



Risk of exercise dependence in university students: A subtyping study utilizing latent profile analysis

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ABSTRACT

Exercise dependence (ED) is a maladaptive pattern of exercise that increases risk of physical and psychological harm. There is a need to identify whether individuals symptomatic/at-risk for exercise dependence are a heterogeneous group, and if so, to identify risk factors associated with different subtypes. This study sought to determine whether subtypes of individuals symptomatic/at-risk for exercise dependence can be distinguished on their self-reported depressive symptoms, eating disorder symptomatology, and alexithymia profiles. Latent profile analysis performed on 379 young adults revealed two classes. One reported stronger affective than cognitive alexithymic traits, and limited feelings of personal distress in response to others' suffering. The other reported stronger cognitive than affective alexithymic traits along with elevated eating disorder symptomatology, concomitant mood disturbance, and heightened signs of personal distress. A follow up mediation analysis demonstrated that cognitive, but not affective, alexithymia mediated the relationship between empathy (personal distress, perspective taking, and empathic concern) and ED, with increased cognitive alexithymia predicting more severe ED. This study is unique as it is the first of its kind to explore the complex dynamics between alexithymic traits, empathy, and ED. Results from this subtyping research provide insights into underlying risk factors that may contribute to the development of ED, and may help to refine existing theories. The results may also inform subsequent research, targeted treatment methods, and psychoeducation programs for use with athletes, parents, and coaches.

1. Introduction

Exercise dependence (ED) refers to a maladaptive pattern of exercise that increases risk of physical and psychological harm (Allegre, Souville, Noel-Jorand, Pellegrin, & Therme, 2007). It is characterized by feelings of loss of control that lead to excessive exercise; symptoms of overtraining such as fatigue and sleep disturbance; and withdrawal symptoms characterized by restlessness, sadness, and irritability (Hausenblas, Schreiber, & Smoliga, 2017).

The prevalence of ED remains unclear due to differences in how it is defined, inconsistent assessment methods, and small sample sizes. It is thought to present an issue for 0.3%–0.5% of the general population and 3% of those who exercise (e.g., gym attendees) (Mónok et al., 2012). However, the true prevalence may be higher and context dependent; for instance, one study found that rates were almost twice as high in sport science students compared to a general exercising population (Szabo & Griffiths, 2007), and rates as high as 25% (Slay, Hayaki, Napolitano, & Brownell, 1998) and 52% (Blaydon & Lindner, 2002)

have been reported in runners and triathletes, respectively. Rates are higher in competitive vs. non-competitive athletes (de la Vega, Parastatidou, Ruiz-Barquin, & Szabo, 2016), but this may reflect differences in how the phenomenon is conceptualized in these populations (de la Vega et al., 2016).

The most significant psychophysiological explanations for ED offered to date include the *β-endorphin hypothesis*, the *sympathetic arousal hypothesis*, and the *affect regulation hypothesis* (Hamer & Karageorghis, 2007). The *β-endorphin hypothesis* suggests that the release of endogenous opioids during exercise inhibits pain perception and improves mood (Berczik et al., 2012; Hamer & Karageorghis, 2007). Although this hypothesis has not been well supported in studies of humans (e.g., Pierce, Eastman, Tripathi, Olson, & Dewey, 1993), preliminary evidence has been gathered implicating the endocannabinoid system in the “runner’s high” (e.g., Dietrich & McDaniel, 2004), leading some to suggest that individuals with ED may exercise in an attempt to increase activation of this system (Antunes et al., 2016). The sympathetic arousal hypothesis suggests that engaging in regular exercise results in

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a “training effect” whereby individuals adapt to consistent aerobic activity by experiencing decreased sympathetic arousal at rest (Thompson & Blanton, 1987). To combat the feelings of lethargy this produces, people exercise more and at a higher intensity (Berczik et al., 2012; Szabo, 2010), which could lead to ED (Hamer & Karageorghis, 2007). Finally, according to the affect regulation hypothesis exercise serves to increase positive and decrease negative affect, and these dual effects may lead some to use it as a means to cope with stress (Berczik et al., 2012; Szabo, 1995). This may be particularly true in those with ED, as they experience larger improvements in mood after exercising than non-dependent exercisers and sedentary individuals (Rosa, Mello, Negrão, & Souza-Formigoni, 2004) along with relief from other negative symptoms (e.g., irritability, guilt and anxiety associated with not exercising).

