



Mental disorders in individuals at risk for exercise addiction – A systematic review

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ABSTRACT

Introduction: Exercise addiction is one of several behavioral addictions which has not yet been designated as an addictive disorder in the Diagnostic and Statistical Manual of Mental Disorders 5 (DSM-5). This is in part due to a lack of clarity concerning co-occurring mental disorders of individuals at risk for exercise addiction. The aim of this review is to summarise the spectrum of psychopathology in populations at risk of exercise addiction.

Methods: The MEDLINE, Web of Science and PsycINFO databases were searched. All studies from the date of database creation until February 2020 were considered eligible. Terms used were “exercise addiction” and other mental disorders mentioned in conjunction with substance-related and addictive disorders. Studies were included if they assessed risk for exercise addiction and at least one other mental disorder.

Results: Twenty studies were included. The disorders assessed were eating disorders (n = 14), depression (n = 6), anxiety (n = 4), other substance-related and addictive disorders (n = 5), and borderline personality disorder (n = 1). In thirteen of the studies, evidence was found for higher rates of at least one mental disorder (most commonly eating disorders, anxiety and other addictive disorders) in individuals at risk for exercise addiction, compared to those not at risk.

Conclusions: Individuals at risk for exercise addiction show a broad range of mental disorders as assessed by self-report, which is in line with sufferers of other addictive disorders. Systematic psychological and clinical assessments in those at risk of exercise addiction are worthwhile, and will serve to characterize the mental health problems of individuals suffering from exercise addiction.

1. Introduction

In the past decade, research into behavioral addictions has gained momentum, as researchers seek to determine whether the various behaviors reported in the literature may have a pathological status (Kardefelt-Winther et al., 2017). Amongst these, the possibility of exercise addiction has been the subject of investigation since 1970 (Baekeland, 1970). Exercise addiction has been defined as a pathological exercise habit, with the affected individual adhering to a strict regime despite negative physical and psychological consequences, which are severe enough to disrupt daily functioning (Szabo, 2015). Case studies have emerged documenting the experiences of individuals who exercised frequently, felt unable to reduce their exercise, continued despite illness, injury and social conflict, and experienced “withdrawal symptoms” when forced to stop (Bamber, Cockerill, Rodgers, & Carroll, 2000;

Griffiths, 1997; Spieker, 1996; Waldstreicher, 1985). In the wake of these case studies, numerous cross-sectional studies have emerged (Colledge, Buchner, Schmidt, & Walter, 2019), which employ questionnaires to assess risk factors for the phenomenon of exercise addiction. While widely varying prevalence rates have led to questions about the validity of the instruments employed (Cook et al., 2013), qualitative research indicates that there are individuals who report mental suffering as a result of their exercise habits (Johnston, Reilly, & Kremer, 2011; Kolnes & Rodriguez-Morales, 2016; Müller, Zander, Herberg, Müller, & de Zwaan, 2014). However, exercise addiction is not classified as an addictive disorder in the DSM-5. This is due to a lack of evidence about the nature and course of the phenomenon (Potenza, 2014), and an ongoing debate about the degree to which substance-related disorder symptoms can simply be translated to non-substance disorders (Billieux et al., 2015).

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Substance-related and addictive disorders frequently present with other mental disorders. In sufferers of substance use disorders, mood disorders, anxiety and psychotic disorders (Darcin, Nurmedov, Noyan, Yilmaz, & Dilbaz, 2015) are often reported. While, as noted above, many cross-sectional studies address exercise addiction as a potential addictive disorder, not all focus on the psychiatric symptoms that present in conjunction with a risk for exercise addiction; instead, the focus is on gender distribution, or type of exercise. Consequently, to our knowledge, there is no systematic reporting of the mental disorders or psychological problems which occur in individuals with a risk for exercise addiction. A review of this data will provide a key contribution to developing an accurate psychiatric profile of individuals with exercise addiction, by offering initial indications of disorders which may also be present. An understanding of co-occurring disorders can, following more detailed clinical screening, contribute to our knowledge of the development of exercise addiction, and this review provides initial indications of disorders which should be thoroughly screened for in this population. Without this information, characterizing the disorder, and establishing guidelines for clinical interviewing and eventual diagnosis, will be delayed.

1.1. Aim

The aim of this review is to summarise the mental disorders which have been reported to occur in individuals at risk for exercise addiction. The secondary aim is to report on whether these disorders are more prevalent in individuals at risk for exercise addiction, compared to individuals not at risk. This information provides valuable evidence concerning the range of mental disorders reported in individuals at risk of exercise addiction.

