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Predictors of Long-Term Exercise Engagement in Patients with Obsessive Compulsive Disorder: The Role of Physical Activity Enjoyment

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Abstract

Most US adults, even more so those with psychiatric conditions like obsessive compulsive disorder (OCD), do not engage in the recommended amount of physical activity (PA), despite the wide array of physical and mental health benefits associated with exercise. Therefore, it is essential to identify mechanistic factors that drive long-term exercise engagement so they can be targeted. Using the science of behavior change (SOBC) framework, this study examined potential predictors of long-term exercise engagement, as a first step towards identifying modifiable mechanisms, in individuals with OCD, such as PA enjoyment, positive or negative affect, and behavioral activation. Fifty-six low-active patients (Mean age=38.8±13.0, 64% female) with a primary diagnosis of OCD were randomized to either aerobic exercise (AE; n=28) or health education (HE; n=28), and completed measures of exercise engagement, PA enjoyment, behavioral activation, and positive and negative affect at baseline, post-intervention, and 3-, 6-, and 12-month follow-up. Significant predictors of long-term exercise engagement up to 6-months post-intervention were baseline PA (Estimate = 0.29, 95%CI [0.09, 0.49], p=.005) and higher baseline PA enjoyment (Estimate = 1.09, 95%CI [0.30, 1.89], p=.008). Change in PA enjoyment from baseline to post-intervention was greater in AE vs. HE (t(44)=−2.06, p=.046, d=−0.61), but endpoint PA enjoyment did not predict follow-up exercise engagement above and beyond baseline PA enjoyment. Other

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hypothesized potential mechanisms (baseline affect or behavioral activation) did not significantly predict exercise engagement. Results suggest that PA enjoyment may be an important modifiable target mechanism for intervention, even prior to a formal exercise intervention. Next steps aligned with the SOBC framework are discussed including examining intervention strategies to target PA enjoyment, particularly among individuals with OCD or other psychiatric conditions, who may benefit most from long-term exercise engagement's effects on physical and mental health.

Keywords

exercise; physical activity; physical activity enjoyment; obsessive compulsive disorder; exercise adherence

Introduction

Exercise is an adaptive health behavior that has broad demonstrated benefits for physical health, including reduced mortality risk and reduced risk for several chronic diseases (e.g., Posadzki, et al., 2020; Warburton & Bredin, 2017), as well as benefits for mental health (e.g., Aylett, Small, & Bower, 2018; Kvam, Kleppe, Nordhus, & Hovland, 2016). Despite these benefits, only 23% of United States adults meet the American College of Sports Medicine (ACSM) recommendations of 150 minutes of moderate intensity exercise per week (Blackwell & Clarke, 2018) with evidence that those with mental health conditions engage in even less exercise (Helgadóttir, Forsell, & Ekblom, 2015; Stubbs, et al., 2017). This may be in spite of intention to be physically active. For example, a meta-analysis demonstrated that only 56% of individuals intending to exercise actually engaged in *any* exercise behavior (Rhodes & de Bruijn, 2013).

Exercise has demonstrated benefits for depression (Kvam, et al., 2016) and anxiety (Ramos-Sanchez, et al., 2021). Fewer studies have investigated exercise for obsessive-compulsive disorder (OCD), a chronic and debilitating condition, but some benefits to obsessions as well as comorbid anxiety and depression have been identified (Freedman & Richter, 2021). Even less is known about possible mechanistic factors that may be targeted to increase exercise engagement within these psychiatric populations. OCD is associated with deficits in emotional awareness (Lazarov, Friedman, Comay, Liberman, & Dar, 2020), tendency to experience negative affect (Bienvenu, et al., 2004), lower levels of positive affect (Spinella, 2005), and higher levels of anhedonia (above and beyond that of comorbid depression) (Abramovitch, Pizzagalli, Reuman, & Wilhelm, 2014), all of which are known targets of exercise in non-psychiatric populations.

Therefore, identifying factors that may predict exercise engagement and adherence is an important first step toward identifying and testing mechanisms associated with long-term exercise maintenance in psychiatric populations, like those with OCD. The National Institutes of Health (NIH) Science of Behavior Change (SOBC) experimental medicine framework provides guidelines for identifying these potential mechanisms of health behavior change with a goal of examining interventions to engage target mechanisms and ultimately to promote adaptive health behaviors, like exercise (Nielsen, et al., 2018; Riddle, 2015). The first step in this process is examining predictors (which eventually will be studied as mechanisms) associated with behaviors (e.g., exercise). SOBC proposes three classes of target mechanisms, including self-regulation, stress resilience and stress reactivity, and interpersonal and social processes (Nielsen, et al., 2018). Briefly, self-regulation encompasses several constructs, including self-control (cognitive and behavioral), emotion regulation, flexible adaptation, and effort modulation, among others. Stress reactivity involves the initial, acute response to a stressor (broadly defined from major traumatic events to novel or unpredictable situations) emotionally, physiologically, cognitively, and behaviorally. Stress resilience refers to positive adaptation in the context of or following a stressor. Interpersonal and social processes include targets of behavior change that occur within the framework of social contexts or relationships.

