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Compulsive exercise and eating disorders

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From the very earliest descriptions, clinicians have observed a tenacious drive for physical activity as a prominent characteristic of many eating disordered patients, even in the face of severe emaciation (Bruch, 1965; Crisp, 1967; Dally, 1969; Eisler & LeGrange, 1990; Gull, 1874; Inches, 1895; Kron, Katz, Gorzynski, & Viner, 1978; Lasegue, 1873; Long, Smith, Midgley, & Cassidy, 1993; Penas-Lledo, Vaz Leal, & Waller, 2002; Shroff, Reba, Thornton, Tozzi, Klump et al., 2006; Touyz, Beumont & Hoek, 1987). Over the last few decades there has been considerable research into compulsive exercise among both eating disordered patients and non-clinical groups (Davis, 2000). Some researchers have argued that problematic exercise occupies a central role in the pathogenesis of the eating disorders (e.g., Davis, Kennedy, Ralevski, & Dionne, 1994; Epling & Pierce, 1992; Kron et al., 1978). Indeed, it is now recognised as a significant factor in the aetiology, development and maintenance of eating disorders across diagnoses (Brewerton, Stelfox, Hibbs, Hodges & Cochrane, 1995; Davis, Katzman, Kaptein, Kirsh, Brewer et al., 1997; Hechler, Beumont, Marks, & Touyz, 2005), although particularly in anorexia nervosa (Beumont, Arthur, Russell, & Touyz, 1994; Davis, 1997; Davis et al., 1997; Katz, 1996; Touyz et al., 1987; Thien, Thomas, Markin, & Birmingham, 2000).

The importance of compulsive exercise in the eating disorders is highlighted by the fact that it is often one of the last symptoms to subside (Crisp, Hsu, Harding & Hartshorn, 1980; Davis et al., 1994; Kron et al., 1978). For example, a 3-year in-patient hospital records analysis found that eating disorder patients across diagnoses who were compulsive exercisers required a longer length of hospitalisation than non-compulsive exercisers (Solenberger, 2001). In addition, compulsive exercise has been identified as a significant risk factor for relapse in AN (Carter, Blackmore, Sutandar-Pinnock & Woodside, 2004; Casper & Jabine, 1996). A 10-year follow up study of 95 patients with anorexia nervosa found that

increased exercise not only significantly predicted a shorter time to relapse, but was also one of only two variables (out of more than 50) that was associated with a chronic outcome (Strober, Freeman & Morrell, 1997).

Despite the documented importance of exercise within the context of the eating disorders, there is currently no consensus about the cognitive attributes that define compulsive exercise. This is problematic, since any interventions tailored at reducing exercise behaviour or altering exercise cognitions requires a clear underpinning theoretical model. Therefore, the broad aim of this review paper is to develop an empirically supported, testable, cognitive behavioural model of compulsive exercise within the context of the eating disorders. In order to achieve this aim, two extensive literature reviews were undertaken. The first, a systematic review aimed at identifying the correlates and predictors of compulsive exercise among eating disordered patients, identified four key correlates of compulsive exercise: eating psychopathology; obsessive-compulsiveness; affect regulation; and perfectionism. Second, a broader review incorporating both clinical and non-clinical samples, as well as literature from the exercise science field, identified similar key indices thereby validating the proposed model. The findings from these searches were then amalgamated. First, an outline of the review methodologies used will be provided. This will be followed by presentation of the proposed model and a subsequent review of the evidence for the inclusion of the key constructs.

Review methods:

Inclusion / exclusion criteria:

For both reviews, empirical work, published in English, which investigated factors associated with compulsive exercise behaviour in eating disordered individuals, was included. Given the variety of terms used to describe compulsive exercise, wider terminology was included (see viewpoint in this edition). For the initial systematic review, any study that recruited all, or part of their sample from a clinical eating disordered population and which investigated exercise (and/or physical activity) behaviour or any qualitative dimension of

exercise (e.g. commitment to exercise, obligatory exercise, exercise addiction, exercise dependence) was included. Eating disorders were restricted to anorexia nervosa, bulimia nervosa, and eating disorder not otherwise specified (EDNOS). Consequently, studies on obesity and binge eating disorder were excluded, as were studies that simply investigated body image or body dissatisfaction, without any further assessment of eating pathology. Additionally, studies that investigated eating disorders among athletic or exercising populations were also excluded from this review, unless the study's specific focus was on compulsive exercise (and/or one of the above terms). Qualitative studies were included, but individual case studies were excluded. Finally, outcome studies were also excluded as these were beyond the focus of this review. With the second review, the sample selection was broadened out to include non-clinical community samples as well as studies that specifically recruited exercisers. In all cases, the studies included were those that had researched links between exercise and eating disorder-related attitudes and behaviours.

Importantly, several identified studies investigated predictors of extreme weight control behaviours and/or eating disordered behaviours, of which excessive exercising was sometimes mentioned. However, these studies were often simply an investigation of exercising for weight management reasons and are not measuring compulsive exercise. Therefore, these studies were also excluded.