2. Material and methods

This study was carried out following the guidelines of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) (Moher, Liberati, Tetzlaff, Altman, 2009). The population of interest was individuals who have been assessed for symptoms of exercise addiction. The study type of interest was cross-sectional or longitudinal assessments of other DSM 5 psychiatric or personality disorders. The comparison group was defined as the sub-sample in each study identified as not at risk for, or displaying symptoms of, exercise addiction. The outcome in question was the presence and prevalence of other psychiatric and/or personality disorders.

In order to include as many psychiatric disorders as possible, we used a variety of terms in our search. These terms are based on the disorders which are frequently reported to accompany substance use disorders.

The MEDLINE, Web of Science and PsycINFO databases were searched. All studies from the date of database creation until the 20th of February 2020 were considered eligible. The following terms were used: “exercise addiction” or “exercise dependence” or “compulsive exercise” AND “depression” or “anxiety” or “trauma” or “ADHD” or “borderline” or “schizophrenia” or “psychiatric” or “alcohol” or “drug” or “eating disorder”. While the terms were only entered in English, studies in English, French or German were included if they were identified following these methods. Manual searches of the reference list of articles identified as being relevant were also carried out. The titles and abstracts of retrieved studies were read, independently, by two team members (FC and IS). Studies meeting the inclusion criteria were gathered, and compared by the two researchers. Any discrepancies were discussed, and in case of uncertainty, were determined by a third team member (MW). The final list of studies included in the review is the result of this process.

2.1. Inclusion criteria

Studies were included if they assessed exercise addiction as the primary disorder, and at least one other psychiatric disorder. In other

words, exercise addiction status was the independent variable, and other disorders were assessed as dependent variables or covariates. While exercise addiction risk is based on self-report questionnaires, for other disorders, both clinical diagnoses and self-report measures were included; the type of measure is reported in Table 2.

2.2. Exclusion criteria

Studies were excluded if another disorder was the primary focus, if the goal of the study was questionnaire validation, or if non-specific symptomatology or pathology, rather than a specific disorder or disturbance, was assessed.

2.3. Data extraction

FC and IS independently read all included studies in full. The following parameters were extracted for this meta-review: study methodology, number of participants, participant characteristics, the instrument used to measure risk for exercise addiction, disorders assessed (and the instruments used to measure them), and data about the prevalence of exercise addiction and disorders in the study sample.

Quality assessment was based on the National Institutes of Health Guidelines for cross-sectional studies (National Institutes of Health). As participants in the studies included here were not exposed to a treatment, questions about the independent variable were interpreted as referring to exercise addiction status.

3. Results

The PRISMA flow diagram in Fig. 1 shows the number of studies identified, screened, excluded and included. Quality assessment of the included studies is presented in Table 1. All studies were deemed to be of fair quality, due to universal clarity in study population, assessment methods, and low loss to follow up. The most common limitations on study quality were an absence of power calculation and failure to assess potential confounders. In addition, the number of potentially eligible participants was typically not reported, which is particularly problematic for the results of this review, as individuals with psychiatric disorders may be less likely to participate in studies.

3.1. Study characteristics

Twenty studies were included in this review. They are presented in Table 2. All took the form of cross-sectional questionnaire-based studies. Sample sizes ranged from 53 to 1601. A variety of athlete types and levels of athletic activity were represented, from students, to regular hobby exercisers to professional athletes. Importantly, clinical diagnoses of mental disorders are made in only one study (Blaydon, Linder, & Kerr, 2004) –all other findings are based on scores of self-report questionnaires.

Eating disorders (anorexia nervosa, $n = 2$; bulimia nervosa, $n = 2$; not specified, $n = 10$) were addressed in fourteen studies (Blaydon et al., 2004; Blaydon & Lindner, 2002; Cook & Luke, 2017; Grandi, Clementi, Guidi, Benassi, & Tossani, 2011; Harris, Gee, d'Acquisto, Ogan, & Pritchett, 2015; Lejoyeux, Avril, Richoux, Embouazza, & Nivoli, 2008; Lejoyeux, Guillot, Chalvin, Petit, & Lequen, 2012; Levit, Weinstein, Weinstein, Tzur-Bitan, & Weinstein, 2018; Lichtenstein, Christiansen, Elkliit, Bilenberg, & Støving, 2014; Maraz, Urbán, Griffiths, & Dementovics, 2015; Meulemans, Pribis, Grajales, & Krivak, 2014; Muller, Loeber, Sochtig, Te Wildt, & De Zwaan, 2015a; Rocks, Pelly, Slater, & Martin, 2017; Torstveit, Fahrenholtz, Lichtenstein, Stenqvist, & Melin, 2019). Six studies addressed depression (Jee & Eun, 2018; Levit et al., 2018; Li, Nie, & Ren, 2015; Mayolas-Pi et al., 2016; Weinstein, Maayan, & Weinstein, 2015), four addressed anxiety (Levit et al., 2018; Li et al., 2015; Mayolas-Pi et al., 2016; Weinstein et al., 2015), five addressed other addictive disorders (alcohol, $n = 3$; nicotine, $n = 2$ buying, $n = 3$;