One potential predictor of exercise engagement, aligned with the stress reactivity class, is physical activity (PA) enjoyment, or a positive affective response associated with exercise behavior which may be distinguished from cognitions related to exercise intentions (e.g., “exercise is good for my health”; Ekkekakis & Dafermos, 2012; Hutchinson, Zenko, Santich, & Dalton, 2020). Examining affective responses as mechanisms of behavior change dates back to early principles of behaviorism, such as Thorndike’s law of effect, which states that responses that produce a satisfying effect are more likely to occur again whereas those producing an uncomfortable effect are less likely to recur. This also aligns with the affect principle of behavioral economics, which posits that judgments and decisions are influenced by affective responses, such as pleasure and enjoyment (Finucane, Alhakami, Slovic, & Johnson, 2000).

Indeed, positive affective change during exercise (Rhodes & Kates, 2015), immediate changes in mood and anxiety following exercise (e.g., Bartholomew, Morrison, & Ciccolo, 2005; Ensari, Greenlee, Motl, & Petruzzello, 2015; Williams, 2008), and PA enjoyment (Jekauc, et al., 2015), particularly of self-selected intensities of exercise (Ekkekakis, Parfitt, & Petruzzello, 2011), have all been associated with engagement in future exercise behavior. However, most studies have been conducted in those without psychiatric conditions. Further, affective responses may interact with cardiorespiratory fitness (CRF) levels or body mass index (BMI) to influence exercise engagement. For example, those with worse CRF or higher BMI may experience exercise as more uncomfortable and may be fearful of exercise; therefore, leading to reduced motivation for subsequent bouts of exercise (e.g., Hamer, Larkin, Relph, & Dey, 2021; Hearon, Quatromoni, Mascoop, & Otto, 2014). However, if exercise intensity is self-selected, this may promote greater enjoyment and more engagement over time (Baldwin, et al., 2016; Ekkekakis & Lind, 2006).

Few studies have examined PA enjoyment within psychiatric populations, a natural question given that negative affect is a hallmark symptom of many prevalent mental health conditions and those with psychiatric conditions are less likely to engage in exercise (Helgadóttir, et al., 2015; Stubbs, et al., 2017). As physical responses to exercise may mimic a stress response (e.g., increased heart rate, shortness of breath, sweating), PA enjoyment can be conceptualized in part as a positive valence affective response to the somatic stressor associated with better ability to tolerate exercise in the long-term (Hartman, Ekkekakis, Dicks, & Pettitt, 2019). Indeed, exercise interventions, especially those targeting the contingency between exercise and mood, have been shown to decrease cognitive and physiological stress responses, such as anxiety sensitivity (Hearon, et al., 2018; Otto & Smits, 2011; Smits, et al., 2016), which may be elevated in those with OCD (Calamari, Rector, Woodard, Cohen, & Chik, 2008).

In addition to affect during exercise, other potential mechanisms associated with exercise engagement may include general positive or negative affect (stress reactivity SOBC target class), outside the context of exercise, both of which are affected in OCD populations (Bienvenu, et al., 2004; Spinella, 2005). Cross-sectional studies suggest an association between positive affect and exercise engagement and adherence (e.g., Duque, Brown, Celano, Healy, & Huffman, 2019; Pasco, et al., 2011); whereas, negative affect, such as anxiety and depression, tends to be associated with less exercise and more sedentary behavior (Teychenne, Costigan, & Parker, 2015; Zhai, Zhang, & Zhang, 2015). However, few studies examine the effects of either positive or negative affect longitudinally on exercise adherence. Given that affect can impact motivation (Teixeira, Marques, & Palmeira, 2018), especially to start and maintain health behaviors, and that affective judgments promote increases in subsequent exercise behavior (Rhodes, Gray, & Husband, 2019), it is important to understand the role of baseline positive and negative affect in exercise adherence over time for those with OCD.

The self-regulation SOBC target class, specifically behavioral activation (BA), may also play a mechanistic role in promoting exercise engagement over time. Behavioral activation, typically a treatment implemented for depression, involves behavior change techniques to impact motivation to engage in activities, such as action planning and goal setting. BA has been used in combination with exercise and has been shown to improve exercise engagement, regardless of an adjunctive exercise-focused intervention, with associated improvements in depression symptoms (e.g., Schneider, et al., 2016; Szuhany & Otto, 2020). BA is conceptualized to operate through the reinforcing value of engaging in meaningful activities (Smith & Merwin, 2021). Therefore, engaging in exercise may enhance general positive affect, increase PA enjoyment specifically, reduce anhedonia (which is elevated in OCD; Abramovitch, et al., 2014), and interact to motivate more behavioral activation and thus more exercise engagement.