1.1. Variables associated with ED

Although several theories have been put forth, consensus has not yet been reached regarding the etiology of ED (Adams, 2009). Examining variables associated with ED, including comorbid conditions, personality traits, and characteristics such as empathy, may lead to new insights into its root causes, and inform intervention efforts (e.g., Berczik et al., 2012).

1.1.1. Comorbidity

ED is positively related to anxiety and obsessive compulsiveness (Spano, 2001). Although previous studies have demonstrated that regular aerobic exercise is associated with lower levels of depression in members of the general public (e.g., Da Silva et al., 2012), depression has been found to be elevated in individuals with ED compared to regular exercisers (Lichtenstein, Nielsen, Gudex, Hinze, & Jørgensen, 2018; Weinstein, Maayan, & Weinstein, 2015), particularly if they have a comorbid eating disorder (Bamber, Cockerill, & Carroll, 2000).

1.1.2. Alexithymia

Past research suggests links between ED and certain personality traits. For example, risk of ED is elevated in individuals scoring high in narcissism, impulsiveness, perfectionism, and obsessive (but not harmonious) passion, and is reduced in those scoring high in agreeableness and self-esteem (de la Vega et al., 2016; Hagan & Hausenblas, 2003; Hausenblas et al., 2017; Spano, 2001; Szabo, 2010). In the present research we examined possible links between ED and alexithymia—a trait seen in approximately 10% of the general population (Salminen, Saarijarvi, Aarela, Toikka, & Kauhanen, 1999), which is characterized by deficits in identifying, verbalizing, and regulating one’s emotional state (Goerlich-Dobre, Lamm, Pripfl, Habel, & Votinov, 2015). Alexithymia is considered to be an important risk factor for various neurological, psychological, and medical conditions ((Goerlich-Dobre et al., 2015a); Salminen et al., 1999) including a wide range of addictive behaviours (e.g., Bossard & Miller, 2009; Morie et al., 2017; Noel et al., 2017). Indeed, it is now considered influential in the development of addiction (Morie et al., 2017). Despite this, little is known about how, or if, it relates to ED.

Findings from the few existing studies examining alexithymia in athletes are mixed. Jodat, Ghasempour, and Tavakoli (2015) found that student athletes reported fewer symptoms of alexithymia than non-athletes, whereas Iacolino, Pellerone, Formica, Lombardo, and Tolini (2017) found the reverse. These discrepant results may reflect the fact that athletes were older and more heavily involved in sport in the latter study. Interestingly, Allegre et al. (2007) found that expert swimmers displayed more severe alexithymic verbal discourse than amateur swimmers, which suggests that those who engage in intense exercise differ from those who do not in at least one aspect of alexithymia. Some suggest that alexithymic traits impact how elite athletes cope with the stress involved in high performance sport (Allegre et al., 2007), although the mechanisms involved are unclear. Some argue that

alexithymia may hamper efforts to manage physiological hyperarousal during stress (Martin & Pihl, 1985), while others link it to anxiety associated with hypoarousal (Donges & Suslow, 2017; Pollatos et al., 2011).

To our knowledge, only one study has directly examined the relationship between alexithymia and ED. Bossard and Miller (2009) found a positive relationship between these variables in an adult sample, with 40% of those with ED also being classified as alexithymic. Unfortunately, the measure of alexithymia used in this study assessed only cognitive alexithymic traits (i.e., difficulties in identifying, analyzing, and verbalizing feelings). It is not clear how it may relate to affective alexithymic traits (i.e., difficulties in emotionalizing and fantasizing), or whether those exhibiting different subtypes of alexithymia, identified based on the relative strength of cognitive and affective traits (Bermond, Bierman, Cladder, Moormann, & Vorst, 2010), show differential vulnerability to ED.

1.1.3. Empathy

Empathy involves the ability to take on the subjective feelings and emotions of another. It can also be divided into cognitive and affective dimensions (Davis, 1980, 1983; Ferrari, Smeraldi, Bottero, & Politi, 2014; (Goerlich-Dobre, Votinov, Habel, Pripfl, & Lamm, (2015b)); Tomei, Besson, & Grivel, 2017), and imbalances in these two aspects of empathy are thought to characterize various clinical disorders (Smith, 2009), including numerous behavioural addictions (e.g., Ferrari et al., 2014; Maurage et al., 2011; Tomei et al., 2017). Although it is not known if ED is associated with atypicalities in empathy, links between atypical empathy and alexithymia are fairly well established (Bird & Viding, 2014). For example, alexithymia has been associated with diminished cognitive empathy (perspective taking and empathic concern; Berthoz, Wessa, Kedia, Wicker, & Grezes, 2008; Bird & Viding, 2014; (Goerlich-Dobre et al., 2015)), and with experiencing heightened personal distress in response to others’ suffering (Patil & Silani, 2014). Interestingly, Tomei et al. (2017) found that problem gambling was associated with this same empathy profile, raising the possibility that alexithymia might mediate the relationship between empathy and behavioural addiction.

