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ORIGINAL ARTICLE

Pilot aerobic exercise intervention for youth at-risk for serious mental illness

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Abstract

Background: This study was conducted as a pilot exercise intervention in youth at-risk for serious mental illness (SMI). The objectives were to examine the feasibility of an exercise intervention and to determine what improvement was observed, following participation in a moderate- to high-intensity aerobic exercise programme.

Methods: Forty-four male and female youth at-risk for SMI were recruited. Participants completed clinical, lifestyle and fitness assessments prior to and following a 16-week moderate- to high-intensity aerobic exercise intervention. Sixty-minute exercise sessions were held three times per week.

Results: Forty-one participants completed the entire intervention and assessments; thus, the retention rate was 93.2%. Exercise participants achieved a mean of 98.3 (standard deviation (SD) 26.1) minutes/week of high-intensity and a mean of 32.8 (SD 8.7) minutes/week of moderate-intensity aerobic exercise over the course of 16 weeks. Improvements in aerobic fitness and body composition as well as reductions in anxiety and depression were observed after the exercise intervention.

Conclusion: Aerobic exercise is a feasible and sound intervention strategy in youth at-risk for SMI. Further research is required to expand upon these initial findings and develop knowledge of the mechanisms, optimum dose and factors that influence the efficacy of exercise.

KEYWORDS

exercise intervention, serious mental illness, symptoms, youth

1 | INTRODUCTION

Regular aerobic exercise has physiological benefits and has been frequently identified as an intervention that reduces the risk of somatic disorders including but not limited to the following: obesity, metabolic syndrome, type II diabetes, heart disease, hypertension and select types of cancers (Moore et al., 2016; Wahid et al., 2016). There is a growing body of evidence that aerobic exercise leads to psychological benefits in both healthy individuals and those with mental illness that include enhanced cognition (Greer, Grannemann, Chansard, Karim, & Trivedi, 2015), improved coping strategies and quality of life (Knapen, Vancampfort, Morien, & Marchal, 2015), decreased psychiatric symptoms) (Dauwan, Begemann, Heringa, & Sommer, 2016; Kvam, Kleppe, Nordhus, & Hovland, 2016; Mittal et al., 2017) and lower stress and anxiety (Vancampfort et al., 2011).

Although there is evidence of the benefits of aerobic exercise for those with mental illness, less is known about the effectiveness of exercise in those considered at-risk for serious mental illness (SMI) in terms of overall health and risk reduction. The onset of mental illness typically occurs between early teens to mid-twenties (Kessler et al., 2005). The Canadian Mental Health Association reports that 10 to 20% of Canadian youth are affected by mental illness (Canadian Mental Health Association, 2016). Despite the potential for both psychological and systemic benefits in those at-risk for SMI, inquiry into exercise as a means of intervention in youth with mental illness is

uncommon (Lederman et al., 2019; McCloughen, Foster, Huws-Thomas, & Delgado, 2012).

Similar to healthy populations and those with mental illness, youth at-risk for SMI likely stand to gain from the potential antidepressive and anxiolytic effects of aerobic exercise. The risk for depression in adulthood is increased in youth with low physical activity (McKercher et al., 2009) and poor cardiovascular fitness (Aberg et al., 2012). Similarly, a study of current exercise practices in individuals at a clinical high-risk (CHR) of psychosis found that the high-risk group exercised at lower rates than healthy controls (Deighton & Addington, 2015). Other studies have suggested that exercise is not only both feasible and acceptable (Lederman et al., 2019) but should be a requirement to target sub-threshold levels of mental illness in young people and consequently reduce the risk of persistence and recurrence of mental illness (Parker et al., 2011).

Compared with pharmacological interventions, aerobic exercise has few adverse effects, is much less expensive, and may be more accessible than psychological therapies such as cognitive behaviour therapy. The potential utility of aerobic exercise is such that it may offer an acceptable, accessible and cost-effective intervention for reducing distress and mitigating risk in youth at-risk of SMI.