The aim of the current study was to identify predictive factors associated with long-term behavioral change (i.e., exercise engagement) within an understudied psychiatric population, those with OCD, aligned with Target 1 of the SOBC developmental format. Specifically, we examined the prediction of exercise engagement by PA enjoyment, positive and negative affect, and behavioral activation, all of which may be eventually targeted as mechanisms if associated with long-term exercise engagement. We completed a secondary analysis of baseline predictors of long-term exercise engagement in individuals with OCD who were randomized to either 12 weeks of aerobic exercise (AE) or health education (HE; control) and were followed for 3-, 6-, and 12-months post-intervention (Abrantes, et al., 2017). As pre-specified (Abrantes, et al., 2012), we hypothesized that baseline PA enjoyment would be associated with exercise engagement across follow-ups. In a post-hoc exploratory analysis, we examined differences between interventions in changes in PA enjoyment. In exploratory analyses informed by the extant literature, we also examined whether baseline positive or negative affect or behavioral activation would be associated with exercise engagement over time. As a post-hoc exploratory analysis of mechanism, we also examined whether post-intervention scores would predict engagement in exercise across the follow-up period.

Material and Methods

Study Design and Participants

Detailed methods (Abrantes, et al., 2012) and primary outcomes (Abrantes, et al., 2017) of the parent trial (clinicaltrials.gov identifier: NCT01242735) have been published elsewhere. Briefly, the current secondary analysis utilized data from this randomized controlled trial examined efficacy of a 12-week aerobic exercise intervention (n=28) as compared to health education control (n=28) in adults with OCD on psychiatric outcomes, such as OCD, anxiety, and depression severity, and exercise outcomes (i.e., exercise engagement and cardiorespiratory fitness). All procedures were approved by the institutional review board from Butler Hospital and all participants signed written informed consent prior to completing study procedures.

Participants were 56 physically inactive (i.e., <60 minutes of moderate to vigorous intensity aerobic exercise per week over the past 3 months) men and women (64% female, Mean age=38.8±13.0) with a primary diagnosis of OCD and a Yale-Brown Obsessive-Compulsive Scale (Y-BOCS) ≥16 (i.e., clinically significant symptoms despite treatment with cognitive behavioral therapy [CBT] or pharmacotherapy). For entry, CBT duration was at least 13 weeks and pharmacotherapy at an adequate and stable dose for the past month, and initiated at least 12 weeks prior. Exclusion criteria were diagnoses of bipolar disorder, psychotic disorder, substance use disorder, anorexia or bulimia as well as current suicidality or homicidality, current or planned pregnancy during the intervention period, or any medical problems that would contraindicate exercise.

Eligible participants were randomized and blocked by: 1) sex (male/female), 2) current OCD severity (low/high: 16–24 vs. >24 on Y-BOCS), 3) current pharmacotherapy for OCD (yes/no), and 4) current CBT for OCD (yes/no).

Measures

Measures, including the primary exercise engagement measure, were administered at baseline, post-intervention (after the 12-week intervention), and at 3-month, 6-month, and 12-month follow-up.

Screening.—Participants were administered the Structured Clinical Interview for DSM-IV Axis I Disorders (SCID; First, Spitzer, Gibbon, & Williams, 1995) to establish inclusion/exclusion criteria. The Butler Hospital OCD Database Interview, a semi-structured clinician-rated interview was utilized to collect information on demographic and clinical features of OCD (Rasmussen, Eisen, & Pato, 1993). The Y-BOCS is a clinician-administered 10-item scale which assesses severity of 5 domains of obsessions and compulsions. A score ≥16, indicative of clinically significant symptoms, was required for study entry. A clinician-rated physical activity screen embedded in a brief interview of a variety of health behaviors assessed amount of weekly engagement in moderate to vigorous intensity activity for at least 20 minutes over the past 6 months. The SCID, Butler Hospital OCD Database Interview, Y-BOCS, and physical activity screen were administered by trained research staff with extensive experience with these measures.

Primary outcome: exercise engagement.—Participants reported average number of days per week and minutes per day exercising (at any intensity) over the past three months consistent with measurement of exercise as a vital sign (EVS; Coleman, et al., 2012; Kuntz, et al., 2021). Average minutes per week was calculated by multiplying responses to these two questions. EVS has demonstrated strong face and discriminant validity (Coleman, et al., 2012) and demonstrates acceptable sensitivity (67%), specificity (68%), positive predictive value (61%), and negative predictive value (73%) when compared against the gold-standard exercise measure of accelerometry for identifying inactive participants (Kuntz, et al., 2021). EVS also matches the measurement of exercise engagement in the primary paper (Abrantes, et al., 2017).