1.2. The present study

Currently, the literature distinguishes between two subtypes of ED (Berczik et al., 2012; Hausenblas et al., 2017). In *primary ED*, exercise is the primary objective and it manifests itself as a behavioural addiction. In *secondary ED*, exercising is used as a means to an end, usually to control weight. The first goal of the present research was to use latent profile analysis (LPA) to determine if this method of subtyping best explains individual variation in ED. To our knowledge, only one other study has used LPA to explore potential subtypes of ED (Magee, Buchanan, & Barrie, 2016). Using a sample of 345 adult Ironman athletes, these authors found that classes with a high proportion of individuals symptomatic or at-risk for ED displayed more unhealthy eating patterns and psychological distress than asymptomatic classes. A potential problem with this study lies in the fact that current assessment tools may overestimate the prevalence of ED in competitive athletes (Szabo, Griffiths, de la Vega, Mervo, & Demetrovics, 2015). Given this, we sought to apply LPA to a sample of university students, who are arguably more representative of a general, young adult population. We predicted that either a two- or three-class model would emerge, and that the classes would be differentiated not only on the basis of self-reported symptoms of eating disorder and depression, but also on the relative strength of the cognitive and affective alexithymic traits they endorsed. We also expected that any observed latent classes might show different sex distributions (Hausenblas et al., 2017).

The second goal of the current study was to investigate the relationship between empathy and ED. A subgoal was to determine if cognitive and/or affective alexithymic traits might mediate any

observed relationships between these variables. Based on past research in general samples, we predicted that: (a) difficulties in perspective-taking and empathic concern (Berthoz et al., 2008; Bird & Viding, 2014; Goerlich-Dobre et al., 2015)) and heightened personal distress (Patil & Silani, 2014), might be more evident in individuals with ED reporting relatively strong cognitive alexithymic traits; and (b) deficits in self-focused aspects of empathy (personal distress, fantasy) might be most evident in individuals with ED reporting relatively strong affective alexithymic traits (Brewer et al., 2018; Patil & Silani, 2014; Tomei et al., 2017).

2. Materials and methods

2.1. Participants and procedures

Each fall, all students registered in the introductory psychology course at the University of Manitoba have the option to complete a mass pre-test survey used by researchers to facilitate recruitment for future studies. The present study was open to any student who had completed an empathy measure (described below) as part of the Fall 2017 mass pre-test ($N = 1904$). These individuals were sent an email inviting them to complete an additional survey, administered via an online survey system (Qualtrics). Those who consented completed the first four measures described below, in the order listed. Data on the fifth measure were obtained from the results of the mass pre-test. Items comprising the final measure were randomly distributed throughout the survey. The final sample (described in more detail below) included 600 individuals. Participants gave informed consent and received credit toward a course requirement. The protocol was approved by the Psychology/Sociology Research Ethics Board at the University of Manitoba.

2.2. Materials

2.2.1. Exercise dependence scale-21 (EDS-21; Hausenblas & Downs, 2002)

The EDS-21 is a self-report measure that screens for ED in a way consistent with criteria outlined in the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV; American Psychiatric Association, 2013). It is comprised of seven subscales tapping into symptoms of tolerance, withdrawal, intention effects (exercising for longer than intended), lack of control (desire or unsuccessful effort to cut down or control exercise), time (devoting large amounts of time to activities necessary to obtain exercise), reductions in other activities, and continuance (exercising despite having a known physical/psychological problem caused/exacerbated by exercise, such as an injury). Participants indicate their responses to each of 21-items using a Likert scale ranging from 1 (*never*) to 6 (*always*). Based on their responses, individuals are categorized into one of three categories: *at risk for ED*, *non-dependent symptomatic*, and *non-dependent asymptomatic*. The EDS-21 has good concurrent validity (Szabo & Griffiths, 2007) and high internal consistency, reliability, and convergent validity (Hausenblas & Downs, 2002).

