



## Physical exercise and obsessive-compulsive disorder: a systematic review

| Review

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**Abstract:** Obsessive-compulsive disorder (OCD) is one of the most common mental disorders, characterized by recurring obsessions and compulsions. OCD is treated primarily with pharmacotherapy and/or cognitive behavioral therapy. However, many patients continue to experience clinically significant symptoms following treatment. Exercise, and in particular moderate intensity aerobic exercise, has been found to be effective in the treatment of various psychological disorders and could also be a useful adjunct treatment for OCD. The present study reviews the effectiveness of exercise in the treatment of OCD and possible adverse effects of exercise on obsessive-compulsive symptoms. The available studies in this area have demonstrated short- and long-term reductions in obsessive-compulsive symptoms and positive changes in mood following exercise interventions. However, in combination with eating disorder symptomatology, exercise may become a potential source of obsessive-compulsive symptoms. Preliminary results show that exercise could be a promising alternative treatment of OCD. Nevertheless, these findings need to be interpreted with caution, given the methodological limitations, including small sample sizes, lack of adequate control groups and the wide variability of the assessment tools. Large-scale, randomized controlled trials are needed in order to clarify the uncertainties in this promising field.

**Key words:** Obsessive-compulsive disorder; physical exercise; therapy; adverse effects.

### 1. Introduction

#### 1.1. Obsessive-compulsive disorder

Obsessive-compulsive disorder (OCD) is a common psychiatric disorder and is characterized by recurrent, intrusive and disturbing thoughts or beliefs (obsessions) and/or repetitive stereotypic behaviors (compulsions) [1]. These symptoms are usually associated with serious distress and anxiety and cause significant impairment of occupational and social functioning [2]. Common themes of obsessive-compulsive symptoms include cleaning/contamination, doubt about harm/checking, ordering/symmetry and unacceptable thoughts [1]. OCD affects 2–3% of the population over the course of a lifetime [3].

Several other conditions are associated with OCD. Among these, OCD co-occurs with depression in about one third of individuals affected, and with anorexia and bulimia nervosa in about 10–20%. Anxiety disorders (generalized anxiety disorder, social phobia, specific phobia) present a co-morbidity with OCD in approximately 10–28% [1,4].

Neuroimaging studies have implicated cortico-striato-thalamo-cortical circuits in the pathophysiology of OCD; this is supported by the observation of specific neuropsychological impairments in individuals with OCD, mainly in executive functions [5]. These circuits have been demonstrated to be hyperactive at rest and during

episodes of symptom provocation. Normalization of activity has been observed following pharmacological or psychological therapy. Genetic studies suggest that genes affecting the serotonergic, dopaminergic and glutamatergic systems play a role in the functioning of the cortico-striato-thalamo-cortical circuits [5]. Environmental factors may influence the manifestation of obsessive-compulsive behaviors, and some evidence suggests that OCD may be associated with altered circadian rhythms [6].

### 1.2. Treatment of OCD

Pharmacotherapy and cognitive-behavioral therapy (CBT) are commonly used methods for the treatment of OCD. The main psychological treatment for OCD is a specific version of CBT, i.e. exposure and response prevention (ERP). The pharmacotherapy of OCD uses mainly selective serotonin reuptake inhibitors. Approximately 40% to 60% of patients with OCD respond to pharmacological therapy in placebo-controlled studies. A decrease of 25% to 35% in the Yale-Brown Obsessive Compulsive Scale (Y-BOCS) is a measure commonly used to define a response to treatment. Even with a symptom reduction of 35%, patients may still experience significant remaining symptoms [7]. Forty percent of individuals treated with SSRIs report only a partial response to treatment or no improvement [4]. Similarly, many patients treated with ERP alone or in combination with pharmacotherapy, continue to experience clinically significant symptoms [8]. Follow-up studies of ERP therapy show a dropout rate of 30% and residual symptoms in approximately 50% of OCD patients [1], indicating that a sizable portion of patients with OCD who receive standard treatments are not effectively treated [9]. Efforts are continually underway to find other effective therapeutic options as alternative or adjunct treatment for individuals with OCD [10].