internet, n = 2; food, n = 1) (Hauck, Schipfer, Ellrott, & Cook, 2020; Lejoyeux et al., 2008; Lejoyeux et al., 2012; Muller et al., 2015a; Szabo, Griffiths, Aarhus Hoglid, & Demetrovics, 2018), and one addressed borderline personality disorder (Maraz et al., 2015). Nine studies addressed only eating disorders (Blaydon et al., 2004; Blaydon & Lindner, 2002; Cook & Luke, 2017; Grandi et al., 2011; Harris et al., 2015; Lichtenstein et al., 2014; Meulemans et al., 2014; Rocks et al., 2017; Torstveit et al., 2019); 11 studies addressed at least one other disorder (Back, Josefsson, Ivarsson, & Gustafsson, 2019; Hauck et al., 2020; Jee & Eun, 2018; Lejoyeux et al., 2008; Lejoyeux et al., 2012; Levit et al., 2018; Li et al., 2015; Maraz et al., 2015; Mayolas-Pi et al., 2017; Muller, Loeber, Sochtig, Te Wildt, & De Zwaan, 2015b; Weinstein et al., 2015).

3.2. Evidence for association between exercise addiction scores and mental disorders.

In the following sections, we report on scores on various psychiatric questionnaires in populations assessed for risk of exercise addiction. The term “scores” refers to the mean totals achieved on the scales used to measure other psychiatric disorders, which are listed by name in Table 2. Statistically significantly higher scores indicate higher symptom severity, or the presence of more symptoms. With one exception, self-

report questionnaires were employed to assess symptoms of other disorders (Blaydon et al., 2004). One study also reported clinical diagnoses of eating disorders, which is noted in section 3.2.1.

Of the 20 studies included in this review, thirteen found evidence for higher scores on at least one psychiatric disorder or disturbance among individuals with high scores for, or at risk of, exercise addiction (Harris et al., 2015; Hauck et al., 2020; Lejoyeux et al., 2008; Lejoyeux et al., 2012; Li et al., 2015; Lichtenstein et al., 2014; Maraz et al., 2015; Mayolas-Pi et al., 2017; Meulemans et al., 2014; Muller et al., 2015b; Rocks et al., 2017; Torstveit et al., 2019; Weinstein et al., 2015) Five did not report prevalence rates of other disorders within the study population (Blaydon & Lindner, 2002; Blaydon et al., 2004; Cook et al., 2017; Grandi et al., 2011; Levit et al., 2018) and two found no difference between the groups (Jee & Eun, 2018; Szabo et al., 2018) and in one case, lower rates of nicotine abuse in the at-risk group (Lejoyeux et al., 2008). Below, we report these findings for each disorder.

3.2.1. Eating disorders

Amongst the fourteen studies which address eating disorders, evidence for higher scores in the populations classed as at risk for exercise addiction was found in nine (Harris et al., 2015; Lejoyeux et al., 2008; Lejoyeux et al., 2012; Lichtenstein et al., 2014; Maraz et al., 2015;