2.2.2. Eating Disorder Examination Questionnaire – Short (EDE-QS; Gideon et al., 2016)

The EDE-QS is a brief, self-report screening measure assessing symptoms of disordered eating; it is not intended to be used for diagnostic purposes. In responding to the first 10 items, participants describe how frequently various thoughts/behaviours occurred in the preceding seven days, using a scale ranging from 0 (*0 days*) to 3 (*6–7 days*). They then report on the extent to which their weight or shape has influenced how they judge themselves (1 item), and how satisfied they have been with their weight (1 item) over the same time period, using a scale ranging from 0 (*Not at all*) to 3 (*Markedly*). A mean score is computed.

2.2.3. Patient Health Questionnaire (PHQ-9; Kroenke, Spitzer, & Williams, 2001)

Severity of depressive symptoms was assessed using the PHQ-9, a brief, self-report tool based on DSM-IV criteria. Participants respond to each of 9-items using a scale ranging from 0 (*Not at all*) to 3 (*Nearly every day*). A total score is computed by summing responses, after which individuals can be assigned to one of four categories (*mild*, *moderate*, *moderately severe*, and *severe depression*) using cut points for the total score of 5, 10, 15, and 20 respectively.

2.2.4. Bermond-Vorst Alexithymia Questionnaire (BVAQ; Vorst & Bermond, 2001)

This 40-item self-report measure has five subscales (eight items each) tapping into cognitive alexithymic traits (Identifying Emotions, Verbalizing Emotions, Analyzing Emotions) and affective alexithymic traits (Emotionalizing, Fantasizing). Participants respond to each item using a scale ranging from 1 (*This definitely applies*) to 5 (*This in no way applies*). Cognitive and affective composite scores are obtained by summing scores on the relevant subscales. Previous studies have confirmed the five-factor structure and psychometric validity of the BVAQ (e.g., Vorst & Bermond, 2001). In the current study we found acceptable-to-high internal validity for all subscales ($\alpha > 0.71$), and for the cognitive ($\alpha = 0.87$) and affective ($\alpha = 0.75$) composite scores.

2.2.5. Interpersonal Reactivity Index (IRI; Davis, 1980)

The IRI assesses empathy using four subscales: Perspective Taking, Fantasy, Empathic Concern, and Personal Distress. These subscales possess good internal consistency (Cronbach's α 0.71 to 0.77) and good test-retest reliability (coefficients 0.61 to 0.81) (Davis, 1980). Each subscale is comprised of seven items that are responded to using a scale ranging from 0 (*Does not describe me well*) to 4 (*Describes me very well*). A total (summed) score is computed for each subscale.

2.2.6. Attention checks: Conscientious Responders Scale (CRS; Marjanovic, Struthers, Cribbie, & Greenglass, 2014)

The nature of the five items that comprise the CRS allow one to determine objectively whether particular instructions are followed or not; as such, they provide a measure of conscientious (honest and accurate) responding.

3. Results

There were 696 completed surveys. Participants were excluded if they: had duplicate entries ($n = 29$); had failed to complete the consent form ($n = 1$); had not completed the mass testing ($n = 31$); had omitted one (or more) subscales of any instrument ($n = 11$); had failed to correctly answer three or more of the attention checks in the CRS ($n = 16$); and/or had taken an abnormally short or long time to complete the survey ($n = 8$). This left a final sample of $N = 600$.

3.1. Characteristics of the full sample

3.1.1. Demographic variables

There was a small amount of missing data for items relating to age (1.0%), ethnicity (0.8%), first language (0.2%), country of birth (0.2%), and biological sex (3.2%). The mean age of respondents was 18.9 years (SD 2.9, range 17–46). The majority identified as female (65.7%), were born in Canada (73.9%), and indicated English as a first language (74.3%). Approximately half of the full sample (53.6%) identified as White/European, 28.3% as Filipino or Asian/South East Asian, and 17.9% as First Nation/Métis or Other.

3.1.2. Study variables

Descriptive statistics for the full sample appear in Table 1. Scores on the EDE-QS covered virtually the full range. The prevalence of moderately severe or severe depressive affect was consistent with that

Table 1
Measures of Exercise Dependence, Eating Disorder Severity, Depressive Affect, Alexithymic Traits, and Empathy in the Full Sample (N = 600).