Although other exercise interventions have proved to be feasible (Dean et al., 2017; Lederman et al., 2019), our current study enrolled a larger sample of symptomatic individuals, utilized a 16-week intervention period, and moderate- to high-intensity aerobic exercise was examined here prior to conducting a full-fledged definitive exercise intervention trial. Specifically, the aims of this pilot study were, first, to test the feasibility of an aerobic exercise intervention with youth at-risk for SMI, and second, to determine whether changes in health measures, distress and/or symptoms would occur after participating in an aerobic exercise programme.

2 | METHODS

2.1 | Participants

The Canadian Psychiatric Risk and Outcome Study (PROCAN) is a longitudinal study examining youth at risk of developing SMI. Details of recruitment and methods of PROCAN are published elsewhere (Addington et al., 2018; Addington et al., 2019). Based on a clinical staging model (Hickie et al., 2013; McGorry, 2013), two of the stages included youth who did not have any diagnoses of mental illness but who were experiencing low mood, or anxiety symptoms and were distressed and youth who were experiencing subthreshold symptoms for a SMI. It was from those two stages that participants for this exercise study were recruited. Exclusion from these two stages included the following: (a) a current or lifetime Axis I disorder of psychosis, bipolar disorder or recurrent major depression, (b) an IQ of less than 70, and 3) a past or current history of a significant central nervous system disorder. Details of the criteria for these two stages (Stages 1a and 1b) are presented in Table 1, with more specific details in Table S1.

TABLE 1 Clinical staging model for mental illness

Stage	Definition
0	*No clinical symptoms—not used in the exercise project* • Increased risk of disorder due to family history
1a	*Distress disorder* • No attenuated psychotic symptoms • Nonspecific symptoms of anxiety or depression • Mild to moderate severity of symptoms • May include subjective/objective evidence of mild cognitive deficits • Evidence of only recent or mild impacts of illness on social, educational or occupational function
1b	*Attenuated syndromes* • Distress disorder plus at least one moderate to severe attenuated psychotic symptom(unusual thoughts, suspiciousness, perceptual abnormalities, grandiosity, disorganization) • Specific symptoms of anxiety or depression, brief hypomania or brief psychotic phenomena • May include subjective/objective evidence of at least moderate cognitive change • Moderate to severe impact of illness on social, education or employment functioning
2-4	*Stages not relevant to this project* • Discrete episodes of psychosis, mania or severe depression • Incomplete remission to multiple relapses • Unremitting course of illness

Specific inclusion criteria for this pilot exercise intervention study were as follows: (a) understood and were willing to sign the consent form (or assent for minors), and (b) had the capacity to walk quickly for 12 minutes without assistance. Exclusion criteria for the aerobic exercise intervention were as follows: (a) any medical condition that precluded exercising at a moderate- to high-intensity, and (b) participation in a rigorous exercise programme at least once per week.

This research study was approved by the University of Calgary Conjoint Health Ethics Board (REB15-1776). The CONSORT guidelines for reporting pilot studies were followed.

2.2 | Assessments

Feasibility, recruitment, retention and adherence rates to the exercise intervention are described qualitatively. Health measures included: body weight, body composition, blood pressure and a self-reported questionnaire covering dietary, sleep and fitness habits. A fitness assessment was completed for all aerobic exercise study participants and involved a submaximal prediction of aerobic capacity (VO_2max) following the Canadian Physical Activity, Fitness and Lifestyle Approach (CPAFLA) protocol, as outlined and accepted as a standard by the Canadian Society for Exercise Physiology (CSEP). Specifically, the Cooper Assessment of Maximal Oxygen Uptake (Cooper, 1968) was administered. VO_2max was estimated based on

the maximum metres an individual ambulated (run or walk or a combination of the two) on the treadmill in 12 minutes. Anxiety was assessed using the Social Interaction Anxiety Scale (Rodebaugh, Woods, Heimberg, Liebowitz, & Schneier, 2006), distress with the K-10 Distress Scale (Kessler et al., 2002) and depression with the Beck Depression Inventory-II (BDI-II) (Beck, Ward, Mendelson, Mock, & Erbaugh, 1961).