### 1.3. Exercise and mental health

Exercise, and in particular moderate intensity aerobic exercise, has been found to be effective in the treatment of various psychological disorders [11]. Several studies support the premise of mental health benefits of exercise and physical activity. Large scale studies and randomized controlled trials have shown a positive association between exercise and psychological well-being both in the general population and in clinical groups. Exercise has been demonstrated to be effective in preventing or delaying the onset of mental disorders as well as

reducing the symptom severity in various conditions [11,12].

In the general population, increased levels of exercise and physical activity were shown to correlate significantly with a decrease in the prevalence of mental disorders such as depression, anxiety, panic disorder, agoraphobia, social phobia and substance abuse [12,13]. Furthermore, it could be shown that patients exercising regularly were more likely to recover from a mental illness at three-year follow-up than those who did not exercise [14].

Clinical intervention studies have examined whether exercise and/or physical activity are effective when used as a sole or adjunct treatment of mental disorders. The effects have been shown to be heterogeneous for different disorders. Evidence in support of beneficial effects of physical activity on mental disorders stems mainly from trials with patients suffering from depression or anxiety disorders. Exercise has been demonstrated to reduce symptoms of depression when compared with no treatment and to show similar effectiveness to that of CBT [15]. In randomized controlled trials of exercise interventions in patients with anxiety disorders, exercise was effective in reducing anxiety symptoms, although less so than antidepressant medication [16]. It should be noted, however, that there are various methodological limitations to most of these studies (e.g. problems with randomization and blinding, no standardization of the type and frequency of exercise etc.) and the results should therefore be interpreted with caution [15-17]. Exercise seems, nevertheless, to be a promising option in the treatment of mental disorders.

### 1.4. OCD and exercise – the rationale for research

The rationale for investigating possible positive effects of exercise on OCD involves a number of considerations. There is a lack of adjunct treatments despite the residual symptoms experienced by a significant number of OCD patients. In addition, there is a co-morbidity of OCD with depression and anxiety [4], in which cases the various mental health benefits of exercise and physical activity have been proven [14]. Even so, only a handful of studies have been conducted investigating the role of exercise in the treatment of OCD. This review aims to present the results of the existing interventions while also considering the possible adverse effects of exercise, as well as to facilitate future research in this important area.

## 2. Methods

We reviewed and analyzed studies focusing on the therapeutic effects of moderate intensity exercise on OCD. The literature search included studies published up until June 2016 in the electronic databases PubMed, PsychInfo, ResearchGate and Google Scholar. On all databases the search terms “obsessive-compulsive disorder” and “OCD” were paired with “exercise”, “physical activity” and “sport”.

### 2.1. Inclusion criteria

In order to be included in this review, studies had to meet three criteria: (1) the participants of the studies had to have been diagnosed with OCD; (2) studies must have lasted at least 6 weeks; (3) the independent variable of the study had to be moderate intensity exercise (the effect of moderate intensity aerobic exercise on obsessions and compulsions). Furthermore, only papers written in English were included. Four papers met the inclusion criteria.

### 2.2. Second literature search

Since our search also found numerous studies focusing on compulsive exercise in eating disorders and the link between OCD and anorexia nervosa, we performed another more thorough search in the same databases using the key words: “exercise”, “excessive exercise”, “compulsive exercise”, “obsessive-compulsive” paired with “eating disorder”, “anorexia nervosa” or “bulimia nervosa”. In regard to these studies, we also included those conducted on non-clinical samples investigating the relationship between obsessive-compulsiveness and excessive exercise. The aim of the second search was to determine whether exercise could also have adverse effects on obsessive-compulsive symptoms and, if so, how this could affect the planning of future studies regarding the exercise-OCD relationship.