Predictors of long-term exercise engagement.—Hypothesized baseline predictors of long-term exercise engagement, which may be targeted in the future as mechanisms, included PA enjoyment, positive and negative affect, behavioral activation, and body mass index (BMI). PA enjoyment was assessed with the Physical Activity Enjoyment Scale (PACES; Kendzierski & DeCarlo, 1991), an 18-item measure with strong internal consistency (Cronbach's alpha (α)=.96), test-retest reliability (.60 to .93) and established construct validity (Kendzierski & DeCarlo, 1991). The 20-item Positive and Negative Affect Scale (PANAS) assessed general positive affective and negative affective dimensions and has high internal consistency (α =.86 to .90 for positive and α=.84 to .87 for negative affect), test-retest reliability (r=.68 for positive and .71 for negative affect; Watson, Clark, & Tellegen, 1988), and strong construct, convergent, and divergent validity (Watson, et al., 1988). The Behavioral Activation for Depression Scale (BADS; Kanter, Mulick, Busch, Berlin, & Martell, 2007) includes a total score as well as four subscales (activation, avoidance/rumination, work/school impairment, and social impairment) and assessed behavioral activation over the past week. The BADS has sufficient internal consistency (α =.79 −.87), sufficient test-retest reliability (r=.74), and good construct validity (Kanter, et al., 2007). BMI was calculated based on measured weight and height during the baseline assessment.

Interventions

For this secondary analysis, we collapsed data across intervention conditions to examine baseline predictors of long-term exercise engagement above and beyond intervention. However, we included the intervention condition as a covariate given this may also predict engagement. Intervention conditions are briefly described below with more detailed descriptions elsewhere (Abrantes, et al., 2017; Abrantes, et al., 2012).

Aerobic exercise (AE).—The 12-week AE condition included three primary components: 1) aerobic exercise; 2) cognitive behavioral skills to promote exercise engagement (e.g., physical health benefits of exercise, goal-setting, time management, identifying and overcoming exercise barriers, exercise and mental health); and 3) an incentive system ($5 for attending each supervised session). Participants completed supervised aerobic exercise once per week and were instructed to complete home-based exercise two to four days per week (two days early in the intervention and 4 days later). The ultimate goal was 150 minutes of moderate intensity exercise per week.

Health education (HE).—The 12-week HE condition matched contact with staff and included weekly hour-long psychoeducational sessions on health and wellness topics as well as incentives comparable to the AE condition.

Data Analysis

The aims, hypotheses, and data analytic plan for baseline predictors of exercise engagement were either pre-specified (Abrantes, et al., 2012) or planned based on extant literature prior to conducting data analysis. Exploratory post-hoc analyses examined post-intervention scores on these same variables predicting exercise during the follow-up period. A formal power analysis was not conducted prior to this secondary data analysis; however, in a sensitivity power analysis with repeated measurements (5 time points), 80% power, and a sample of n=56, a small effect size (d=0.14) can be detected (G Power). Additionally, the sample size is greater than that of other exercise trials for OCD (n=11 to n=16; Freedman & Richter, 2021).

Baseline characteristics were summarized using frequency and proportion for categorical variables and mean and standard deviation for continuous variables. Separate longitudinal mixed effects models for each hypothesized baseline predictor (i.e., PACES, PANAS positive affect, PANAS negative affect, BADS, and BMI) were used to predict exercise engagement at each assessment through 12-month follow-up, controlling for average baseline minutes of exercise per week (baseline exercise) and intervention condition. The hypothesized predictor, time, baseline exercise, and condition were entered as fixed effects. The models used restricted maximum likelihood (REML) estimation and an unstructured variance-covariance matrix where all assessments after baseline (post-treatment, 3-month, 6-month, 12-month follow-ups) were entered as repeated dependent variables. Follow-up linear regressions, covarying for baseline exercise and condition, at each follow-up timepoint were conducted for significant predictors in the mixed models to examine course of longitudinal engagement in exercise.

Post-hoc exploratory analyses utilized similar longitudinal mixed effects models with only follow-up assessments (3-month, 6-month, and 12-month) entered as dependent variables. Correlations between baseline and post-intervention scores on each measure were assessed for multicollinearity (r>.80). If multicollinearity was not indicated, baseline and post-intervention scores were entered for the predictor, controlling for intervention condition and baseline exercise. All significance tests were two-tailed at a significance level of 0.05. All analyses were conducted in SPSS Version 25.0.

Results

Baseline characteristics

The CONSORT diagram is published elsewhere (Abrantes, et al., 2017). Across intervention groups, baseline exercise was 78.4±182.4 minutes per week. Average exercise >60 minute entry threshold may reflect differences in clinician-rated vs. self-reported exercise, exercise changes between screening and baseline visits, or differences in assessing all exercise vs. only moderate and vigorous intensity exercise. Participants were, on average, in the moderate severity range for OCD symptoms at baseline (24.8±5.3). There were no significant differences at baseline in demographic or clinical characteristics; however, OCD severity was higher at a trend level for participants randomized to the AE group (Mean(AE)=26.2±5.2; Mean(HE)=23.5±4.9, p=.056). See Table 1 for select baseline characteristics.