2.3 | Procedures

The health and fitness assessments were administered on the first and last days of the intervention. The fitness assessments were administered at Kinetix, a fitness facility in the University of Calgary. The testing protocol was explained to the participants, including a demonstration of the emergency stop button on the calibrated treadmill that was used. Participants were asked to cover as much distance as possible in 12 minutes. The grade was set at 1%; however, the participant set their desired pace to walk, jog, run or any combination throughout the 12 minute period, including a cool down period. Altogether, the fitness assessment was less than 25 minutes in duration.

All clinical assessments were completed as part of the parent PROCAN study and conducted by clinical raters who were trained on all clinical measures and tested annually for reliability.

2.4 | Aerobic exercise intervention

The intervention protocol was aerobic exercise executed at a 12-14 rate of preserved exertion (RPE) as a warm up for 10 minutes, followed by 45 minutes ≥15 RPE as the target intervention intensity, then cooling down with an additional five minutes at 10-12 RPE. On the first day of the intervention, participants were introduced to the self-report RPE Borg scale (rankings from 6—no exertion to 20—maximal exertion) (Borg, 1982) to understand and tailor their exercise intensity for each session. Exercise intensity was periodically checked manually by the supervising researcher, by asking participants their RPE and by using heart rate sensors on the various pieces of exercise equipment. The intervention was three times/week for 16 weeks; a total of 48 hours of formal aerobic exercise time. Aerobic exercise permitted in the study included: skipping ropes, callisthenics, running on a treadmill and/or on stairs, rowing on an ergometer, cycling on a stationary bike and using an elliptical machine. Exercise sessions changed throughout the course of the intervention in terms of order and activity.

Aerobic exercise sessions were supervised by Dr. S. Corbett, a professional fitness coach, and on occasion, with the help of a research assistant at Kinetix. Supervision for all aerobic exercise sessions ensured safety, as well as appropriate protocol execution in terms of time and intensity. In addition, supervised sessions provided participants with a chance to ask questions and feel supported through the study duration in order to ideally improve study adherence. Programme delivery ranged from private to semi-private to group training depending on how many participants showed up on any given day. This was incorporated to improve adherence and social connections, and to be available for the varied schedules of participants.

Kinetix had the capacity to accommodate eight participants at any one time. Exercise equipment was readily available for use by participants, in addition to hallways and stairwells adjacent to the facility in the cases where more than eight participants were completing their aerobic exercise session at any given time.

2.5 | Estimate of required sample size

It was expected that the data collected would be normally distributed across each study variable. With a threshold effect size set at 0.5 (minimum effect size that is considered significant), a statistical power of 0.80 and a significance of 0.05, an estimated sample size of 32 people would be required (Binu, Mayya, & Dhar, 2014; Howell, 1982). The dropout rate was projected to be 15%, thus increasing the sample size to 38.

2.6 | Statistical analysis

Qualitative descriptions are presented for recruitment, retention and adherence. Descriptive statistics were used to describe the study sample. Paired *t*-tests determined changes between baseline and post-treatment in all outcome measures, and to examine differences in the high and low attendance groups. Effect sizes (ie, Cohen's *d*) were calculated for all changes in the outcome measures. A Shapiro-Wilk test was used to assess normality of the data.

3 | RESULTS

3.1 | Recruitment

As this was a feasibility study, we limited recruitment to participants in Groups 1a and 1b (see staging details in Table 1) who were already engaged in the PROCAN study. PROCAN research personnel invited all current PROCAN 1a and 1b participants to join the exercise programme and subsequently invited all new participants. S. Corbett followed up and met individually with all participants that expressed an interest. Our recruitment efforts for PROCAN (Addington et al., 2018; Addington et al., 2019) included presentations to all clinical agencies that might be seeing youth, school counsellors and school social workers, advertising in local papers and presentations to the general public and relevant youth groups. In the final three months of the study, we included a brief description of the exercise study in all our PROCAN recruitment presentations and had some posters specifically advertising the exercise study that could be done in conjunction with PROCAN. We recruited over a 17-month span between