## 3. Results

### 3.1. Results of intervention studies on the effects of exercise on OCD symptoms (Table 1)

#### 3.1.1. Study by Lancer et al. [18]

In a preliminary investigation of exercise and OCD, the effects of low-impact aerobic exercise on obsessive-compulsive symptoms, anxiety and depression were examined [18]. Participants were recruited from OCD foundations (e.g. Obsessive Compulsive Anonymous) and had to meet the inclusion criteria of the study (Y-BOCS score of 14+, exercised no more than once a week in the month prior to the study and acceptance of the study

protocol). Selected participants (n=11, mean age: 34.5 years) were receiving standard treatment but reported no improvement in their symptoms following medication over a six month period (n=10) and/or CBT (n=7). At the start of the study, participants were given a financial incentive in order to maximize compliance, and initial criteria were established (Y-BOCS, efficacy of current treatment, demographic information). The average Y-BOCS score at baseline was 24.28, which is considered as severe OCD. Other baseline dependent measures were then completed (BDI-II and STAI-Y). During the intervention period, participants were required to engage in a 30-minute moderate intensity aerobic walking exercise three times a week for six weeks in addition to their usual therapy (medication and/or CBT). In the 1-month follow-up period, participants were asked to refrain from exercising in order to determine the effects of the intervention. Dependent measures were again completed post-intervention and at 1-month follow-up. In comparison to baseline scores (mean Y-BOCS: 24.28), both post-intervention (mean Y-BOCS: 18.28) and follow-up scores (mean Y-BOCS: 19.81) showed a significant decrease in OCD symptoms. Depressive symptoms, as well as state and trait anxiety scores also decreased significantly. It is important to note that the positive effects of exercising continued even when the exercise was not maintained. Despite these promising results, the study also had serious limitations, including the small sample size, the lack of a control group, the possible motivational aspect due to the financial incentive and the administration of other treatments. These limitations do not permit the generalizability of the results [18].

#### 3.1.2. Study by Brown et al. [19]

Another preliminary study examined the role of physical activity in the treatment of OCD [19]. The study attempted to assess whether exercise can reduce obsessive thoughts and compulsive behavior in patients not sufficiently responding to pharmacotherapy and/or CBT. Participants were recruited from an OCD specialty clinic through clinician referrals. Forty-five patients expressed interest but only 15 met the inclusion criteria, namely aged 18–65 years, a Y-BOCS score of 16+, receiving standard OCD treatment for at least three months and currently sedentary. Participants were treatment non-responders, i.e. individuals experiencing significant OCD symptoms despite receiving medication and/or CBT. At the beginning of the procedure, physical- (treadmill test) and clinical eligibility (SCID-P for DSM-IV)

of the participants were tested. After determined eligible, participants began a 12-week moderate-intensity aerobic exercise program. Dependent measures (OCD symptoms and quality of life) were assessed using self-rating scales (Y-BOCS; Q-LES-Q) at baseline, before and after every exercise session, at the end of the intervention, and three weeks, six weeks and six months after the completion of the trial. Effects of exercise on OCD symptoms were also measured post-intervention. The intervention included three components: aerobic exercise, CBT and incentives. Participants engaged in 20–40 minute aerobic exercise sessions three or four times a week. They were also requested to engage in physical activity in their private environment and to keep a detailed weekly exercise log of these additional activities. The CBT component consisted of group discussions before each exercise session on the benefits of exercise for OCD, motivation, coping with negative moods etc. Participants received remuneration for attending the exercise sessions and filling in their weekly logs. This financial incentive was intended to encourage adherence to the program [19]. Results of the study suggest that the intervention had positive effects on the variables in question. After completion of the program, participants reported a decrease in their obsessive-compulsive symptoms and a greater overall sense of well-being. Mean Y-BOCS scores ranged as follows: baseline 22.9; end of treatment 15.2; 3-week follow-up 15.5; 6-week follow-up 15.4; 6-month follow-up 16.0. This may suggest that regular moderate-intensity aerobic exercise could be effective in reducing OCD symptoms, but the methodological problems (lack of control group, very small sample size) allow no firm conclusions to be drawn. In addition, since CBT was an aspect of the intervention, the effects of exercise and CBT were indistinguishable from one another and positive symptom changes may have been the result of the psychological treatment [19].