Reliability and validity of baseline predictors (potential mechanisms)

Reliability on all predictors at baseline was high within this sample: PACES (Cronbach's alpha=.95); PANAS positive affect (Cronbach's alpha=.87); PANAS negative affect (Cronbach's alpha=.94); and BADS (Cronbach's alpha=.88). PA enjoyment was significantly correlated with some other measures at baseline, in the small to medium effect size range (PANAS negative affect: r(52)=−.36, p=.008; BADS: r(49)=.42, p=.002) in expected directions. PANAS positive and negative affect were significantly correlated (r(53)=−.29, p=.03), aligned with newer conceptualizations that the factors are moderately interrelated (e.g., Crawford & Henry, 2004; Díaz-García, et al., 2020; Merz, et al., 2013). BADS was significantly correlated with all other predictors at the medium effect size range (PANAS positive affect: r(50)=.49, p<.001; PANAS negative affect: r(50)=−.51, p<.001).

Predictors of long-term exercise engagement

In all longitudinal mixed effects models, more baseline exercise significantly predicted long-term exercise engagement (all p<.012). Intervention condition (Estimate=−36.3, t=−2.2, 95%CI= [−69.8, −2.9], p=.034) was only significant in the model including BMI as a predictor. Those in the AE group exercised more at the same BMI level (29.9) compared to those in the HE group (Mean minutes: AE: 128.3; HE: 91.9). In other models, effects of other predictors (e.g., baseline exercise) were stronger than intervention condition.

Physical activity enjoyment.—In addition to baseline exercise (Estimate=0.29, t=2.94, 95%CI= [0.09, 4.90], p=.005), higher baseline PA enjoyment significantly predicted exercise engagement (Estimate=1.09, t=2.79, 95%CI= [0.30, 1.89], p=.008); a 1 point increase in PA enjoyment (on a 126 point scale) was associated with 1.09 more minutes of exercise per week. For context, the range of responses for baseline PA enjoyment was 93 points (33–126); for those higher on PA enjoyment, approximately 1.5 extra hours of exercise might be completed per week. Intervention condition and time were not statistically significant in this model.

In separate follow-up linear regressions, higher levels of both baseline exercise and baseline PA enjoyment predicted greater exercise engagement at post-intervention (baseline exercise: β=.35, p=.01; PA enjoyment: β=.30, p=.03), 3-month (baseline exercise: β=.31, p=.03; PA enjoyment: β=.43, p=.003) and 6-month follow-ups (baseline exercise: β=.35, p=.02; PA enjoyment: β=.29, p=.04) but not 12-month follow-up (baseline exercise: β=−.15, p=.37; PA enjoyment: β=.16, p=.32). Figure 1 displays differences for individuals with high vs. low baseline PA enjoyment over time. For purposes of the figure, baseline PA enjoyment was dichotomized via median split.

Exploratory analyses aimed to examine 1) baseline differences in PA enjoyment by amount of exercise; 2) whether PA enjoyment was affected by intervention condition and 3) whether post-intervention PA enjoyment predicted exercise engagement during the follow-up period. There was a significant difference in baseline PA enjoyment for individuals reporting no exercise engagement (M(SD)=66.73(17.64) vs. any exercise engagement (M(SD)=84.21(23.15) at baseline ($t(51)=-2.86$, $p=.006$, $d=-0.82$). Change in PA enjoyment from baseline to post-intervention was greater in AE vs. HE ($t(44)=-2.06$, $p=.046$, $d=-0.61$; M(SD) 20.76(20.97) vs. 7.92(21.20)). Baseline and post-intervention PA enjoyment were moderately correlated among the full sample ($r(46)=.519$, $p<.001$), which did not preclude including them in the same mixed model. In a longitudinal mixed effects model with repeated dependent variables (3 follow-up timepoints), baseline PA enjoyment (Estimate=1.44, $t=2.52$, 95%CI=[0.27, 2.60], $p=.017$) continued to predict exercise engagement above and beyond treatment endpoint PA enjoyment (Estimate=0.16, $t=0.23$, 95%CI=[−1.22, 1.53], $p=0.818$), intervention condition (Estimate=−12.94, $t=-0.54$, 95%CI=[−62.15, 36.27], $p=.596$), and even baseline exercise (Estimate=0.24, $t=1.88$, 95%CI=[−0.018, 0.495], $p=.068$).

Behavioral activation, positive and negative affect, and BMI.—Higher baseline behavioral activation (Estimate=0.79, $t=1.69$, 95%CI= [−0.16, 1.75], $p=.10$,), when accounting for baseline exercise (Estimate=0.29, $t=2.62$, 95%CI= [0.07, 0.51], $p=.012$), demonstrated trend level significance. Baseline positive (Estimate=2.36, $t=1.57$, 95%CI= [−0.68, 5.40], $p=.12$) and negative affect (Estimate=−1.24, $t=-1.29$, 95%CI= [−3.19, 0.70], $p=.21$), and BMI (Estimate=−0.66, $t=-0.54$, 95%CI= −3.13, 1.81, $p=.59$) were not significantly predictive of long-term exercise after accounting for intervention condition and baseline exercise.