Search method:

Evidence for both reviews was gathered via a comprehensive three-stage literature search. First, key electronic databases were used. These were Web of Science, PubMed, PsycInfo, Science Direct, EBSCO, OVID and SCOPUS. Search terms included, but were not limited to: *exercise, activity, excessive, compulsive, obsessive, obligatory, addiction, dependence, habitual, commitment, abuse, disordered, eating, anorexia, bulimia*. Wildcards were used wherever required to enable all possible permutations of a root word to be found. For example **exercis** would find the word "exercise" together with all possible prefixes and suffixes, such as *over-exercise, over-exercising, over-exerciser, exercising, exerciser,*

exercised, and so on. In addition, in order to narrow the search to relevant findings only, Boolean Operators were used to specify relationships between specific search terms/word. For example, **exercis** AND *eat** OR *excessive*. Second, eating disorder journals were subjected to individual searches using the same search terms (including European Eating Disorders Review, International Journal of Eating Disorders, Eating Behaviors, and Eating & Weight Disorders). Finally, reference lists of relevant review papers as well as reference lists of identified articles were systematically searched to ensure that any further articles missed by the database and journal searches were also identified and included for the review.

Results of the systematic review:

The following section outlines the results specifically of the initial systematic review. Due to the large number of search terms employed, over 500 possible articles were produced from the databases. However, after accounting for duplications, and using the exclusion and inclusion criteria stipulated, 39 articles were retained for closer inspection. Following on from the procedures outlined in Berkman, Lohr & Bulik (2007) and Atlantis & Baker (2008), these 39 articles were graded according to relevance, from '0' representing irrelevance, through to '4', which represented high relevance. A total of 22 articles were graded as either 3 or 4 and were subsequently retained for this review. The remaining articles, which had rankings of below 3, were excluded.

Description of the studies

The characteristics of the different samples were largely similar across the studies. Participants were predominantly recruited at eating disorder clinics and the majority of the studies used young adult female samples. This is reflective of the demographics typical of eating disorder clinics. The only exception to the use of a female-only sample was that of Blaydon, Linder, and Kerr (2004), who also recruited highly active male exercisers.

The vast majority of the studies adopted cross-sectional designs (n = 15). One paper used a prospective design (Davis & Kaptein, 2006) and two were quasi-experimental (Davis,

Kaptein, Kaplan, Olmsted, & Woodside 1998; Klein, Mayer, Schebendach, & Walsh, 2007). Several studies involved a retrospective case series design, by investigating connections between various features of the eating disorder patients (Kron et al., 1978; Penas-Lledo et al., 2002; Solenberger, 2001). Finally, one study adopted a daily process design (Vansteelandt, Rijmen, Pieters, Probst, & Vanderlinden, 2007).

The majority of studies utilised one of two methods for gathering data. Self report measures were used either on their own, or as part of an overall assessment. Structured interviews were the other key method used to identify key features and qualitative experiences. Objective measures of height and weight were taken in several studies, whilst physical activity was assessed using objective measures in only one study (Klein et al., 2007).

From this point on, the outcome of the systematic review and the subsequent broader review of the non-clinical and exercise science fields will be combined to provide a rationale for inclusion of the key constructs within the ensuing model.

Development of an empirical model of compulsive exercise in the eating disorders

The reviews outlined above revealed several key indices of the compulsive dimension of exercise that are consistently described. Each of these indices can be viewed from a cognitive behavioural perspective as constituting potential maintenance factors for compulsive exercise. These key factors are schematically presented in Fig 1. This review will now critically consider the evidence supporting these factors in the maintenance of compulsive exercise.

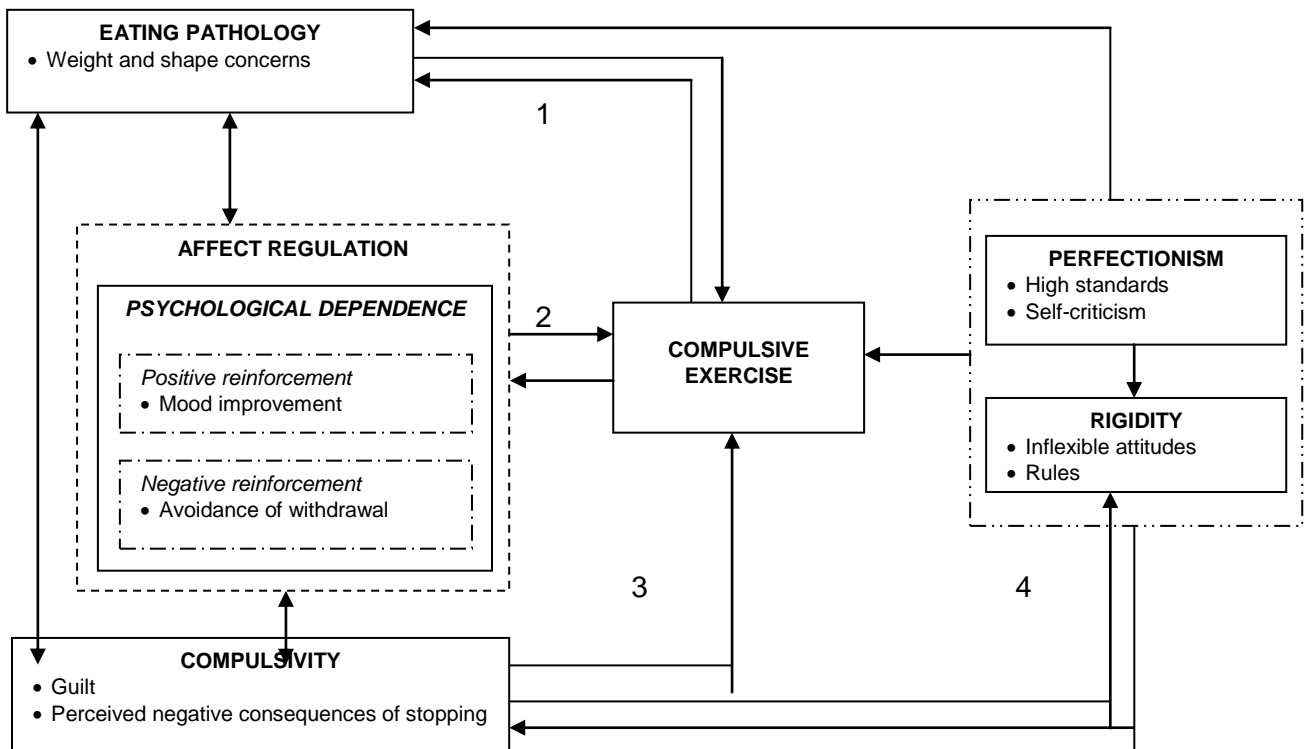


Figure 1. A schematic representation of the maintenance model of compulsive exercise