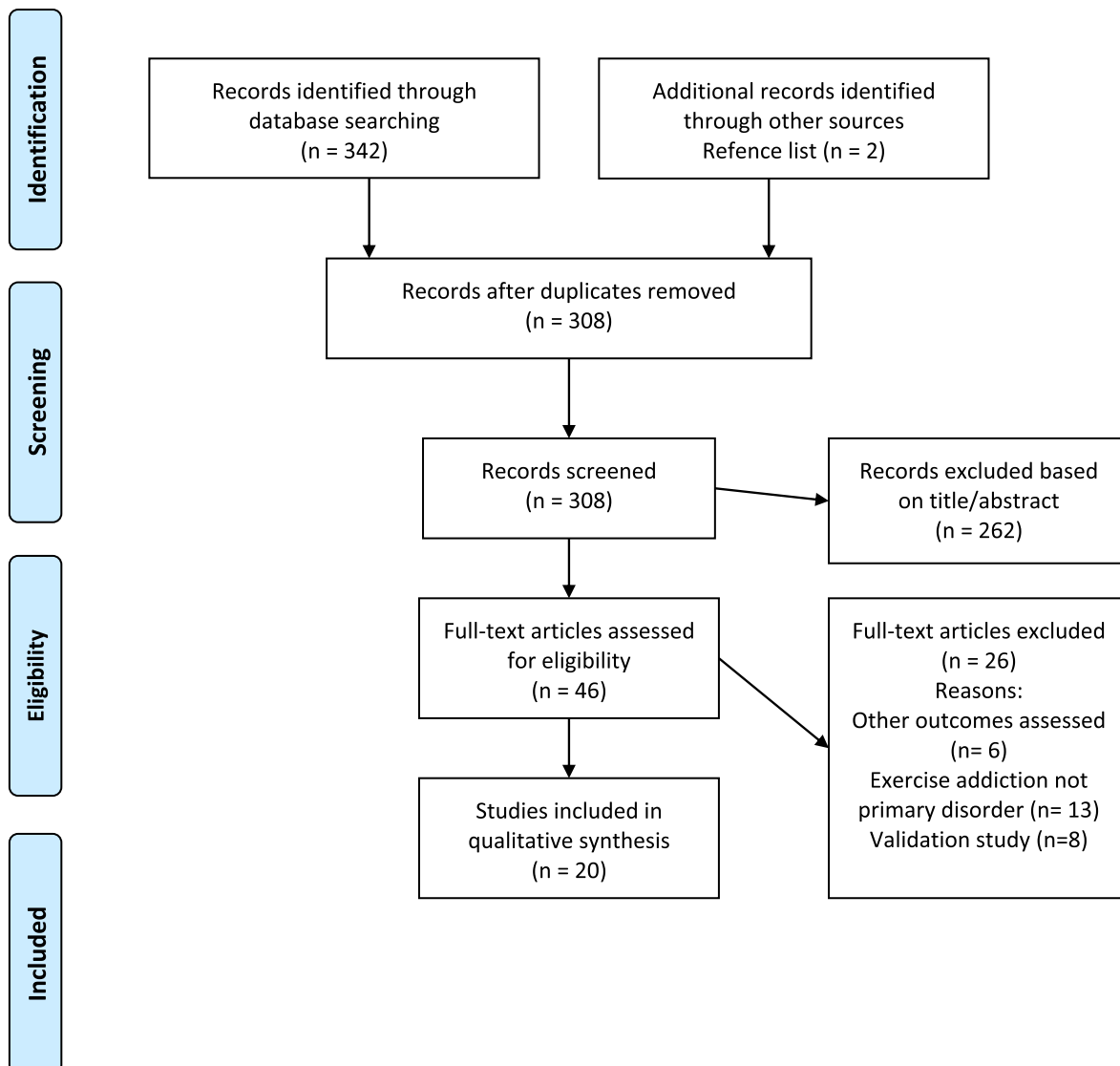


Fig. 1. PRISMA flow diagram.

Table 1
Quality assessment of included studies.

	1. Was the research question or objective in this paper clearly stated?	2. Was the study population clearly specified and defined?	3. Was the participation rate of eligible persons at least 50%?	4. Were all the subjects selected or recruited from the same or similar populations (including the same time period)? Were inclusion and exclusion criteria for being in the study prespecified and applied uniformly to all participants?	5. Was a sample size justification, power description, or variance and effect estimates provided?	6. For the analyses in this paper, were the exposure(s) of interest measured prior to the outcome(s) being measured?	7. Was the timeframe sufficient so that one could reasonably expect to see an association between exposure and outcome if it existed?	8. For exposures that can vary in amount or level, did the study examine different levels of the exposure as related to the outcome (e.g., categories of exposure, or exposure measured as continuous variable)?	9. Were the exposure measures (independent variables) clearly defined, valid, reliable, and implemented consistently across all study participants?	10. Was the exposure (s) assessed more than once over time?	11. Were the outcome measures (dependent variables) clearly defined, valid, reliable, and implemented consistently across all study participants?	12. Were the outcome assessors blinded to the status of participants?	13. Was loss to follow-up after baseline 20% or less?	14. Were key potential confounding variables measured and adjusted statistically for their impact on the relationship between exposure(s) and outcome (s)?	Quality rating (overall)
Blaydon, 2002	Y	Y	Y	Y	N	NA	NA	N	Y	NA	Y	N	Y	N	Fair
Blaydon, 2004	Y	Y	CD	Y	N	NA	NA	Y	Y	NA	Y	N	Y	N	Fair
Cook, 2017	Y	Y	CD	Y	N	NA	NA	Y	Y	NA	Y	N	Y	N	Fair
Grandi, 2011	Y	Y	CD	Y	N	NA	NA	Y	Y	NA	Y	N	Y	Y	Fair
Harris, 2015	Y	Y	CD	Y	N	NA	NA	Y	Y	NA	Y	N	Y	N	Fair
Hauck, 2019	Y	Y	CD	Y	N	NA	NA	Y	Y	NA	Y	N	Y	N	Fair
Jee, 2018	CD	Y	N	Y	N	NA	NA	Y	Y	NA	Y	N	Y	N	Fair
Lejoyeux, 2008	Y	Y	CD	Y	N	NA	NS	Y	Y	NA	Y	N	Y	N	Fair
Lejoyeux, 2012	Y	Y	CD	Y	N	NA	NA	Y	Y	NA	Y	N	Y	N	Fair
Levit, 2018	Y	Y	CD	Y	N	NA	NA	Y	Y	NA	Y	N	Y	N	Fair
Li, 2015	Y	Y	CD	Y	N	NA	NA	Y	Y	NA	Y	N	Y	N	Fair
Lichtenstein, 2014	Y	Y	CD	Y	N	NA	NA	Y	Y	NA	Y	N	Y	Y	Fair
Maraz, 2015	Y	Y	CD	Y	N	NA	NA	Y	Y	NA	Y	N	Y	Y	Fair
Mayolas, 2017	Y	Y	N	Y	N	NA	NA	Y	Y	NA	Y	N	Y	Y	Fair
Meulemans, 2014	Y	Y	CD	Y	N	NA	NA	Y	Y	NA	Y	N	Y	Y	Fair
Müller, 2015	Y	Y	N	Y	N	NA	NA	Y	Y	NA	Y	N	Y	Y	Fair
Rocks 2017	Y	Y	CD	Y	N	NA	NA	Y	Y	NA	Y	N	Y	Y	Fair
Szabo, 2017	Y	Y	CD	Y	N	NA	NA	Y	Y	NA	Y	N	Y	Y	Fair
Torstveit, 2019	Y	Y	CD	Y	N	NA	NA	Y	Y	NA	Y	N	Y	N	Fair
Weinstein, 2015	Y	Y	CD	Y	N	NA	NA	Y	Y	NA	Y	N	Y	N	Fair