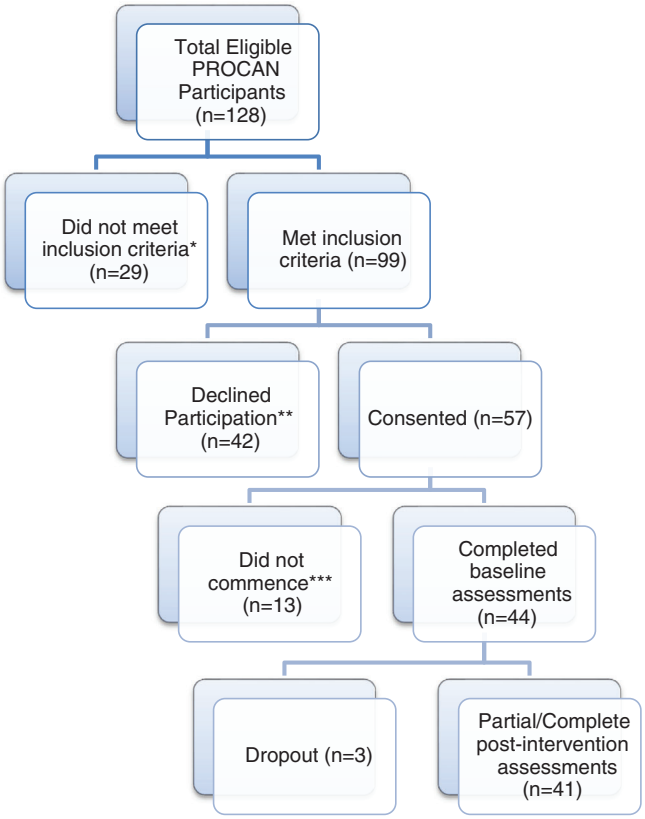

FIGURE 1 CONSORT Diagram of the Exercise Study. *Did not meet criteria; too active (n = 11), in another group (n = 18). **Declined participation; live too far (n = 6), time commitments (n = 5), not interested (n = 31). ***Did not commence; no longer interested (n = 13)

TABLE 2 Demographic characteristics of exercise participants

Characteristic	Exercise participants (n = 41); n (%)
Age (years)[a]	17.7 (3.4)
Gender	
Female	29 (71)
Male	12 (29)
Race	
Black	4 (9.8)
Caucasian	28 (68.3)
Other minorities	9 (21.9)
Marital status	
Single/never married	39 (95.1)
Other	2 (4.9)
Current living arrangement	
Living with family	34 (82.9)
Living with partner/others	5 (12.2)
Living on own	2 (4.9)
Current student	31 (75.6)
Current employment	
Full-time	4 (9.8)
Not full-time	37 (90.2)
SOPS summary scores[a]	
Positive	4.6 (4.1)
Negative	4.9 (3.7)
General	7.3 (3.4)
Disorganization	1.9 (1.7)

[a]Reported as mean (SD).

November 2015 and March 2017. In one to 14 months, we recruited and consented 20 participants, and in the final three months we recruited 20 participants to PROCAN that also consented to this exercise study, including nine new participants during the one month that we had newspaper ads.

Thus, a total of 128 symptomatic individuals from the two stages described earlier who had consented and were enrolled in PROCAN were invited to participate. Fifty-seven participants consented to the exercise intervention study. Thirteen either changed their mind about participating, realized it was not feasible to participate or offered no reason, leaving 44 individuals who began the aerobic exercise intervention. Forty-one completed at least some sessions and the follow-up assessment. Of the three participants that did not finish the exercise intervention, one participant actively dropped out of the intervention and two were lost to follow-up (see Figure 1 for the consort diagram).

Of the 41 participants who completed the study, 17 participants were Stage 1a and 24 were Stage 1b. Exercise participants achieved a mean of 98.3 (standard deviation (SD) 26.1) minutes/week of high intensity and a mean of 32.8 (SD 8.7) minutes/week of moderate-intensity aerobic exercise over the course of 16 weeks. The mean number of participants per session was 5.4 (SD 4.6) with a mode of 2.