1 Links between compulsive exercise and eating pathology

Among eating disordered samples, increased compulsive exercise has been shown to be significantly associated with higher levels of eating disordered symptoms (Shroff et al., 2006), dietary restraint, weight and shape concerns (Dalle Grave, Calugi, & Marchesini, 2008; Holtkamp, Hebebrand, & Herpertz-Dahlman, 2004), drive for thinness (Solenburger, 2001), and body dissatisfaction (Brewerton et al., 1995; Solenburger, 2001). Likewise, among non-eating disordered samples, the relationship between compulsive exercise and elevated scores on measures of eating psychopathology is similarly well established (e.g., Elbourne & Chen, 2007; Lipsey, Barton, Hulley, & Hill, 2006). For example, compulsive exercise has been shown to be associated with higher scores on measures of eating and weight restriction (Thome & Espelage, 2007), drive for thinness (Ackard, Brehm, & Steffen, 2002; Adkins & Keel, 2005; Gulker, Laskis, & Kuba, 2001; Matheson & Crawford-Wright,

2000; Steffen & Brehm, 1999), bulimic tendencies (Ackard et al., 2002; Adkins & Keel, 2005; Steffen & Brehm, 1999), and body dissatisfaction (Ackard, Brehm, & Steffen, 2002; Adkins & Keel, 2005; Gulker, Laskis, & Kuba, 2001; Steffen & Brehm, 1999). In addition, Mond and colleagues (Mond, Hay, Rodgers, Owen, & Beumont, 2004;2006a; Mond, Hay Rodgers, & Owen, 2006b; Mond, Myers, Crosby, Hay, & Mitchell, 2008; Mond & Calogero, 2009) have consistently demonstrated that the extent to which exercise is undertaken solely or primarily to change weight or shape is one of the dimensions of compulsive exercise most strongly associated with eating disorder psychopathology and reduced quality of life. Indeed, such compulsive exercise was shown to clearly differentiate between eating disordered and non-eating disordered samples (Mond & Calogero, 2009).

Furthermore, it has been noted that behaviours such as dieting and exercise tend to reinforce each other because of the many personal and social benefits that accrue (Davis, 1997). Indeed, several studies have shown that exercising for weight loss is one of the principal reasons reported by men and women for beginning an exercise program (Davis et al., 1995; Markland & Hardy, 1993; McDonald & Thompson, 1992). However, worryingly, exercise can foster weight and diet concerns in certain susceptible individuals because the initial weight loss that often accompanies regular exercise elicits certain social reinforcers which, in turn, may lead to a heightened interest in physical appearance (Katz, 1986). This is in contrast to the prevalent social-cognitive/cognitive-behavioural perspective that views compulsive exercise as symptomatic of, rather than antecedent to, an eating disorder (Davis, Fox, Cowles, Hastings, & Schwass, 1990; Fairburn, Cooper, & Shafran, 2003) and suggests a reciprocally reinforcing relationship between compulsive exercise and eating pathology.

The importance of the links between exercise and eating pathology are underpinned by compelling empirical support for weight and shape concerns being a central feature of compulsive exercise, such that in the absence of eating pathology, compulsive exercise is not considered to constitute a clinically significant syndrome (Keski-Rahkonen, 2001; Mond et al., 2006a). Indeed, Mond et al. (2006a) demonstrated that there was no association

between exercise and reduced quality of life when eating pathology was statistically controlled for.

The evidence presented above clearly supports eating pathology as a central component of compulsive exercise both in terms of its development and maintenance. Critically, the evidence also suggests that the relationship between compulsive exercise and eating pathology is not one sided. Rather, each is suggested to reciprocally reinforce the other. However, despite the central importance of eating pathology in the development and maintenance of compulsive exercise, it is now recognised that compulsive exercise is more than simply a strategy for wasting energy or burning calories in weight preoccupied individuals (Davis, Katzman, & Kirsh, 1999). Whilst weight and shape concerns remain an essential component of compulsive exercise (e.g., Hubbard, Gray, & Parker, 1998; Keski-Rahkonen, 2001; Mond et al., 2006a), there is evidence to suggest that this model is too simplistic. Indeed, a review of the literature clearly suggests other key factors in addition to weight and shape concerns that may also be contributing to the maintenance of compulsive exercise. One such factor is the regulation of negative affect (e.g., Thome & Espelage, 2004), which will now be considered.