Table 2
Results of the systematic review, in alphabetical order.

Author, date	Study type and statistical methods	Study aim	N	Participant characteristics	Exercise addiction measure	Other psychiatric disorders (instrument)	Prevalence data
Blaydon, 2002	Cross-sectional, questionnaire, Chi-square test for association	Associations between exercise, anxiety and depression	171	Triathletes	EDQ	Anorexia nervosa (EAT-26)	High EDQ, low EAT: n = 52; high EDQ, high EAT: n = 37; low EDQ, high EAT: n = 21
Blaydon, 2004	Cross-sectional, questionnaire, cluster analysis	Differentiation between primary and secondary exercise dependence	393	Amateur athletes	EDQ	Anorexia nervosa (EAT and clinical diagnosis)	High EDQ, low EAT: n = 58; high EDQ, high EAT: n = 52; low EDQ, high EAT: n = 45
Cook, 2017	Cross-sectional, questionnaire, descriptive statistics	Prevalence of primary and secondary exercise dependence	179	Cyclists	EDS	Eating disorder (DT subscale of EDI-2)	Primary EXD at-risk = 8.24%, primary EXD asymptomatic = 8.82%, secondary EXD at-risk = 1.18%, secondary EXD symptomatic = 10.59%, secondary EXD asymptomatic = 1.18%.
Grandi, 2011	Cross-sectional, questionnaire, MANOVA	Personality characteristics and psychological distress associated with exercise addiction	79	Regular exercisers	EDQ	Eating disorder (EDI-2)	Primary exercise addiction in total sample: 29.9% Individuals with exercise dependence more likely to report disordered eating (p < 0.05 on 9 subscales)
Harris, 2015	Cross-sectional, questionnaire, correlation analysis	Compare eating disorder and exercise dependence risk in various student groups	89	Female nutrition and sports students	EDS	Eating disorder (EAT-26)	Positive relationship between EAT-26 scores and EDS (p ≤ 0.001, r = 0.622) for all groups
Hauck, 2019	Cross-sectional, questionnaire, Pearson correlations	Examine association between food addiction and exercise dependence	1022	Amateur athletes	FESA	Food addiction (YFAS 2.0)	Significant correlations were observed: food addiction scores and exercise dependence scores (r = 0.180, p < 0.001)
Jee, 2018	Cross-sectional, questionnaire, mann-Whitney U test	Examine effects of exercise addiction on psychological health	75	College students participating in exercise programme	EAI, EDS, CET, OEQ	Depression (CES-D modified)	No differences between those at risk of exercise addiction and those not at risk
Lejoyeux, 2008	Cross-sectional, questionnaire, Chi-square and Student's T test	Presence of psychiatric disorders in those with and without exercise dependence	300	Fitness centre clients	EDS	Bulimia (DSM IV), alcohol abuse (CAGE), nicotine abuse (Fagerström), compulsive buying, internet addiction	Above EDS cutoff more likely to suffer from bulimia (Student t = 4.1, df = 298, P < 0.001), compulsive buying (χ ² = 16.3, df = 1, P < 0.0001); no more likely to abuse alcohol, nicotine or internet.
Lejoyeux, 2012	Cross-sectional, questionnaire, Chi-square and Student's T test	Presence of psychiatric disorders in those with and without exercise dependence	500	Sport shop customers	EDS	Bulimia (DSM IV), alcohol abuse (CAGE), nicotine abuse (Fagerström), compulsive buying	Above EDS cutoff more likely to suffer from bulimia (x ² = 6.9, df = 1, p = 0.008) alcohol abuse (x ² = 4.2, df = 1, p = 0.03); no more likely to suffer from nicotine dependence, compulsive buying
Levit, 2018	Cross-sectional, questionnaire	Examine relationship between exercise addiction, abnormal eating attitudes, anxiety, and depression among competitive and amateur athletes.	100	Amateur & professional athletes	EAI	Depression (BDI), anxiety (STAI), eating disorder (EAT)	-
Li, 2015	Cross-sectional, questionnaire, T test	Examine effects of exercise addiction on psychological health	1601	College students	EAI	Anxiety (STAI), depression (CES-D)	Above EAI cutoff had higher state anxiety scores t = 4.67, P < 0.001 and depression, t = 35.73, P < 0.001
Lichtenstein, 2014	Cross-sectional, questionnaire, Chi-square	Compare eating disorder symptoms in individuals with and without exercise addiction	121	Regular exercisers	EAI	Eating disorders (EDI-2)	Above EAI cutoff higher scores on eating disorder scale, p < 0.001
Maraz, 2015	Cross-sectional, questionnaire, Pearson correlation	Examine psychopathological factors associated with dance addiction	447	Salsa and ballroom dancers	DAI (dance-adapted EAI)	Borderline personality disorder (MSI-BPD), eating disorder (SCOFF)	Above DAI cutoff positively associated with borderline (r = 0.18, p < 0.001) and eating disorder (r = 0.19, p < 0.001) symptoms
Mayolas, 2017	Cross-sectional, questionnaire, ANOVA	Assess relationship between the risk of exercise addiction and health status	1577	Amateur cyclists and inactive controls	EAI	Anxiety, depression (HADS)	Higher anxiety score in men above EAI cutoff ((1, 749) = 10,685, p = 0.001)
Meulemans, 2014			517	Colledge students	EDS	Eating disorder (EDS-21)	