A summary of the sample's descriptive characteristics are presented in Table 2.

Demographic characteristics of exercise intervention participants (n = 41) were compared with those who chose not to participate (n = 87). The only notable difference was that 70% of the exercise intervention participants were female, whereas just under 50% were female among those that did not participate (see Table S2).

A summary of physical health and lifestyle measures at baseline and post-intervention are presented in Table 3. Results indicate a significant increase in aerobic fitness and a significant reduction in body fat percentage from baseline to post-intervention. However, mean reductions in systolic and diastolic blood pressure were not significant. There was a statistically significant increase in the numbers of hours slept and ratings of sleep quality, diet health and exercise enjoyment from baseline to post-intervention.

Associations between the number of sessions attended and physical health ratings are presented in Table 4 and Table S3. There was a slightly greater improvement in aerobic fitness in participants who attended ≥50% of the sessions relative to those who attended <50%. Attendance was unrelated to age, gender or stage.

There were some significant clinical improvements in anxiety and depression but not distress over time (data not shown).

TABLE 3 Physical and lifestyle measures

	Baseline (n = 41)	Post-intervention (n = 41)	Paired differences			
Assessment	***M* (SD)**	***M* (SD)**	***M* (SD)**	***t* (df)**	***P***	***d***
Physical						
Systolic BP (mmHg)	114.3 (10.9)	110.6 (10.7)	−3.7 (10.8)	−1.6 (35)	.126	-
Diastolic BP (mmHg)	75.9 (10.6)	73.2 (8.7)	−2.7 (9.7)	−1.4 (35)	.168	-
Body composition (% fat)	24.2 (7.8)	22.1 (7.7)	−2.1 (7.7)	−4.3 (39)	<.001***	0.27
Aerobic fitness (ml O_2/kg^{-1} $minute^{-1}$)	20.0 (7.2)	31.0 (9.3)	9.0 (7.2)	7.9 (39)	<.001***	1.25
Lifestyle						
Sleep hours	7.4 (1.6)	8.0 (1.2)	0.6 (1.6)	2.3 (39)	.030*	0.36
Sleep quality	6.6 (2.0)	7.2 (1.8)	0.8 (1.9)	2.6 (39)	.013*	0.41
Diet health	6.0 (2.0)	6.6 (1.6)	0.5 (1.5)	2.1 (39)	.044*	0.33
Exercise enjoyment	6.1 (2.0)	8.0 (1.8)	1.6 (1.4)	7.2 (39)	<.001***	1.14

Note: d is Cohen's *d* effect size.
*$P < .05$; **$P < .01$; ***$P < .001$.

TABLE 4 Attendance comparison among exercise participants

Characteristic	<50% attendance; *M* (SD)	≥50% attendance; *M* (SD)	Test statistic; *t*	*P*	Effect size; *D*
Age (years)	18.0 (3.7)	17.6 (3.4)	−0.05	.958	0.11
Change in aerobic fitness	5.4 (8.5)	10.3 (6.3)	−2.0	.49*	0.67
Gender	n (%)	n (%)	X^2		φ
Female	8 (67)	21 (72)	0.135	.713	0.18
Male	4 (33)	8 (28)			
Stage					
Stage 1a	3 (25)	13 (45)	1.41	.236	0.18
Stage 1b	9 (75)	16 (55)			

*$P < .05$.