2 Links between affect regulation and compulsive exercise

Researchers and clinicians have long recognised eating disorders as, in part, ineffective coping mechanisms used to manage uncomfortable emotions (Heilbrun & Harris, 1986; Slade, 1982; Soukup, Beiler, & Terrell, 1998). Indeed, links between affect regulation and eating psychopathology are well established (e.g., Killen, Taylor, Hayward, Wilson, Haydel et al., 1996; Meyer, Waller & Waters, 1998). Given the affect regulatory function of restriction and bulimic behaviours (Fairburn, 1997; Fairburn, Cooper, & Shafran, 2003; Hawkins & Clement, 1984; Heatherton & Baumeister, 1991; Meyer et al., 1998), a plausible model would suggest that compulsive behaviours (such as exercise) serve a similar regulatory function in the eating disorders; indeed this was the conclusion reached by

Lawson, Waller and Lockwood (2007). This notion is supported by the fact that, in general, compulsivity is associated with a wide range of negative emotions (Spinella, 2005).

Within the exercise science literature, the affect regulatory role of exercise has been well established (Callaghan, 2004), with mood regulation being one of the most frequently endorsed motivations for exercising (e.g., Markland & Ingledew, 1997). As has been pointed out by several researchers, any behaviour that is under voluntary control and that can influence mood can be used to regulate emotions (e.g., Jackson, Cooper, Mintz, & Albino, 2003; Parkinson & Totterdell, 1999; Sher & Trull, 1994). The suggestion that physical activity may be used as a compensatory behaviour not just to burn calories but to alleviate or counteract dysphoric mood states, is further supported by frequent patient reports that exercise is often being maintained primarily for the control of negative affect as much as it is to expend calories (Blumenthal, O'Toole, & Chang, 1984; Davis & Woodside, 2002; Long et al., 1993).

Certainly among eating disordered patients, compulsive exercise has been shown to be associated with elevated levels of negative affect (e.g., Brewerton et al., 1995; Penas-Lledo et al., 2002; Vansteelandt et al., 2007; Vansteelandt, Vandereycken, Claes, Probst, & Mechelen, 2004). Furthermore, the association between drive for thinness and physical activity is most pronounced in those patients with the highest levels of chronic negative affect (Vansteelandt et al., 2007).

Similar associations between compulsive exercise and increased levels of negative affect have also been found in non-eating disordered samples (e.g., Siegel & Hetta, 2001; Spano, 2001). For example, in those with high levels of eating pathology, exercise is associated with negative affect (Thome & Espelage, 2004). Conversely, among females with relatively low eating pathology, exercise is associated with positive affect (Thome & Espelage, 2004). This not only suggests that exercise might be differentially associated with affect based on the presence or absence of eating pathology (Thome & Espelage, 2004), but also supports the previously proposed model that exercise does not constitute a clinically

significant syndrome in the absence of eating pathology (Keski-Rahkonen, 2002; Mond et al., 2006a).

There is also evidence that increased exercise is associated with specific negative emotional states. For example, in both anorexia nervosa (AN) and bulimia nervosa (BN) patients, compulsive exercise has consistently been found to be associated with elevated ratings of anxiety (Brewerton et al., 1995; Klein, Bennett, Schebendach, Foltin, Devlin & Walsh, 2004; Penas-Lledo et al., 2002). The anxiolytic properties of strenuous physical activity are well established in both animal and human studies (e.g., Binder, Droste, Ohl, & Reul, 2004; Cox, Thomas, Hinton, & Donahue, 2004; Greenwood, Foley, Day, Burhans, Brooks et al., 2005). To date, there have been over 35 published reviews dealing with the anxiolytic effects of exercise providing consistent empirical support for the anxiolytic effects of exercise in clinical and non-clinical populations (Callaghan, 2004; Salmon, 2001; Scully, Kremer, Meade, Graham & Dudgeon, 1998). Indeed, it has been repeatedly shown that exercise can reduce anxiety symptoms in healthy adults (e.g., Hale & Raglin, 2002), in anxious women (e.g., Breus & O'Connor, 1998), and in psychiatric patients (Broocks, Bandelow, Pekrun, George, Meyer et al., 1998). In one study, among patients in the acute phase of AN, physical activity levels were predicted only by the level of food restriction and anxiety symptoms, supporting the notion that physical activity may be a way of coping with anxiety in some patients (Holtkamp et al., 2004).

In addition to anxiety, compulsive exercise has been shown to be associated with higher levels of depression in eating disorder patients (Penas-Lledo et al., 2002) and in non-clinical samples (Seigel & Hetta, 2001; Thome & Espelage, 2004). In addition, exercise has been shown to significantly decrease depressive symptoms following a single bout of exercise (Maraki, Tsofliou, Pitsiladis, Malkova, Mutrie & Higgins, 2005) and in regular exercisers (Steinberg, Nicholls, Sykes, LeBoutillier, Ramlakham et al., 1998). Meta-analyses of studies examining the efficacy of exercise in the prevention and/or alleviation of depression have consistently found that there is consistent empirical support for the efficacy of exercise in preventing and alleviating the symptoms of depression in clinically and non-

clinically depressed populations. This anti-depressive effect is largely independent of the frequency, mode, or intensity of exercise – and that exercise is as effective as alternative treatments for depression (e.g., Craft & Landers, 1998; North, McCullagh & Tran, 1990). Similarly, several more recent reviews have also concluded that exercise is associated with decreased depression and is effective at reducing depression in clinically and non-clinically depressed populations (Callaghan, 2004; Phillips, Kiernan & King, 2003).