Discussion

Despite the multitude of mental and physical health benefits of PA, the intention-behavior gap is wide, with only about 1/4 of individuals engaging in the recommended amount of PA weekly (Blackwell & Clarke, 2018; Rhodes & de Bruijn, 2013), and even less in psychiatric populations with anxiety and depression (Helgadóttir, et al., 2015), with little known about PA patterns in OCD. Given the association of sedentary behavior and lack of PA with myriad medical conditions and even early mortality (Posadzki, et al., 2020; Warburton & Bredin, 2017), use of SOBC methodologies to identify possible mechanisms responsible for maintaining PA over the long term can be highly informative toward the development of effective interventions. As much of the PA data is cross-sectional, little is known about the predictive role of possible mechanisms, such as PA enjoyment, affect, and behavioral activation, in long-term exercise engagement, especially in psychiatric populations, with even less investigation in OCD. Identifying exercise-promoting mechanisms within OCD may be of particular importance given the tendency to experience heightened negative affect (Bienvenu, et al., 2004), lower levels of positive affect (Spinella, 2005), difficulties with emotional awareness (Lazarov, et al., 2020), and anhedonia (Abramovitch, et al., 2014), all of which may be targeted by exercise.

The current study highlights the importance of pre-intervention PA enjoyment in predicting long-term exercise engagement, up to at least 6 months post-intervention, in a sample who may benefit most from both physical and mental health benefits of exercise, individuals with OCD. Of note, the aerobic exercise intervention did significantly increase PA enjoyment, suggesting some components of this CBT-based intervention may be useful in promoting PA enjoyment in a low active, OCD sample. However, baseline PA enjoyment was predictive of long-term engagement in exercise, above and beyond the intervention (whether health or exercise-focused) and beyond post-intervention PA enjoyment. This suggests that for those with low existing PA enjoyment, an additional supplemental intervention solely focused on promoting PA enjoyment, perhaps integrating CBT principles, may be required before entering a more traditional exercise intervention. Conversely, a sample willing to increase exercise, supplemental exercise-focused interventions may not be necessary.

Our findings within an OCD population align with the well-established finding that affective judgment variables, particularly enjoyment and pleasure associated with PA, are convincing moderators of the intention behavior relationship for PA in healthy individuals (Rhodes, Cox, & Sayar, 2022). Further, positive affective variables, such as PA enjoyment, positive affect during exercise, and remembered pleasure, were found to mediate the relationship between interventions and their ultimate effects on PA adherence in a meta-analysis of 40 studies, though long-term outcomes were not available for most studies (Chen, Finne, Kopp, & Jekauc, 2020). Enjoyment may also be linked to the intensity of the exercise performed. For example, a recent meta-analysis found that high intensity interval training (HIIT) produced greater immediate enjoyment than continuous training ($g=.75$), with some suggestion this effect is maintained in chronic exercise studies. However, continuous training produced better acute affective responses ($g=-1.09$) suggesting enjoyment and affect may be related, but different constructs. Relatively few studies ($n= 3$ in this meta-analysis) examined this effect long-term (Tavares, et al., 2021), suggesting the need for more longitudinal studies on this topic.

Our other hypothesized potential mechanisms of general negative or positive affect and behavioral activation were not significantly predictive of long-term exercise engagement in our sample of individuals with OCD. Regarding affect, general tendency towards positive affect may not be enough to promote PA behavior in patients with OCD unless contingently linked with the behavior. Indeed, animal models suggest that reverse conditioning, meaning presenting the unconditioned stimulus (e.g., affect) prior to another stimulus (e.g., exercise) does not produce as salient of a learning effect (Lonsdorf, et al., 2017). Monetary contingency management, linking an adaptive behavior with an explicit reward, has long been utilized in interventions for substance use disorders as well as weight loss to promote early motivation for behavioral change (Dalton, Bishop, & Darcy, 2021; Sykes-Muskett, Prestwich, Lawton, & Armitage, 2015). Similarly, studies suggest that attending to the acute mood benefits of exercise (i.e., positive affect linked to exercise), which are suggested to occur almost immediately after exercise completion (Ekkekakis, Hall, & Petruzzello, 2008; Hale & Raglin, 2002), may enhance exercise engagement at least in the short-term, especially as compared to health promotion messages (Segar & Richardson, 2014), including among those with serious mental illness (Hearon, et al., 2018). Studies using ecological momentary assessment (EMA) may be able to capture the real-world acute mood benefits of exercise and their subsequent effects on exercise engagement more effectively. For example, a recent EMA study found that feeling more energetic and less negative during exercise was associated with higher levels of engagement in moderate to vigorous PA 6–12 months later (Liao, Chou, Huh, Leventhal, & Dunton, 2017).

Negative affect, especially within a psychiatric sample, may better approximate severity of psychiatric symptoms, such as anxiety and depression, which have been shown to improve with exercise interventions (Kvam, et al., 2016; Ramos-Sanchez, et al., 2021). Indeed, negative affect scores were correlated with overall OCD severity at baseline ($r(53)=.39$, $p=.003$) and post-treatment ($r(42)=.46$, $p=.002$) in our sample. Therefore, the effect of negative affect may be interactive with exercise whereby exercise improves negative affect as opposed to baseline negative affect predicting future exercise engagement, particularly in this sample with OCD. In cross-sectional studies, negative affect and stress have been associated with less engagement in PA and sedentary behavior (Stults-Kolehmainen & Sinha, 2014; Teychenne, et al., 2015; Zhai, et al., 2015), but for those interested in engaging in more exercise, it may not be wholly predictive of future behavior.