4 | DISCUSSION

This pilot study suggested that moderate- to high-intensity aerobic exercise may be a feasible intervention for at-risk youth. The increase in recruitment once the exercise intervention was specifically advertised suggests that young people were keen to participate. The 93% retention rate of study participants is encouraging considering that non-adherence to treatment with pharmacological interventions, such as antidepressants, is common (Pampallona, Bollini, Tibaldi, Kupelnick, & Munizza, 2002). Additionally, in contrast to the poor adherence reported in prior research of exercise and mental illness (Vancampfort et al., 2012), this study demonstrated a high level of engagement. Participants were adherent, with average attendance being two to three times per week, far surpassing the exercise minimum of 75 minutes of vigorous intensity exercise per week as recommended in the CSEP 2011 guidelines (Tremblay et al., 2011). Interestingly, females were more likely to participate in the study. Although individualized training has been shown to be effective in previous studies of mental illness such as first-episode psychosis (Firth et al., 2018), the option of semi-private or group training likely helped with adherence, as social connections were made, as did supervision by a professional fitness coach plus the option of a variety of exercise types (eg, treadmill, stationary bike and exercise class).

In general, these results are consistent with evidence that indicates that moderate- to high-intensity exercise can be beneficial in improving both physical and mental health measures, in at-risk youth. Two recent pilot studies (Dean et al., 2017; Lederman et al., 2019) found that an exercise intervention was beneficial in terms of physical health and clinical, social, and cognitive domains for youth at CHR for psychosis. Although these studies only included up to 20 participants, our study benefitted from an increased sample size and a longer exercise intervention (16-week vs 12-week; 60- vs 30-minute sessions).

It is well documented that those diagnosed with mental illness are commonly less active than the general population (Vancampfort et al., 2017), putting them at further risk for physical disease. Here, several facets of the participants' fitness and physical health improved. Aerobic fitness improved markedly after the intervention, as participants were largely sedentary prior to the study. However, although it was a success to have observed these participants completing higher intensities of exercise, it should be noted that the exercise intensities examined here were comparatively higher than

previous research. Therefore, determining the optimal dose of aerobic exercise is warranted in youth at-risk for SMI.

High levels of adherence and participation to the exercise intervention possibly led to the observed lifestyle improvements. For example, quantity and quality of sleep was reported to have improved, which is in line with a meta-analysis reporting that regular exercise has small beneficial effects on total sleep time and moderate beneficial effects on sleep quality (Kredlow, Capozzoli, Hearon, Calkins, & Otto, 2015). Furthermore, significant improvement in the enjoyment of exercise post-intervention was an important outcome reported here. Previously, perception of fitness has been an impediment to the feasibility and participation in exercise interventions in individuals at-risk for SMI (Newberry, Dean, Sayyah, & Mittal, 2018). In particular, one study examining exercise practices of youth at CHR of psychosis found that previous negative experiences with exercise and a lack of skills and knowledge on how to perform types of exercise were barriers to participation (Deighton & Addington, 2015). Perhaps knowledge and fitness gains acquired in the current study bolstered confidence and influenced the participant's perspectives and should, therefore, be confirmed in larger samples.

Although the objective of this pilot study was to assess the feasibility and effects of aerobic exercise, there are limitations. Selection bias may have occurred as 13 individuals that originally consented to participate did not start. Understanding more about the facilitators and barriers to exercise would be beneficial for future studies. Therefore, it would be important for future studies to report on habits and barriers to exercise and to focus on motivation as both a recruitment and retention strategy, which in turn, may improve commitment to the exercise intervention. Finally, caution must be taken in generalizing these results to the greater population of youth at-risk for SMI, since those enrolled here may have had a better attitude towards exercise and more apt to prioritizing a healthy lifestyle and were already consenting to participate in a naturalistic study.

A growing body of evidence suggests that aerobic exercise programmes such as the one employed in this pilot study offer support for its feasibility and inclusion as a sound intervention strategy for youth at-risk for SMI. In addition, the results, while preliminary, offer justification for randomized controlled trials with larger sample sizes to determine whether aerobic exercise promotes mental health in youth at-risk for SMI. A larger study could examine many unanswered questions related to the underlying biological mechanisms, the optimum dosing, frequency and type of exercise training to be employed and the moderating factors associated with positive effects of aerobic exercise has on youth at-risk for SMI.

CONFLICT OF INTEREST

GM has been on advisory board or speaker for Allergen, Lundbeck, Lilly, Pfizer, Janssen. All other authors list no competing interests.

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DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of this article.

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