The suggestion that compulsive exercise may function as a means of compensating for or suppressing adverse emotional states in ED patients is not new (e.g., Geller, Cockell & Goldner, 2000; Markland & Ingledew, 1997; Penas-Lledo et al., 2002). Fairburn et al. (2003) suggest that the inability to cope appropriately with adverse mood states, such as anxiety and depression is a central component in the maintenance of the eating disorders. Termed “mood intolerance”, it is characterised by engagement in various dysfunctional mood modulatory behaviours, such as compulsive exercising, that serve the purpose of neutralising the mood state as well as reducing awareness of the associated cognitions (Fairburn et al., 1993). They further suggest that these mood modulatory behaviours may then become habitual forms of mood modulation. This also supports the suggestion that compulsive exercise may be functioning as a mood modulatory behaviour in eating disordered patients. The use of exercise as a mood modulatory behaviour may not be so pronounced among bulimic patients as they exhibit a range of behaviours (e.g., bingeing, purging, self-harm, or drug abuse) that serve the same function more effectively (McManus & Waller, 1995). The idea that compulsive exercise may become a habitual method of affect regulation is supported by evidence that among eating disordered patients who exercise compulsively, exercise may become the primary and even the only means by which they regulate their emotional state (Geller et al., 2000; Markland & Ingledew, 1997).

In summary, the functional utility of exercise in regulating emotion further suggests a functional equivalence with eating pathology. It is probable that an inability to cope appropriately with adverse mood states results in exercise being maintained as an affect regulation strategy. It follows, therefore, that affect regulation may constitute a further

maintenance factor for compulsive exercise. Moreover, given the assumption that the use of exercise to regulate affect can become habitual, it is little wonder that the concepts of exercise dependence and/or exercise addiction have been proposed to explain the observed *reliance* on exercise among eating disordered patients to regulate their emotional state (Adams & Kirkby, 2002; Klein et al., 2004).

Within the literature there are two plausible mechanisms for the maintenance of the observed *reliance on exercise* that characterise some eating disordered patients. These mechanisms are positive and negative reinforcement. This notion is compatible with the 'addiction' model of compulsive exercise. For example, Davis (2000) postulates that in order for exercise to have the potential for addiction, it has to be either a positively or negatively reinforcing activity. In other words, it must either increase pleasure or ameliorate distress and suffering. Indeed, on the nature of addiction, Goodman (1990) notes that the behaviour indulged in (albeit no longer able to be controlled) is of a kind that can function not only to produce pleasure, but also to provide escape (avoidance/alleviate) from internal discomfort.

Positive reinforcement

The positive reinforcement function of exercise is reflected in the positive addiction model of exercise dependence which proposed that exercise dependence was attributable to exercise-induced euphoric states that were highly enjoyable (Glasser, 1976). However, strenuous exercising of the type typical of compulsive exercise is not a primary reinforcing behaviour for most people since relatively few individuals engage in exercise for the euphoria it produces (Davis, 2000).

Whilst there is evidence that exercise is associated with positive affect (Thome & Espelage, 2004), which no doubt is a positively reinforcing factor, other studies have demonstrated that doing exercise for enjoyment is by far the least endorsed reason among men and women (e.g., Davis et al., 1995). In particular, there is strong evidence that compulsive exercise is primarily maintained by secondary reinforcing factors of which weight and shape concerns are the strongest predictors (Brehm & Steffen, 1998; Davis, Brewer, &

Ratusny, 1993) followed by affect regulation (Geller et al., 2000; Markland & Ingledrew, 1997).

Supporting the affect regulatory model of compulsive exercise is the model of exercise dependence whereby exercise is maintained primarily to mitigate the affective withdrawal symptoms that manifest when unable to exercise (e.g., Bamber, Cockerill, Rodgers, & Carroll, 2003; Hausenblas & Symons Downs, 2002a; Morgan, 1979; Veale, 1987;1995), essentially constituting a form of negative reinforcement.

Negative reinforcement (withdrawal symptoms)

Of all the various definitional and diagnostic criteria proposed for exercise dependence (e.g., Hausenblas & Symons Downs, 2002b; Veale, 1995), the largest body of evidence is for the experience of affective withdrawal symptoms as a consequence of being unable to exercise (e.g., Bamber, Cockerill, Rodgers, & Carroll, 2003). Indeed, Aidman and Woollard (2003) make the point that exercise dependence is characterised by a pattern of withdrawal symptoms. Based on the premise that in some exercisers the cessation of regular exercise may result in negative psychological states (Hausenblas & Symons Downs, 2002a;b), withdrawal symptoms have been posited as the cardinal characteristic of exercise dependence (Szabo, 1995).

Withdrawal symptoms have been described as the psychological effects that occur as a result of not exercising, and are manifested either by emotional symptoms, or further exercise to avoid such symptoms (American Psychiatric Association, 1994). The most frequently reported symptoms of withdrawal were guilt, anxiety, depression, and irritability (Bamber, Cockerill, & Carroll, 2000; Szabo, Frenkl, & Caputo, 1997). It has been suggested that as little as 24 hours without exercise may be sufficient to produce significant withdrawal symptoms in some individuals (e.g., Sachs, 1981; Thaxton, 1982).

Whilst the experience of withdrawal symptoms is common to many regular exercisers, it has been suggested that only some can be classed as dependent (Szabo, 1995). However, in a recent study attempting to delineate diagnostic criteria, withdrawal

symptoms emerged as one of only two criteria implying dependence (Bamber et al., 2003). It has certainly been suggested that habitual exercisers may learn to rely on exercise to counteract anxiety or depression, control mood states, or lose weight, and that a subsequent inability to exercise results in negative psychological consequences in the form of withdrawal symptoms (Baekeland, 1970; Morris, Steinberg, Sykes, & Salmon, 1990; Thaxton, 1982). Indeed, such exercise-related dysphoria has even been shown to discriminate between eating disordered and non-clinical groups (Boyd, Abraham, & Luscombe, 2007).