### 3.1.3. Study by Abrantes et al. [20]

In 2009, the same research group analyzed the data of the study discussed above [19] from a different perspective. They wanted to establish whether or not moderate intensity aerobic exercise elicited acute effects on OCD symptoms [20]. In order to do so, they examined the effects of the single exercise sessions in detail. Participants engaged in 20-40 minute aerobic exercise sessions three or four times a week for a period of 12 weeks. Self-rating measures of mood, anxiety (NIMH self-rating scale) and obsessive-compulsive symptoms (Y-BOCS) were completed before and after every exercise

session. The results showed that the participants experienced significant positive changes in mood and anxiety levels as well as obsessive-compulsive symptoms. The average Cohen's d effect size for obsessions was medium at week 1 (-.62) and small at week 12 (-.29). The average Cohen's d effect size for compulsions was near to large at week 1 (-.77) and small at week 12 (-.14). This indicates that the exercise intervention resulted in large to small reductions in obsessive-compulsive symptoms throughout the treatment, with significant acute effects after the single exercise sessions. A similar tendency was observed in mood and anxiety ratings. In order to be able to interpret the results more conclusively, these findings need to be replicated, taking into account the various limitations of the study (see Table 1) [19,20].

### 3.1.4. Study by Rector et al. [21]

A recent pilot study focused on the feasibility of using physical exercise as an adjunct treatment to CBT in medication-refractory OCD patients [21]. The authors hypothesized that the combination of CBT and exercise could be more effective in reducing obsessive-compulsive symptoms than either treatment alone. Obsessive-compulsive patients were recruited for the study from a large university-based tertiary care (specialty OCD assessment and treatment center). In order to participate, they had to meet DSM-V criteria for principal OCD (SCID for DSM Axis I Disorders), have a clinician-rated Y-BOCS score of 16+ and be on stable medications with no changes in the three months prior to the study. Applicants who had completed a full course of OCD-related CBT (8 weeks) in the two years prior to the study were excluded from participation. Eleven individuals met the study criteria, with a mean age of 35.5 years. The intervention consisted of a 12-week aerobic exercise program combined with 15 weeks of OCD-related CBT (ERP). Following an exercise test, the exercise sessions were individualized to each participant and implemented in local gyms three times a week. Both intensity and duration of the exercise sessions increased during the intervention. Adherence was monitored using self-report exercise logs and weekly phone-checks by the research assistants. Study assessment measures regarding OCD symptoms (Y-BOCS, OBQ-44 – Obsessional Beliefs Questionnaire-44), depression (BDI-II – Beck Depression Inventory II), anxiety (BAI – Beck Anxiety Inventory) and exercise (Physical Activity Readiness Questionnaire) were completed before and after treatment [21]. Results showed significant treatment effects on all measures. Pre- to post-treatment changes

in the Y-BOCS scores were very large (determined with a paired sample t-test and Cohen's d). OCD symptoms decreased considerably from pre- to post-treatment ( $d=2.20$ ). The mean Y-BOCS scores changed from baseline to post-treatment from 26.36 to 14.73 points. The OBQ-44 scores also showed a significant and large treatment effect ( $d=.02$ ). Mean scores on the OBQ-44 changed from 165.60 to 126.40 pre- to post-treatment. A moderate to large effect was shown in depression, measured on the BDI-II ( $d=0.76$ ), and a small effect in anxiety levels, measured on the BAI ( $d=0.29$ ). The authors interpreted their results as support for the feasibility of combined CBT and exercise treatment in patients with OCD. However, the study's small sample size and the lack of a control group need to be considered. Since there was no follow-up assessment, these results show only the acute effects of the intervention. Furthermore, it is unclear whether exercise, CBT or the combination of both are responsible for the effects on the symptoms.

### **3.2. Possible adverse effects of exercise in individuals with OCD**

One rationale for research regarding a positive influence of exercise on obsessive-compulsive symptoms is OCD's co-morbidity with depression and anxiety, for which some therapeutic efficacy of exercise has been demonstrated [14,15]. Another co-morbid psychiatric disorder of OCD is anorexia nervosa. In this disorder, a distorted perception of body weight may cause sufferers to exercise compulsively in order to lose weight [22–25]. This connection needs to be considered in the relationship between exercise and OCD. Several studies have addressed this issue in both clinical and non-clinical settings. We included these studies in our review in order to clarify whether exercise could also have detrimental effects on obsessive-compulsive symptoms, and, if so, in what way this should be implemented in the planning of future intervention trials.