Interestingly, baseline behavioral activation did not have a significant effect on long-term exercise engagement, despite previous evidence suggesting a potential link between behavioral activation interventions and increasing exercise behavior in depressed populations (e.g., Schneider, et al., 2016; Szuhany & Otto, 2020). However, this may be due to a potential reciprocal effect whereby beginning to increase engagement in valued activities may increase physical activity. Therefore, baseline levels of behavioral activation alone may not be predictive of exercise engagement overall. Given the small sample size in this study, we were not powered to examine these reciprocal effects; however, this is an important avenue for future research. Further, behavioral activation has typically been utilized in samples with primary depressive disorders (Ciharova, et al., 2021; Lejuez, Hopko, Acierno, Daughters, & Pagoto, 2011), so it may not have applied to this OCD population.

This study is not without limitations. First, the sample size was small limiting the ability to examine reciprocal effects of mid-intervention changes in the proposed mechanistic factors on exercise adherence. However, post-hoc sensitivity power analyses indicate ability to detect small main effects with repeated measures. All individuals had a primary diagnosis of OCD, limiting generalizability to other mental health conditions, but this highlights the importance of further investigation of PA enjoyment in this understudied population with regards to exercise interventions. Future research should extend findings about PA enjoyment promoting long-term exercise engagement in other psychiatric populations, given the dearth of current literature and the applicability of mood-related benefits and increased risk for medical conditions in these populations. Finally, participants enrolled in this study were likely motivated to increase exercise as evidenced by increases in exercise in both the AE and HE groups (Abrantes, et al., 2017), a phenomenon that occurs for control groups across several exercise intervention studies (e.g., Bloom, et al., 2017; Schneider, et al., 2016; Szuhany & Otto, 2020). Therefore, it would be important to investigate the effects longitudinally in a sample not participating in an intervention study.

Given this study identified PA enjoyment as a predictor driving long-term engagement in exercise behaviors, next steps in the SOBC model are 1) strategies to appropriately measure target engagement and 2) pilot-testing interventions to engage this potential target mechanism (Nielsen, et al., 2018; Riddle, 2015). The PACES, utilized in this study, is a validated self-report measure of PA enjoyment (Kendzierski & DeCarlo, 1991). Though not direct measures of PA enjoyment, other related measures that may be included in future investigations are the Feeling Scale (Hardy & Rejeski, 1989), which measures pleasure/displeasure experienced during exercise from −5 (very bad) to +5 (very good), measures of affect during and after exercise (often rated from 0–100), and the enjoyment/interest subscale of the Intrinsic Motivation Inventory (McAuley, Duncan, & Tammen, 1989), all of which are self-report measures. A task-based measure of implicit attitudes towards physical activity is the Single-Target Implicit Association Test (ST-IAT; Greenwald, McGhee, & Schwartz, 1998), which has been utilized to examine implicit preference for or aversion to PA (Cody, et al., 2021; Locke & Berry, 2021). These measures may be a slightly different constructs than PA enjoyment given suggestions that affective (e.g., enjoyment) and instrumental (e.g., exercise is good for you) judgments about PA may differ (Rhodes, et al., 2022).

For those interested in increasing exercise who have low baseline levels of PA enjoyment, interventions to enhance PA enjoyment may improve initial uptake and maintenance of exercise regimens. This may be especially important for psychiatric populations, who typically engage in less exercise (Helgadóttir, et al., 2015), report more barriers to exercise (van Rijen & Ten Hoor, 2022), and may benefit most from the mental health benefits of exercise. Suggested strategies to enhance enjoyment during exercise include attending to the immediate mood benefits of exercise as opposed to the health benefits (Otto & Smits, 2011), which has efficacy in psychiatric populations (Hearon, et al., 2018), finishing well (e.g., reducing exercise intensity to increase pleasure at the end of exercise; Zenko, Ekkekakis, & Ariely, 2016), self-selected exercise intensity (Baldwin, et al., 2016; Ekkekakis & Lind, 2006), and mindfulness during exercise. A recent pilot study evaluated the preliminary efficacy of an online mindfulness-based guided imagery intervention and found a positive effect for PA enjoyment and exercise engagement (Mitchell, Martin, Baldwin, & Levens, 2021). Few other studies have examined the effect of psychoeducational interventions at improving PA enjoyment, so future interventional studies may examine these effects on this mechanistic target.