Withdrawal symptoms are known to be universally present at, if not responsible for, the onset of most addictions, including opiates, nicotine and alcohol (e.g., Galanter, 1993; Niaura, Rohsenow, Binkoff, & Monti, 1988; Powel, Bradley, & Gray, 1992) and the withdrawal phenomenon is considered a common consequence of dependence (Farrell, 1994). From the earliest descriptions, emotional withdrawal symptoms have been consistently reported as a consequence of exercise deprivation among habitual exercisers (e.g., Aidman & Woollard, 2003; Baekeland, 1970; Chan & Grossman, 1988; Conboy, 1994; Mondin et al., 1996; Morgan, 1979; Morris et al., 1990; Ogles, Masters, & Richardson, 1995; Veale, 1987; Yates, Leehey, & Shisslak, 1983).

Whilst it has been suggested that withdrawal can take the forms of physiological and/or psychological disturbance (Sachs & Pargman, 1979; West & Gossop, 1994), the evidence for a physiological basis to exercise dependence remains equivocal (Adams & Kirkby, 2002; Davis, 2000; Hamer & Karageorghis, 2007). Indeed, the model currently most supported by the empirical literature suggests that the presence of affective withdrawal symptoms is indicative of a *psychological* dependence on exercise whereby exercise is maintained via negative reinforcement specifically to avoid the experience of such withdrawal.

In summary, evidence has been presented suggesting that among compulsive exercisers, the experience of affective withdrawal symptoms when unable to exercise is common in both clinical and non-clinical samples (Szabo, 1995). In some cases this may result in a psychological dependency/addiction upon exercise whereby exercise behaviour is

maintained specifically to avoid the withdrawal symptoms (i.e., negative reinforcement). In addition, for some individuals there is potentially a further powerful maintenance factor of positive reinforcement as a result of elevated positive affect (i.e., positive addiction) (Glasser, 1976). Taken together, the evidence discussed so far supports the notion that in some susceptible individuals (i.e., those who are mood intolerant), engaging in exercise may inadvertently result in a psychological dependence, which then reciprocally maintains the exercise behaviour.

3 Compulsivity and the maintenance of exercise

It is plausible to suggest that *addictive* behaviours and *compulsive* behaviours are essentially similar, since they are both characterised by a need to perform a behaviour that is no longer intrinsically rewarding. The following section will focus on the compulsivity element of exercise in more detail.

Compulsivity describes an insistent urge to perform some action (i.e., behaviour) to relieve the *anxiety* stemming from a fear of perceived negative consequences if the behaviour is not performed (American Psychiatric Association, 2000; Frost, Steketee, Cohn, & Griess, 1994). Therefore, the primary function of compulsive behaviours is to mitigate *anxiety* via the *avoidance* of perceived negative consequences. Furthermore, such compulsive behaviours are typically characterised by being performed persistently, repetitively and excessively, without leading to any reward or pleasure (Evans, Lewis, & Iobst, 2004).

Compulsivity has been shown to be significantly related to levels of activity in both eating disordered patients and non-eating disordered exercisers (Gulker et al., 2001; Davis et al., 1995; Shroff et al., 2006). Furthermore, eating disorder symptomatology has been shown to be associated with compulsive attitudes to exercise, rather than just exercise quantity (Adkins & Keel, 2005; Seigel & Hetta, 2000). Indeed, excessive exercising has been described as one of the most obvious compulsions in the eating disorders with a lifetime occurrence in up to 84% of patients (Davis, 1997).

Supporting the importance of the avoidance of perceived negative consequences component of compulsivity, it has been demonstrated that compulsive exercise is associated with heightened concerns about the consequences of not exercising (Bamber et al., 2000; Penas-Lledo, Sancho, & Waller, 2002). For example, avoidance of failure has been identified as a maintaining factor for compulsive exercise (Hall, Kerr, Kozub, & Finnie, 2007). In addition, a tendency towards avoidance (i.e., an avoidant coping style) has been found to be associated with disordered eating attitudes and behaviours in both eating disordered and non-eating disordered women (Sherwood, Crowther, Wills, & Ben-Porath, 2000; VanBoven & Espelage, 2006). More specifically, avoidance of emotional arousal has been shown to be associated with increased compulsivity in both eating disordered (Lawson, Waller, & Lockwood, 2007) and non-eating disordered samples (Abramowitz, Lackey, & Wheaton, 2009). It is plausible that the experience of affective withdrawal symptoms when unable to exercise leads to a fear of such negative consequences, resulting in compulsive exercise behaviour in order to avoid experiencing such withdrawal. Exercise behaviour therefore becomes maintained by the need to avoid the experience of the withdrawal component of compulsivity. This suggestion that a fear of the negative consequences of not exercising is a maintaining factor for compulsive exercise is not new (Penas-Lledo, Sancho, & Waller, 2002; Thaxton, 1982) and supports the centrality of compulsivity in the maintenance of compulsive exercise.

In addition to the evidence described above, there are also established links between low body weight and compulsivity. For example, Crisp (1967) concluded that starvation facilitates generalised compulsive behaviour so that exercising, like various other activities, can involuntarily become stereotyped, ritualised, and excessive, simply as a consequence of the disorder. Supporting this, serotonin dysregulation, a frequent consequence of malnutrition, has been implicated in the development of compulsive behaviours (Barr, Goodman, Price, McDougle, & Charney, 1992; Holden, 1990; Kaye, Weltzin, & Hsu, 1993). The links between starvation and compulsivity can readily be observed within the context of anorexia nervosa. Specifically, it is frequently observed in AN that as the condition worsens,

patients feel an increasingly strong compulsion to be physically active even when they no longer enjoy it, and continuing even when the process is painful and exhausting (Davis, 1997). Indeed, AN patients showed both a higher level of physical activity and more compulsive exercise than controls (Davis, Blackmore, Katzman, & Fox, 2005).