	M (SD)	Minimum	Maximum
EDS Total	51.8 (19.5)	21	126
EDE-QS Total	0.7 (0.6)	0	2.9
PHQ-9 Total	8.7 (5.8)	0	27
BVAQ Cognitive Total	62.8 (14.1)	25	100
BVAQ Affective Total	39.6 (8.7)	19	67
Perspective Taking	42.4 (8.6)	19	68
Fantasy	43.5 (11.5)	13	70
Personal Distress	34.7 (9.7)	7	65
Empathic Concern	50.5 (9.7)	11	70

Note: EDS: Exercise Dependence Scale; EDE-QS: Eating Disorder Examination Questionnaire-Short; PHQ-9: Patient Health Questionnaire; BVAQ: Bermond-Vorst Alexithymia Questionnaire

reported in systematic reviews examining depression in university students (e.g., Ibrahim, Kelly, Adams, & Glazebrook, 2013). Scores on the BVAQ were somewhat higher than expected (Vorst & Bermond, 2001); however, university students are reported to be at higher risk for alexithymia than members of the general population (e.g., Lyvers, Duric, & Thorberg, 2014). Based on the EDS, 221 participants were rated as “asymptomatic,” 359 as “symptomatic,” and 20 as “at-risk” for ED. The prevalence of “at-risk” individuals (3.3%) was slightly higher than that seen in past research conducted in a general population (Mónok et al., 2012), but consistent with research conducted with habitual exercisers (Griffiths, Szabo, & Terry, 2005; Szabo & Griffiths, 2007). Due to the low number of “at-risk” participants, the symptomatic and at-risk groups were combined for all subsequent analyses.

3.2. Latent profile analysis

We explored the multidimensionality of exercise-dependent behaviour through LPA, using Mplus Version 6.0 (Muthén and Muthén, 1998-2010). Total scores from the EDS-21, EDE-QS, and PHQ-9, and cognitive and affective composite scores from the BVAQ, were entered into the analysis. Table 2 presents the fit statistics for the estimated model solutions. Although the 4- and 5-class models fit the data reasonably well, the 2-class model was retained for three reasons. First, the Lo, Mendell, and Rubin (2001) likelihood ratio test statistic indicated that only this model was significant. Second, this model is consistent with extant literature suggesting two subtypes of ED. Finally, some classes in the 4- and 5-class models were too small to examine meaningfully ($n < 5\%$ of the total sample; Nylund, Asparouhov, & Muthén, 2007).

Class 2 ($n = 79$) was smaller than Class 1 ($n = 300$), and had a larger proportion of females (75.9% vs. 59%, $X^2(2) = 11.83$, $p = .003$). Welch’s tests were performed to explore how well the two classes could be distinguished from one another (and, in some cases, from asymptomatic individuals) on the basis of the study variables (see Table 3). Class 1 scored significantly higher on all seven symptoms of ED and was significantly less depressed than the asymptomatic group (data not

Table 2
Selected Fit Indices for 2- to 6-Class Latent Profile Models Among University Students Symptomatic or At-Risk for Exercise Dependence (N = 379).

Model	BIC	Change in BIC	Entropy	LMR-LRT
2-Class	11866.15	0	0.811	0.01
3-Class	11817.03	-49.12	0.867	0.48
4-Class	11797.61	-19.42	0.871	0.06
5-Class	11757.23	-40.38	0.841	0.07
6-Class	11753.07	-4.16	0.810	0.21

Note: BIC: Bayesian Information Criterion; LMR-LRT: Lo et al. (2001) likelihood ratio test.

shown). Class 2 had higher EDS-21 total scores than Class 1, and reported more withdrawal symptoms, continuance symptoms, reductions in other activities, and intention effects. Class 2 also had a larger proportion of individuals classified as “at-risk” for ED than Class 1 [10% vs. 4%; $X^2(1) = 4.70$, $p = .03$, $\eta^2 = 0.11$]. Symptoms of eating disorder were much more evident in Class 2, with 73.4% of individuals (vs. 15.05% in Class 1) having EDE-QS total scores falling in the top quartile of the distribution of scores seen in the full sample. They also reported more frequent use of exercise to control weight, shape, or body fat, or to burn off calories than Class 1 (EDE-QS, Question 8), Welch $F(1, 377) = 34.8$, $p < .001$, $g = 0.84$. In addition to the above, those in Class 2 were also much more depressed than those in Class 1; indeed, whereas only 1.33% of individuals in Class 1 scored in the severe range for depressive affect, 72.2% of those in Class 2 scored in this range. Finally, almost all individuals in Class 2 showed stronger cognitive but weaker affective alexithymic traits, whereas this was not the case in Class 1; this is clearly evident in Fig. 1, which plots individuals’ scores on the two composites (expressed as Z scores based on the distributions seen in the full sample).