(continued on next page)

Table 2 (continued)

Author, date	Study type and statistical methods	Study aim	N	Participant characteristics	Exercise addiction measure	Other psychiatric disorders (instrument)	Prevalence data
Müller, 2015	Cross-sectional, questionnaire, ANOVA Cross-sectional, questionnaire, Spearman's rank order correlations	Examine relationship between exercise dependence and eating disorders Examine relationship between exercise dependence and other psychiatric disorders	128	Fitness centre clients	EDS	Alcohol dependence (AUDIT), eating disorder (EDE-Q), compulsive buying (CBS), video game abuse (new scale).	At-risk for exercise dependence had higher eating disorder scores ($p < 0.05$) At risk for exercise dependence positively correlated with eating disorders (ρ and compulsive buying ($\rho = \text{slate}$)
Rocks 2017	Cross-sectional, questionnaire, Spearman correlation	Association between exercise addiction and eating disorders	165	Nutrition and dietetics students	EAI	Eating disorder (EAT-26)	At risk for exercise addiction positively associated with eating disordered attitudes ($r_s = 0.24$; $P = 0.008$)
Szabo, 2017	Cross-sectional, questionnaire, MANOVA	Occurrence of substance addictions with varying levels of exercise	538	Regular exercisers	EAI	Alcohol dependence (AUDIT), drug dependence (DUDIT), nicotine dependence (Fägerstrom)	No difference between at risk and not at risk groups for alcohol and drug dependence; lower nicotine consumption in at risk group
Torstveit, 2019	Cross-sectional, questionnaire, Spearman correlation	Association between exercise addiction and eating disorders	53	Male endurance athletes	EDS	Eating disorder (EDE-Q)	EXDS total score was positively correlated with EDE-Q global score ($r = 0.41$, $p < 0.05$)
Weinstein, 2015	Cross-sectional, questionnaire, Spearman correlation	Associations between exercise, anxiety and depression	71	Professional and recreational exercisers	CES	Depression (BDI), anxiety (STAI)	Compulsive exercise positively associated with depression $r = 0.495$; $p < 0.01$ and trait anxiety $r = 0.288$; $p < 0.05$