#### **3.2.1. Results of studies with non-clinical participants (Table 2)**

A study with non-clinical participants examined psychological risk factors of compulsive exercise [26]. The authors of this study attempted to identify potential cross-sectional predictors, including obsessive-compulsive symptoms, of compulsive exercise. One thousand four hundred and eighty-eight male and female adolescents (aged 12 to 14 years) completed measures of compulsive exercise, personality, psychological

morbidity, and disordered eating attitudes (see Table 2). Multiple stepwise regressions showed that the strongest cross-sectional predictors of compulsive exercise were a drive for thinness, perfectionism, and obsessive-compulsiveness. However, there was no correlation between compulsive exercise and the other psychological factors (depression, anxiety) [26]. Results suggest that obsessive-compulsiveness as a personality trait could predict excessive exercising in teenage years. Limitations to this study included the cross sectional design, the exclusive use of self-report measures and the young age of the sample.

Another study investigated the potential relationship between elevated (but subclinical) OCD symptoms, depression, anxiety or low self-esteem and exercise [27]. A total of 85 community-based exercisers from local fitness facilities participated in the study and completed questionnaires regarding the aforementioned factors. Five men and five women presenting with elevated OCD symptoms were asked to participate in a semi-structured interview regarding exercise habits and their obsessive beliefs and compulsive behavior. Strong correlations between the psychological symptoms (obsessions and compulsions, depression, anxiety and low self-esteem) were found, while only one exercise-related factor (commitment to exercise) correlated with elevated OCD symptoms. Qualitative analysis of the interviews showed that exercise was not a source of obsessions or compulsions but rather served as a coping mechanism for these individuals [27]. Similar results were found in another study with 210 non-clinical adult participants [28], examining the relationship between exercise, anxiety, obsessive compulsiveness and narcissism. Increased levels of obsessive-compulsiveness were associated with a higher commitment to exercise but no other exercise factor, such as frequency. In view of the limited methodology of the studies (small sample size, no control group, exclusive use of self-report measures and qualitative interviews), the results need to be interpreted cautiously.

#### **3.2.2. Results of studies in clinical settings (Table 2)**

Several studies have been conducted on OCD symptoms and excessive exercise in the clinical population (patients with anorexia nervosa). A systematic review from 2013 summarizes the findings of a total of 10 studies [29]. The majority of these studies were cross-sectional and used self-report measures and/or structured interviews in patients with anorexia nervosa from inpatient and outpatient care. Seven of 10 studies showed a positive

relationship between excessive exercise and OCD and/or obsessive-compulsive personality disorder in patients with anorexia nervosa. The association between obsessive-compulsive personality and excessive exercise appeared to be very strong, while the relationship with OCD was less clear. Three other studies showed a negative or no correlation [29]. The variability of these results may derive from the limitations of the studies. Various instruments measuring different constructs were used and most studies were cross-sectional and used self-report measures. Many questions regarding other factors possibly influencing the relationship between OCD and exercise remain to be answered. These factors include, for example, motivation for exercise or other exercise-related factors. It is unclear whether individuals with obsessive-compulsive tendencies are more likely to engage in compulsive exercise, or whether exercise serves as a mechanism to reduce anxiety caused by weight or food-related obsessions [29]. Furthermore, the relationship between obsessive-compulsiveness and excessive exercising in anorexia nervosa may be mediated by a third factor such as exercise dependence [30].

In summary, obsessive-compulsiveness per se does not appear to be a source of excessive exercising either on a subclinical or on a clinical level. It appears that obsessive-compulsiveness contributes to an increased commitment to exercise, which can have many beneficial effects on both physical and psychological well-being. However, in patients with anorexia nervosa or adolescent participants, obsessive-compulsiveness can elevate the risk of engaging in excessive exercise. These results need to be considered in both research and therapy.