Obsessive-compulsive disorder and obsessive-compulsive personality disorder

Both ED and compulsive exercise share a strong relationship with obsessionality. For example, it has been suggested that an inherent obsessionality may underlie both compulsive exercise and eating pathology (Davis et al., 1998; Gulker, Laskis, & Kuba, 2001) and several studies report that compulsive exercisers typically display an obsessional and rigid personality profile as well as a compulsive behaviour pattern (Davis, Brewer, & Ratusny, 1993; Goldfarb & Plante, 1984; Kagan, 1987; Yates, 1991). As a result, compulsive exercise is often viewed as being related to obsessive-compulsiveness (Davis & Claridge, 1998; Davis et al., 1995;1998;1999). Consequently, much of the research into compulsive exercise has tended to focus on its links with obsessive-compulsive personality traits and obsessive-compulsive symptomatology (Penas-Lledo et al., 2002). Indeed, it has even been suggested that it may be useful to consider compulsive exercise as stemming from an anxiety disorder (Gulker et al., 2001), which fits with the idea that the function of compulsive exercise in the ED is to reduce anxiety, much like the function of compulsions in obsessive-compulsive disorder (Davis & Kaptein, 2006).

The existing literature clearly suggests a significant relationship between AN and obsessive-compulsive personality traits (Serpell, Livingstone, Neiderman, & Lask, 2002), with evidence to support a more obsessive-compulsive personality profile in exercising AN patients than their non-exercising counterparts (Davis & Claridge, 1998; Davis et al., 1998; Davis & Kaptein, 2006). Furthermore, both anorexic and bulimic patients classified as compulsive exercisers had higher scores on measures of obsessive-compulsive personality than their non-exercising counterparts (Davis & Claridge, 1998). As a result, obsessive-compulsive personality factors are presumed to be probable risk factors for both disordered

eating (Wonderlich, Lilenfeld, Riso, Engel, & Mitchell, 2005) and compulsive exercising (Gulker et al., 2001).

Guilt

Guilt has been shown to be associated with obsessive-compulsive symptomatology in both clinical and non-clinical samples (e.g., Frost et al., 1994; Mancini, Gangemi, Perdighe, & Marini, 2008; Shafran, Watkins, & Charman, 1996). Indeed, guilt has been shown to predict compulsivity independent of anxiety and depression (Shafran, Watkins, & Charman, 1996) and fear of guilt has been linked to increased rates of compulsive behaviours (Mancini & Gangemi, 2006). In addition, guilt has been implicated as an aetiological factor in the development of obsessive compulsive disorder (OCD) (Gibbs, 1996).

Mond and colleagues (2004a;2006;2008;2009) have consistently demonstrated that the degree of guilt (feeling bad if one has been prevented from exercising a certain amount) experienced whenever exercise is unable to be undertaken is one of the components of compulsive exercise most strongly associated with eating disorder psychopathology and reduced quality of life. The importance of guilt is further supported by the finding that guilt when unable to exercise discriminated between ED and non-ED groups (Boyd, Abraham, & Luscombe, 2007; Mond & Calogero, 2009). Indeed, the experience of guilt has consistently been reported as a consequence of being unable to exercise among compulsive exercisers (Bamber et al., 2000; Szabo et al., 1997).

In summary, compulsivity is linked with both increased exercise and eating disorders. Specifically, the avoidance of perceived negative consequences and the experience of guilt when exercise is unable to be undertaken have been shown to be the components of compulsivity most strongly implicated in the maintenance of compulsive exercise.

Taken together, the evidence presented so far clearly supports compulsivity as an important factor in the maintenance of compulsive exercise and further supports the conception of problematic exercise as a compulsive behaviour.

4 Perfectionism and rigidity in the maintenance of compulsive exercise

Of all the obsessive-compulsive personality traits associated with disordered eating such as perfectionism, inflexibility, rigidity, and preoccupation with interpersonal and mental control (Halmi, 2005), it is perfectionism that is posited as the most strongly associated with both compulsive exercising (Flett & Hewitt, 2005) and disordered eating (Cassidy, Allsopp & Williams, 1999; Halmi et al., 2000). In addition, rigidity has long been described as a feature of compulsive exercise (e.g., Beumont et al., 1994; Wyatt, 1997; Yates, 1991) and a cluster analysis of personality pathology in ED patients found that nearly half of patients were included in a cluster characterised by rigid compulsivity (Goldner, Srikameswaran, Schroeder, Livesley, & Birmingham, 1999).

Perfectionism

Perfectionism typically describes a personality trait characterised by having and striving for high personal standards (Frost, Marten, Lahart, & Rosenblate, 1990), and is well established as an important factor in the development and maintenance of the eating disorders (Fairburn, Cooper, Doll, & Welch, 1999; Fairburn et al., 2003; Fairburn, Shafran, & Cooper, 1999; Lilenfeld, Wonderlich, Riso, Crosby, & Mitchell, 2006; Stice, 2002). In terms of compulsive exercise, recent evidence suggests that perfectionism is a robust correlate of compulsive exercise (e.g., Shroff et al., 2006). Indeed, compulsive exercise has been shown to be consistently associated with higher levels of perfectionism in both eating disordered and non-eating disordered samples (Ackard et al., 2002; Brehm & Steffen, 1998; Coen & Ogles, 1993; Cook 1996; Symons Downs, Hausenblas, & Nigg, 2004; Gulker et al., 2001; Hagan & Hausenblas, 2003; Hall et al., 2007; Hausenblas & Symons Downs, 2002b; Seigel & Hetta, 2001; Shroff et al., 2006).