Note: EDQ = Exercise Dependence Questionnaire; EDS = Exercise Dependence Scale; FESA: Fragebogen zur Erfassung des Sportverhaltens von Ausdauersportlern; EAI = Exercise Addiction Inventory; CET = Compulsive Exercise Test; OEQ = Obsessive Exercise Questionnaire; CES = Compulsive Exercise Scale; EAT = Eating Attitudes Test; EDI = Eating Disorder Inventory; YFAS = Yale Food Addiction Scale; CES-D = Centre for Epidemiologic Studies Depression Scale; DSM IV = Diagnostic and Statistical Manual of the American Psychiatric Association, 4th Edition; CAGE = alcohol use screening; Fagerström = Fagerström Test for Nicotine Dependence; BDI = Beck Depression Inventory; STAI = State Trait Anxiety Inventory; MSI-BPD = McLean Screening Instrument for Borderline Personality Disorder; SCOFF = non-clinical eating disorder assessment; EDE-Q = Eating Disorder Examination Questionnaire; HADS = Hospital Anxiety and Depression Scale; AUDIT = Alcohol Use Disorders Identification Test; CBS = Compulsive Buying Scale; DUDIT = Drug Use Disorders Identification Test.

Meulemans et al., 2014; Muller et al., 2015a; Rocks et al., 2017; Torstveit et al., 2019). One found no difference in the scores between groups (Levit et al., 2018); furthermore, four studies reported only whether subjects had high scores in one or both domains, not whether there were specific associations (Blaydon et al., 2004; Blaydon & Lindner, 2002; Cook & Luke, 2017; Grandi et al., 2011).

3.2.2. Anxiety

Three of the four studies addressing anxiety found evidence for higher scores among individuals with high scores for, or at risk of, exercise addiction (Li et al., 2015; Mayolas-Pi et al., 2017; Weinstein et al., 2015); one did not (Levit et al., 2018). One study found only higher state, not trait, anxiety (Li et al., 2015), while another found only higher trait, not state, anxiety (Weinstein et al., 2015).

3.2.3. Depression

Two of the five studies addressing depression found evidence for higher scores among individuals with high scores for, or at risk of, exercise addiction (Li et al., 2015; Weinstein et al., 2015). Three did not (Jee & Eun, 2018; Levit et al., 2018; Mayolas-Pi et al., 2017).

3.2.4. Other substance-related and addictive disorders

Four of the five studies addressing other addictions found evidence for higher scores for at least one form of addiction among individuals with high scores for, or at risk of, exercise addiction (Hauck et al., 2020; Lejoyeux et al., 2008; Lejoyeux et al., 2012; Muller et al., 2015b). Specifically, in certain studies positive associations were found with symptoms of food addiction (Hauck et al., 2020), alcohol use disorder (Lejoyeux et al., 2012) and compulsive buying (Muller et al., 2015b). However, in others, no association was found for symptoms of alcohol use disorder (Lejoyeux et al., 2008; Muller et al., 2015b), nicotine use

disorder (Lejoyeux et al., 2008; Lejoyeux et al., 2012), compulsive buying (Lejoyeux et al., 2012), video game use (Muller et al., 2015b) or internet use (Lejoyeux et al., 2008). One study found no evidence for higher levels of alcohol or drug dependence, and lower scores for nicotine dependence, in respondents at risk of exercise addiction (Szabo et al., 2018).

3.2.5. Borderline personality disorder

The sole study to address borderline personality disorder found evidence for a higher score among individuals with high scores for, or at risk of, exercise addiction (Maraz et al., 2015).

4. Discussion

The key finding of our review is that a majority of the studies included (13 out of 20, 65%) reported higher scores on other mental disorders in individuals at risk for exercise addiction, compared to those not (or less) at risk. In light of the large number of studies which address exercise addiction (Colledge et al., 2019), these 20 studies represent a very small proportion of current research, suggesting that a robust evidence base for psychiatric disorders in this population is lacking. While all included studies were deemed to be of fair quality, the lack of controlling for potential confounders (such as status as a competitive athlete) is concerning, and should be addressed in future studies. Blind scoring of questionnaires would also be advisable. The questionnaires employed and methods of analysis are heterogeneous, and so should be considered as initial exploratory findings to guide subsequent research. Based on the results of this review, it appears that individuals at risk for exercise addiction frequently present with a variety of comorbid psychological problems. Below, we summarise the outcomes of this review which are most relevant for future research in exercise addiction.

