates improved mental health).

[b] Possible wellbeing scores range from 0 to 110, higher scores represent greater wellbeing.

[c] A total of 12 participants (HIIT n=6, MICT n=6) completed the post-intervention maximal fitness tests. One HIIT participant's VO_2max results were excluded due to a technical error.


Assessed for eligibility (n=54)
Ineligible (n=30)
Randomised (n=24)
HIIT (n=12)
MICT (n=12)
Withdrew (n=2) a
Withdrew (n=4) b
1 Self-conscious
1 Medical reason
1 Psychiatric admission
1 Unknown
Baseline (n=12)
Baseline (n=10)
Withdrew (n=2) b
1 "Too much going on"
1 Unknown
Began program (n=8)
Began program (n=8)
Withdrew (n=4)
2 Previous injury
1 "Too hard"
1 Transport costs
Withdrew (n=3)
2 Previous injury
1 Disorganisation
Follow-up (n=1) c
1 Questionnaires
1 Anthropometry
1 Fitness test
Follow-up (n=4) c
4 Questionnaires
2 Anthropometry
1 Fitness test
Completed (n=4)
4 Questionnaires
4 Anthropometry
4 Fitness tests
Completed (n=5)
5 Questionnaires
5 Anthropometry
3 Fitness tests
Follow-up (n=3) c
3 Questionnaires
3 Anthropometry
1 Fitness test
Follow-up (n=2) c
2 Questionnaires
2 Anthropometry
2 Fitness tests
Per protocol analysis (>70% of sessions)
3xHIIT, 4xMICT
Analyses (all with post-intervention data)
9xHIIT, 10xMICT


Depression
Anxiety
Stress
Wellbeing
20
15
10
5
0
100
50
MICT
HIIT

High-intensity interval training (HIIT) and moderate-intensity continuous training (MICT) have similar acceptability and feasibility for adults with mental illness.

Larger trials are necessary to compare the efficacy of HIIT and MICT on mental health and fitness for adults with mental illness.

Community-based, individualised exercise programs with support to overcome physical activity barriers and enhance motivation may improve feasibility.