3.3. Links between empathy and exercise dependence

Although self-reported perspective taking and empathic concern were comparable in the two classes, individuals in Class 1 reported being less able to empathize with a fictional character ($M_{\text{Fantasy}} = 42.22$ vs. 46.20) and experiencing lower levels of personal distress in response to others’ suffering ($M_{\text{Personal Distress}} = 33.47$ vs. 36.34) than those in Class 2 ($F \geq 5.08$, $p \leq .03$, $g \geq 0.31$ in both cases). Class 1 also scored lower than the asymptomatic group on these two subscales ($F > 3.90$, $p < .049$, $g \geq 0.18$ in both cases). Together, these results suggest a relative weakness in these aspects of empathy in Class 1, and a relative strength in Class 2.

To explore whether alexithymia mediated the relationship between empathy and ED, we performed a mediation analysis in Mplus Version 6.0 (Muthén and Muthén, 1998-2010). Here, cognitive and affective alexithymia scores were evaluated as correlated mediators of the relationship between the four IRI subscale scores and EDS-21 total scores. This analysis was run on all individuals scoring in the symptomatic/at-risk range, due to the relatively small size of Class 2. Based on accepted criteria (e.g., Kline, 2011), the model provided a good fit to the data [$\chi^2(4) = 6.64$, $p = .16$; $CFI = 0.98$; $RMSEA = 0.04$, 90% $CI [0.00, 0.10]$; $SRMR = 0.02$]. Given the lack of longitudinal data we also tested the reverse model by flipping the predictors and the mediators and found that it provided a poorer fit to the data [$\chi^2(2) = 8.07$, $p = .02$; $CFI = 0.98$; $RMSEA = 0.09$, 90% $CI [0.03, 0.16]$; $SRMR = 0.02$]. This lends support to the proposed causal pathway.

As illustrated in Fig. 2, the original model showed a significant indirect effect of perspective taking ($b = -0.025$, 95% $CI [-0.391, -0.027]$), empathic concern ($b = -0.026$, 95% $CI [-0.399, -0.038]$), and personal distress ($b = 0.039$, 95% $CI [.139, 0.483]$) on ED through cognitive alexithymia. Specifically, cognitive alexithymia (which was more prevalent in Class 2) mediated the link between reporting heightened personal distress, and decreased perspective taking and empathic concern, and increased ED severity. In contrast, although negatively associated with empathic concern, personal distress, and fantasy, affective alexithymia was not a significant mediator. Together, these results suggest that past reports linking deficits in aspects of empathy to alcohol-dependence (Maurage et al., 2011) and drug addiction (Ferrari et al., 2014) may need to be reassessed taking individual differences in cognitive and affective alexithymia into account.

4. Discussion

The results of the present study support past research suggesting that individuals who are symptomatic/at-risk for ED fall into two distinct subtypes. The percentage of those rated as at-risk for ED in Class 1

Table 3
Differences Between Class 1 and Class 2 on Measures of Exercise Dependence, Eating Disorder Severity, Depressive Affect, Alexithymic Traits, and Empathy.

	Class 1		Class 2		F	p	g
	M (SD)	M (SD)	Lower Bound 95% CI	Upper Bound 95% CI			
EDS Total	62.2 (13.8)	66.7 (16.7)	61.7	64.6	4.81	.030	0.31
Tolerance	12.6 (3.1)	12.3 (3.4)	12.2	12.9	0.60	.442	0.09
Withdrawal	10.1 (3.4)	11.8 (3.2)	10.2	10.8	17.01	< .001	0.60
Intention Effect	8.6 (3.1)	9.6 (3.7)	8.5	9.2	4.41	.038	0.31
Lack of Control	7.3 (2.9)	7.5 (3.3)	7.1	7.7	0.09	.770	0.07
Time	9.1 (3.0)	8.8 (3.6)	8.7	9.4	0.70	.405	0.10
Reductions	6.6 (2.6)	7.6 (3.2)	6.5	7.1	6.46	.012	0.36
Continuance	7.8 (3.6)	9.2 (3.6)	7.7	8.4	9.51	.003	0.39
EDE-QS Total	0.6 (0.5)	1.5 (0.7)	0.7	0.8	125.33	< .001	1.64
PHQ-9 Total	6.4 (3.6)	16.9 (4.1)	8.0	9.2	433.21	< .001	2.83
BVAQ Cognitive Total	61.2 (13.1)	73.9 (13.9)	62.4	65.3	53.63	< .001	0.96
BVAQ Affective Total	41.2 (8.8)	37.6 (8.3)	39.6	41.4	11.52	.001	0.41
Perspective Taking	42.5 (8.6)	41.4 (8.4)	41.4	43.1	0.92	.339	0.13
Empathic Concern	50.1 (9.4)	50.4 (10.5)	49.2	51.1	0.05	.816	0.03
Personal Distress	33.5 (8.9)	36.3 (10.3)	33.1	35	5.08	.026	0.30
Fantasy	42.2 (11.1)	46.2 (12.2)	41.9	44.2	6.90	.010	0.35