A variety of mental disorders was found to be present amongst individuals at risk for exercise addiction. This provides some evidence to counter suggestions that exercise addiction itself is merely a symptom of eating disorders (Bamber, Cockerill, Rodgers, & Carroll, 2003). Numerous scholars make a distinction between primary exercise addiction, where the pursuit of exercise itself is paramount, and secondary exercise addiction, where exercise is engaged in as a means to some other end, such as weight loss (Veale, 1987). On this understanding, individuals with eating disorders would suffer from secondary exercise addiction. Four studies which met our inclusion criteria did not report data on the prevalence of eating disorders in the exercising sample; however, these studies did provide evidence that there are individuals who display high scores of risk for exercise addiction, but not eating disorder symptoms. In fact, Grandi and colleagues specifically excluded individuals identified as having eating disorder symptoms, leaving a population which would fit the criteria for primary exercise addiction (Grandi et al., 2011). This finding has been confirmed in a meta-analysis by Trott and colleagues addressing eating disorder prevalence among those addicted to exercise (Trott et al., 2020).

While associations between exercise addiction and other disorders were identified in this review, the nature of this data does not permit us to speculate about causal factors which may underlie exercise addiction. It is possible that exercise addiction develops, in some individuals, as a coping mechanism for other psychiatric conditions, with the negative effects of exercise deprivation taking on pathological form (Szabo, 1995). While potentially rewarding effects of exercise are not well understood, there is robust evidence for the anti-depressive and anxiolytic properties of exercise (Schuch et al., 2016). Egorov and Szabo (2013), in their interactional model of the emergence of exercise addiction, suggest that certain pre-existing individual factors (in combination), which are currently not being assessed in studies of the phenomenon, may explain why for some individuals, exercise ceases to be a healthy coping mechanism, and slides out of control. Regular exercisers are likely to expect that exercise will help them feel better, so an unexpected stressful life event may cause the sudden development of symptoms in some of these individuals. On this understanding, other psychiatric comorbidities could be the stressors which cause individuals to lose control of their exercise behavior. It may also be the case that other psychiatric problems arise as result of the burden of exercise addiction, and are not themselves underlying causal factors. A detailed clinical history of affected individuals is an essential step in assessing causal factors, and this review indicates which disorders should be included on this list of potential co-occurring factors.

It should be emphasized that, in all studies included in this review, risk of exercise addiction was measured with a multi-dimensional instrument. Hence, the populations represented do not simply exercise a lot; they report feeling unable to stop, exercising despite negative mental and physical consequences, and suffering physically and psychologically when unable to continue. However, there is still a clear lack of evidence about the severity of these disorders, and the history of their development in the context of symptoms of exercise addiction. Self-report questionnaires do not replace clinical diagnoses, which must still be carried out before statements about comorbidities can be made. Furthermore, a wide variety of assessments of exercise addiction is represented, and these are based on different theoretical constructs of exercise addiction, with corresponding specific ways of formulating questions (Colledge et al., 2019). Their comparability cannot be taken as read. Based on the current state of the literature, we do not suggest that there is sufficient evidence to include exercise addiction in the DSM-5. Rather, we hold that this review suggests that there is reason to believe that exercise addiction does not appear only in the presence of eating disorders, and that, in order to correctly categorise the symptoms, detailed and systematic investigations are now warranted. Finally, it would also be interesting if further studies adopted the approach of Back and colleagues, and assessed whether individuals suffering from mental disorders are at higher risk for exercise addiction than the general population (Back et al., 2019).

4.1. Limitations

The extent and quality of the evidence presented here is limited. For example, depression, the most frequently reported comorbid disorder in substance use disorders, was only found at higher rates in two of the five studies which addressed it. While more studies reported higher levels of anxiety symptoms, five is still a limited number for establishing information about a new disorder. Furthermore, a wide variety of questionnaire forms was employed, and statistical analyses were heterogeneous, with effect sizes never reported, and information about associations available only in certain studies.

5. Conclusion

Symptoms of mental disorders are commonly present in individuals with addictive disorders. In this review, a variety of mental disorders, including eating disorders, anxiety and depression were reported in individuals at risk for exercise addiction. Compared to those not at risk, this group shows more psychological problems, which is in line with sufferers of other addictive disorders. Systematic psychological assessments and clinical interviews of mental disorders in those at risk of exercise addiction are worthwhile, and will serve to characterize this phenomenon.

CRedit authorship contribution statement

Flora Colledge: Conceptualization, Formal analysis. **Isabel Sattler:** Formal analysis. **Hanna Schilling:** Formal analysis. **Markus Gerber:** Supervision. **Uwe Pühse:** . **Marc Walter:** Conceptualization, Formal analysis.

Declaration of Competing Interest

The authors declared that there is no conflict of interest.

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