The importance of perfectionism is further highlighted by the finding that AN patients classified as compulsive exercisers report significantly higher levels of perfectionism than their non-exercising counterparts (Davis et al., 1998). Perfectionism has been shown to be

independent of the state of nutrition in AN (Kaye, 1997), and in a sample of compulsively exercising AN patients, elevated perfectionism was associated with poor outcome from the treatment of their compulsive exercise (Long & Hollin, 1995). This supports the notion that perfectionism is a significant factor in compulsive exercise and furthermore, may be an important maintenance factor in its own right (i.e., independent of compulsivity).

Despite the preceding evidence, understanding of the relationship between perfectionism and compulsive exercise is impaired by the use of disparate conceptualizations of perfectionism (e.g., Frost et al., 1990; Hewitt & Flett, 1991). For example, empirical findings have suggested that whilst high personal standards remain an undisputed component of perfectionism they are not necessarily, by themselves, pathological (Dunkley, Blankstein, Halsall, Williams & Winkworth, 2000; Frost et al., 1990; Serpell, Waller, Fearon, & Meyer, 2009). Indeed, recent findings have consistently demonstrated the existence of two distinct, albeit related, dimensions of perfectionism (e.g., Bieling, Israeli, & Antony, 2004; Blankstein & Dunkley, 2002). Whereas the first dimension reflects the setting and striving for high personal standards, the second reflects a tendency towards self-criticism (Dunkley, Blankstein, Masheb, & Grilo, 2006) and it is the self-critical dimension that is posited as the primary indicator of the dysfunctional component of perfectionism (Dunkley et al., 2006).

Unfortunately, no studies examining the relationship between perfectionism and compulsive exercise have specifically considered the self-critical dimension of perfectionism. However, despite the lack of studies explicitly considering the two proposed dimensions of perfectionism, there is evidence that both are associated with compulsive exercise. For example, whilst not explicitly considered, many current perfectionism measures have been shown to tap both dimensions (e.g., Bieling et al., 2004; Dunkley, Zuroff, & Blankstein, 2003). An examination of studies using these measures with measures of compulsive exercise clearly supports an association between compulsive exercise and both the high personal standards and self-critical dimensions of perfectionism (e.g., Cook 1996; Symons Downs et al., 2004; Shroff et al., 2006). In addition, compulsive exercisers are reported to

often strive to achieve perfection with any failure to reach this standard resulting in self-criticism (Beumont et al., 1994) and Davis (1997) has posited a co-occurrence of self-criticism and high personal standards as a potential risk factor for compulsive exercise.

Rigidity

Rigidity has been defined as a pattern of resisting "...the acquisition of new behaviour patterns by holding onto previous and non-adaptive styles of performance" (Schaie & Parman, 1975: p. 1) and is regarded as an essential component of dysfunctional perfectionism (Shafran & Mansell, 2001). Indeed, Ferrari and Mautz (1997) previously demonstrated an association between rigidity and perfectionism, and a recent qualitative analysis of perfectionism identified rigidity as a consistent theme implicated in its maintenance (Riley & Shafran, 2005), thereby supporting previous descriptions of dysfunctional perfectionism (e.g., Burns, 1980). Endorsing rigidity as a significant component of compulsive exercise is the fact that it remains central to the definition of obsessive-compulsive personality disorder, which has been demonstrated to have a significant association with both ED (Halmi, 2005) and compulsive exercise (Davis & Claridge, 1998; Davis et al., 1999; Serpell et al., 2002).

In terms of compulsive exercise, rigidity has been linked to the emotional consequences of not meeting personal standards. Specifically, it is suggested that repetitive behaviour helps filter out both extraneous stimuli and disruptive affect-laden cognitions (Rauch & Savage, 2000). Rauch and Savage (2000) proposed that repetitive behaviours in the anxious state represent an attempt to homeostatically reduce anxiety-caused increased levels of arousal by soothing limbic tone. Because compulsive exercisers often express their exercise in a stereotyped and repetitive manner (e.g., Beumont et al., 1994; Wyatt, 1997; Yates, 1991), it has been suggested that this characteristic of their exercise further supports the anxiolytic effect of the exercise (Holtkamp et al., 2004). Indeed, Bamber, Cockerill, Rodgers and Carroll (2003) found that inflexible attitudes towards exercising was an important signifier of compulsive exercise resulting in inflexible and stereotyped exercise

behaviour. Furthermore, Boyd et al. (2007) found that the setting of rigid exercise rules was a significant predictor of an ED diagnosis.

In summary, the evidence above clearly supports perfectionism as a significant component of compulsive exercise. Evidence was presented supporting perfectionism as a maintenance factor for compulsive exercise in the ED. Similarly, evidence was presented that suggests rigidity may also be a central component in the maintenance of compulsive exercise, likely stemming from its anxiolytic function and association with perfectionism. Whilst both perfectionism and rigidity overlap with the construct of compulsivity the evidence supports their conceptualisation as separate constructs in terms of maintaining compulsive exercise

Conclusions

This review has presented a novel conceptualisation of compulsive exercise within the context of the eating disorders. Several key constructs have been identified that are empirically supported as being potentially maintaining of exercise within this domain. Future research into compulsive exercise should take into account these factors when providing working definitions of exercise with the eating disorders field.

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