#### 4. Conclusions

There is an increasing need to examine the potential advantages of physical activity and exercise for mental health [31]. A growing body of evidence supports the view that physical activity and exercise could be useful in the prevention and treatment of various psychological disorders [12]. However, there are considerable methodological limitations to most of the research conducted in this area, including small sample sizes, lack of control groups and the wide variability of the assessment tools. Most studies have focused on depression or anxiety, while there is little knowledge about other disorders [31]. OCD is a debilitating mental disorder, and many sufferers continue to experience clinically significant symptoms following pharmaco-

therapy and/or CBT [8]. Given the evidence supporting the positive effects of exercise on mental health, exercise could also serve as a potentially useful adjunct treatment for OCD. The aim of this study was to review relevant published literature focusing on the therapeutic effects of exercise on obsessive-compulsive disorder. By analyzing the results of the studies and pointing out their methodological weaknesses, as well as the possible adverse effects of exercise on OCD, we sought to emphasize the importance of this field and provide directions for future research. To date, few studies have investigated the relationship between exercise and OCD [32]. These concluded that exercise produces a beneficial effect on obsessive-compulsive disorder, eliciting short- and long-term reductions in obsessive-compulsive symptoms and positive changes in mood following 6–12 week exercise interventions [18–21]. However, these findings need to be interpreted with caution, given the methodological limitations and also the potential links to anorexia nervosa, where exercise itself could become compulsive. It is important to clarify these questions and improve the methodology of future trials. Further research is therefore needed in order to replicate these findings and to assess the acute and chronic effects of exercise on obsessive-compulsive symptoms. It also remains to be established whether exercise produces a direct effect on OCD symptoms or whether mediating factors such as mood enhancement, motivation or executive functioning play a role [20]. Large-scale, randomized controlled trials need to be conducted in order to clarify the uncertainties in this promising but, as yet, relatively unexplored area.

#### Conflict of interest

The authors declare no conflict of interest.

**Table 1.** Exercise interventions in the treatment of OCD

Authors	Aim of study	Study design	Sample	Treatments	Study measures	Results	Limitations
<b>Lancer et al. [18]</b>	Effects of exercise on reducing OCD and related symptoms	Repeated-measures design with baseline, post-intervention and 1-month follow-up	n = 11  Diagnosed OCD patients receiving standard treatment  Mean age: 34.5 years	Moderate intensity aerobic walking  30 minutes 3 times weekly for 6 weeks	Questionnaires: Y-BOCS (Yale-Brown Obsessive Compulsive Scale); STAI-Y (State-Trait Anxiety Inventory-Form); BDI-II (Beck Depression Inventory)  Incentive (money)	Comparison between baseline scores and post-intervention and follow-up scores revealed significant decrease in OCD and depressive symptoms, as well as state and trait anxiety	No randomization, no control group  No blinding  Limited generalizability (small sample size, motivated participants)
<b>Brown et al. [19]</b>	Impact of aerobic exercise as an adjunct treatment for OCD patients	Pilot study, repeated measures design with baseline, end of treatment and 3-, 6-week and 6-month follow-up	n = 15  Diagnosed OCD patients receiving standard treatment  Mean age: 41.9 years	12-week moderate intensity aerobic exercise intervention (treadmill, elliptical machines etc.)  20–40 minute sessions 3–4 times weekly (+additional exercise at home 2–3 times per week)  Cognitive-behavioral group training before exercise sessions	Structured Clinical Interview for DSM-IV  Questionnaires: Y-BOCS; Self-Report Measure of Exercise’s Influence on OCD; Q-LES-Q (Quality of Life)  Incentive (money)	Participants reported a decrease in their obsessive-compulsive symptoms and a greater overall sense of well-being. These effects persisted to a certain extent even 6 months after the program	Underlying mechanisms not addressed  Participants were receiving other treatment

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**Table 1.** Exercise interventions in the treatment of OCD (continued from page 7)