Conclusions

Overall, PA enjoyment may be an important modifiable potential target mechanism for intervention, especially within psychiatric populations, such as OCD, who may benefit from the mental and physical health benefits of higher levels of exercise engagement. In this sample with OCD, higher baseline PA enjoyment was predictive of exercise engagement up to 6-months later above and beyond randomization to aerobic exercise or health education intervention, though the exercise intervention did increase PA enjoyment. Aligned with the

SOBC framework, next steps would be to identify intervention strategies to modify PA enjoyment, possibly including some of the CBT strategies involved in the AE intervention as well as as mindfulness-based interventions or psychoeducation focused on the mood benefits of exercise. Improving PA enjoyment may lead to long-term exercise maintenance for more individuals, especially those with psychiatric conditions, who tend to be more sedentary and may benefit most from improvements in overall physical and mental health.

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Highlights

- Identifying potential mechanisms of long-term physical activity (PA) is important
- This is especially needed in psychiatric populations, such as OCD
- Baseline PA enjoyment predicted PA engagement up to 6-months later
- General affect and behavioral activation did not predict PA engagement
- PA enjoyment may be a modifiable target for future interventions

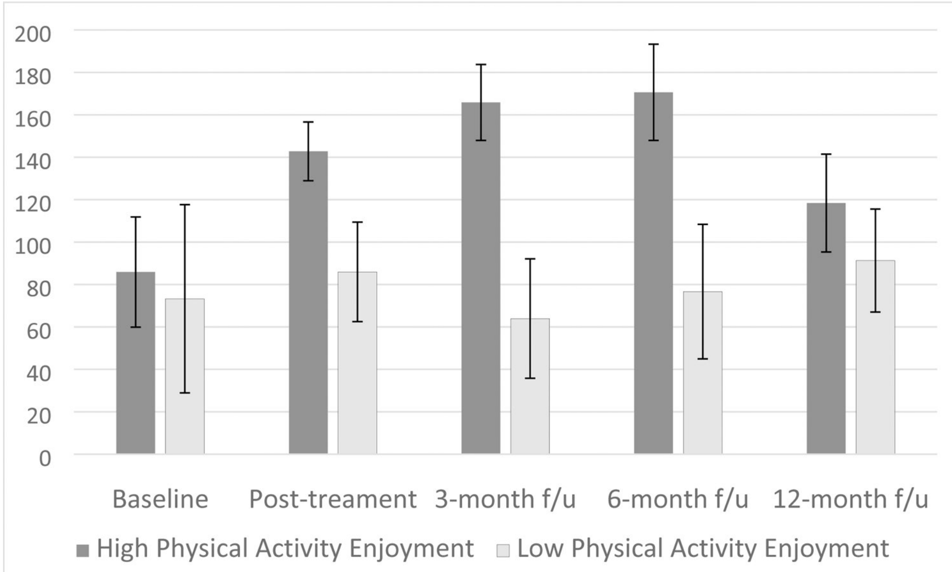

Figure 1.

Average exercise for individuals with high vs. low baseline physical activity enjoyment over time

Note. Exercise measured in average minutes per week. Physical activity enjoyment median split for figure. Error bars show standard error of the mean.

Table 1.

Baseline Demographic and Clinical Characteristics

	Aerobic Exercise (n=28)	Health Education (n=28)	Total (n=56)
Age, mean (SD)	39.5 (13.9)	38.1 (12.2)	38.8 (13.0)
Gender, n (%)			
Female	20 (71.4%)	16 (57.1%)	36 (64.3%)
Male	8 (28.6 %)	12 (42.9%)	20 (35.7%)
Race, n (%)			
White	25 (89.3%)	26 (92.9%)	51 (91.1%)
Black/African American	0 (0%)	3 (10.7%)	3 (5.4%)
American Indian/Alaska Native	1 (3.6%)	2 (7.1%)	3 (5.4%)
Asian American	1 (3.6%)	0 (0%)	1 (1.8%)
Hispanic/Latinx, n (%)	3 (10.7%)	1 (3.6%)	4 (7.1 %)
Education, n (%)			
High school/GED or less	5 (17.9%)	5 (17.9%)	10 (17.9%)
Technical school or some college	9 (32.2%)	3 (10.7%)	12 (21.4%)
College graduate	6 (21.4%)	13 (46.4%)	19 (33.9%)
Graduate or professional school (some or completed)	8 (28.6%)	7 (25%)	15 (26.8%)
BMI, mean (SD)	31.2 (8.4)	29.3 (6.1)	30.2 (7.4)
Y-BOCS, mean (SD)	26.2 (5.3)	23.5 (4.9)	24.8 (5.3)
PACES, mean (SD)	73.4 (21.6)	82.1 (23.5)	77.6 (22.7)
PANAS negative, mean (SD)	23.8 (10.4)	20.1 (10.3)	22.0 (10.4)
PANAS positive, mean (SD)	21.8 (5.7)	21.3 (7.0)	21.5 (6.3)
Behavioral activation, mean (SD)	79.0 (19.6)	89.0 (23.4)	84.0 (22.0)
Exercise, mean (SD)	85.0 (217.0)	71.5 (14.9)	78.4 (182.4)

Note. SD: standard deviation; BMI: Body Mass Index; Y-BOCS: Yale-Brown Obsessive-Compulsive Scale; PACES: Physical Activity Enjoyment Scale; PANAS: Positive and Negative Affect Scale