Note: EDS: Exercise Dependence Scale; Reductions: Reductions in Other Activities; EDE-QS: Eating Disorder Examination Questionnaire-Short; PHQ-9: Patient Health Questionnaire; BVAQ: Bermond-Vorst Alexithymia Questionnaire

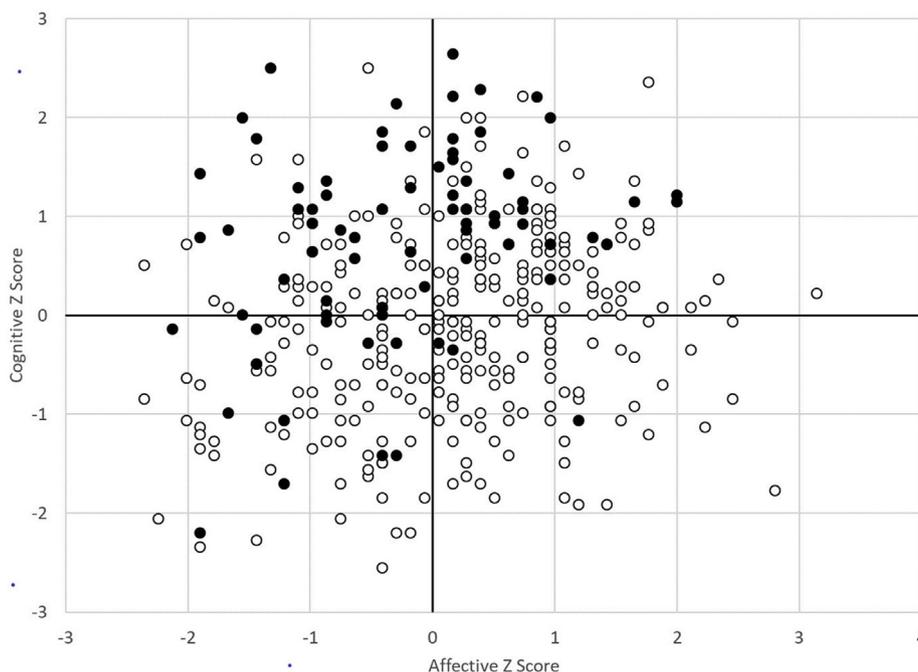


Fig. 1. Scatterplot showing scores for participants in Class 1 (open circles) and Class 2 (closed circles) on the Cognitive and Affective scales of the BVAQ (expressed as Z scores).

(4%) was consistent with what has been reported in the literature for a general exercising population. The clinical presentation of members of this class was consistent with primary ED, as they showed few symptoms of eating disorder, depression, or cognitive alexithymia. In contrast, those in Class 2 could be characterized as having secondary ED. They reported stronger signs of ED (with 10% being classified as at-risk), severe symptoms of eating disorder and depression, and strong cognitive alexithymic traits. These findings support previous research (e.g., Bamber et al., 2000) suggesting that depression poses a more severe problem for those with comorbid ED and eating disorder, than for those with ED alone and/or healthy controls. Although females were over-represented in our sample, Class 1 had a higher proportion of males than Class 2, consistent with previous reports suggesting that men are more likely to be affected by primary than secondary ED (Hausenblas et al., 2017).

Individuals in Class 1 reported even fewer signs of depression that

the asymptomatic group, consistent with the view that exercise may have a (positively reinforcing) mood enhancement effect for those with primary ED. Whether this effect is linked to achieving a “runner’s high” (Antunes et al., 2016) and/or to experiencing increased arousal/energy levels [consistent with both the sympathetic arousal hypothesis (Thompson & Blanton, 1987) and hypoarousal theory (Donges & Suslow, 2017)] is an important question for future research.