Authors	Aim of study	Study design	Sample	Treatments	Study measures	Results	Limitations
<b>Abrantes et al. [20]</b>	To measure acute changes in obsessive-compulsive symptoms following exercise	Secondary data analysis from earlier pilot study (Brown et al. [19])  Repeated measures design with assessment after every exercise session	n = 15  Diagnosed OCD patients receiving standard treatment  Mean age: 41.9 years	12-week moderate intensity aerobic exercise intervention (treadmill, elliptical machines etc.)  20–40 minute sessions 3-4 times weekly (+additional exercise at home 2–3 times per week)  Cognitive-behavioral group training prior to exercise sessions	Structured Clinical Interview for DSM-IV  Questionnaires: Y-BOCS; Self-Report Measure of Exercise’s Influence on OCD; Q-LES-Q (Quality of Life)  Incentive (money)	Participants consistently reported improvements in mood, as well as a decrease in anxiety and OCD symptomatology after every exercise session. These acute changes were fairly consistent during the 12-week intervention period.	No randomization, no control group  No blinding  Limited generalizability (small sample size, motivated participants)
<b>Rector et al. [21]</b>	To examine the additive benefits of physical exercise to CBT for OCD	Pilot study. Repeated measures design with assessment at baseline and post-treatment	n = 11  Diagnosed OCD patients receiving medical treatment but no CBT  Mean age: 35.5 years	12-week aerobic exercise intervention (e.g. bicycle, elliptical machines, treadmill, swimming). Physical exercise was individualized to each participant based on peak heartrate.  3 times per week, with increasing intensity and duration during the intervention  CBT (ERP) delivered in group sessions for 15 consecutive weeks	SCID – Structured Clinical Interview for DSM Axis I Disorders  Questionnaires: Y-BOCS; OBQ-44 (Obsessional Beliefs Questionnaire); BDI-II (Beck Depression Inventory); BAI (Beck Anxiety Inventory); Physical Activity Readiness Questionnaire	Significant treatment effects on all measures. OCD symptoms decreased considerably from pre- to post-treatment, as did depression and anxiety levels.  These results support the feasibility of combined CBT and exercise treatment in patients with OCD.	Underlying mechanisms not addressed  Participants were receiving other treatment  No follow-up assessment

**Table 2.** Obsessive-compulsiveness and excessive exercise

Authors	Aim of study	Study design	Sample	Type of exercise	Study measures	Results	Limitations
<b>Goodwin et al. [26]</b>	To determine the predictors of excessive exercise	Cross-sectional study	n = 1488  Non-clinical sample of 12-14-year-old adolescents	Not specified	Questionnaires: CET (Compulsive exercise test); EDI-2 (Eating Disorder Inventory); CAPS (Child&Adolescent Perfectionism Scale); SCAS (Spence Child Anxiety Scale); HADS; SPAS (Social Physique Anxiety Scale)	Best predictor of excessive exercise was a drive for thinness, followed by perfectionism and obsessive-compulsiveness.	Cross sectional nature of the study  Self-report measures  Relatively young age of the sample
<b>Readdy and Ebbeck [27]</b>	To examine the relationship between OCD symptoms and anxiety, depression, self-esteem and commitment to exercise	Mixed-methods approach  Exploratory study	n = 85  Non-clinical, community exercisers recruited from local fitness facilities, with membership of at least 3 months and regular exercise during this period	Not specified  Various types of exercise, e.g. running, swimming, aerobic fitness, etc.	Questionnaires: OCI-R; BDI; BAI; CES (Commitment to Exercise); RSES (Rosenberg Self Esteem Scale); LTEQ. 60-90 min qualitative semi-structured interview with 10 participants exhibiting highest levels of OCD sympt.	Significant correlations between following variables: OCD symptoms, depression, anxiety, self-esteem and commitment to exercise. Exercise was not a source of obsessions or compulsions.	No generalizability (non-clinical sample without subclinical symptoms; qualitative interview; small sample size)
<b>Young et al. [29]</b>	To examine the relationship between obsessive-compulsive personality disorder, OCD and excessive exercise in patients with anorexia nervosa	Systematic review – cross sectional, retrospective and quasi experimental studies	Ten studies met the inclusion criteria for the review.  Clinical samples – patients diagnosed with anorexia nervosa	Not specified	Self-report measures and/or structured interviews	7 of 10 studies showed a positive relationship between excessive exercise and OCD and/or obsessive-compuls. personality disorder in patients with anorexia nervosa. 3 of 10 studies showed negative or no correlation.	Small sample sizes  Retrospective methods  Cross-sectional designs

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