Class 1 may have included some individuals with a commitment, rather than an addiction, to exercise. However, the proportion of committed exercisers was likely small, given that Class 1 scored higher than asymptomatic individuals on all symptoms of ED, including experiencing loss of control—a feature said to distinguish addicted from committed exercisers (Berczik et al., 2012). Future research is needed to illuminate the differences between committed exercisers and those with primary ED, and to explore the possibility that some committed exercisers transition, over time, to primary ED. Having participants self-

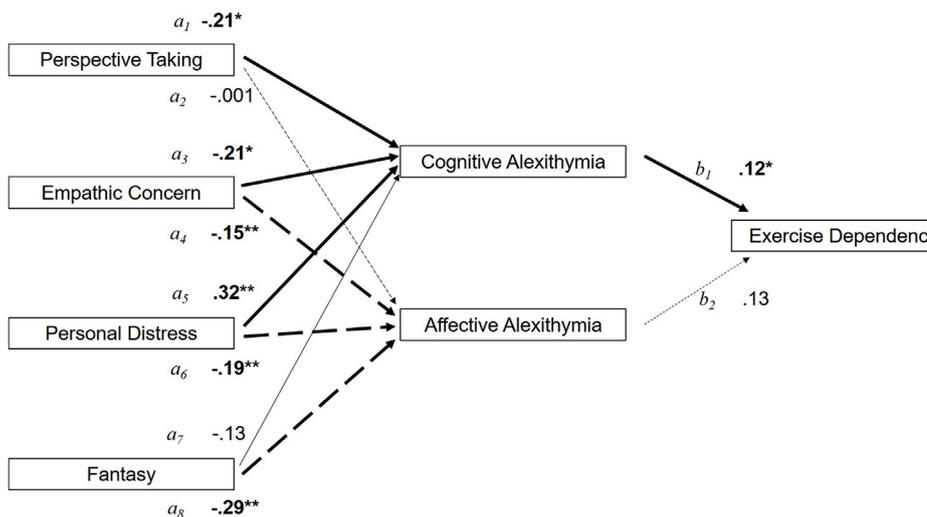


Fig. 2. Mediation model testing the indirect effects of cognitive and affective alexithymia on the relationship between empathy and exercise dependence on individuals symptomatic/at-risk for exercise dependence ($N = 379$). The four dimensions of empathy were included as correlated predictors. Cognitive and affective alexithymia were included as correlated mediators. The solid lines indicate the cognitive alexithymia pathway. Hashed lines indicate the affective alexithymia pathway. Bold lines indicate a significant effect. * $p < .05$; ** $p < .01$.

identify as athletes or non-athletes will be important in this work, given that current ED assessment tools (including the EDS-21 used here) may overestimate the prevalence of ED in competitive athletes (Szabo, Griffiths, de la Vega, Mervó, & Demetrovics, 2015).

We speculate that cognitive alexithymia likely plays a causal role in the development or maintenance of secondary ED. Those who struggle to understand their emotions at a cognitive level are unlikely to develop effective emotion regulations skills, making it harder for them to manage feelings of personal distress. They may turn to exercise to combat overwhelming negative emotions (see Taylor, Bagby, & Parker, 1999), as suggested by the affect regulation hypothesis of ED (Hamer & Karageorghis, 2007). Our mediation analysis provides preliminary support for this idea, but longitudinal research is needed to test it directly.

4.1. Conclusions and clinical implications

Some argue that primary ED either does not exist or is not harmful enough to warrant a diagnosis (Bamber et al., 2000; Blaydon & Lindner, 2002), or that secondary ED might not represent an addiction at all (Adams, 2009). In the present study, individuals in both classes reported engaging in an uncontrollable behaviour despite negative consequences, which is how addiction is operationalized in the DSM-V. We suspect that even though individuals in Class 1 did not show the comorbid eating disorders or depression that characterized those in Class 2, their excessive exercise and their empathic weaknesses likely contribute to other problems that could negatively impact their quality of life (e.g., social isolation).

Researchers and clinicians should explore the motivations that drive exercise-use in the moment (e.g., mood enhancement, social engagement, stress relief), as this may provide important clues about the specific factors driving excessive exercise in particular individuals. In addition, subtyping research like this may shape how we assess and treat ED. For example, treatment approaches that utilize role playing or that target nonverbal communication may be beneficial for individuals with primary ED, as a way to develop their empathic skills (Beresnevaite, 2000). In contrast, emotion focused therapy (Greenberg, 2002) might be used in the treatment of secondary ED to increase emotional awareness.

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Conflicts of interest

There are no conflicts of interest to report.

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