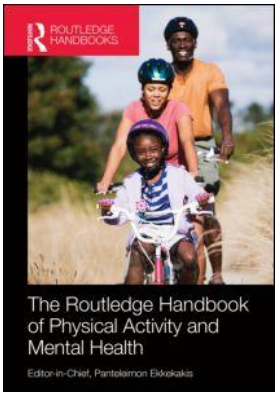


# Routledge Handbook of Physical Activity and Mental Health

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## The Relationship Between Physical Activity and Anxiety and Its Disorders

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# PART 2

# Anxiety disorders

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# THE RELATIONSHIP BETWEEN PHYSICAL ACTIVITY AND ANXIETY AND ITS DISORDERS

*Angela C. Utschig, Michael W. Otto, Mark B. Powers, and Jasper A. J. Smits*

Regular physical activity (PA) is associated with fewer symptoms of anxiety and depression, lower levels of stress, anger, and cynical distrust, as well as better social functioning and vitality among persons with anxiety disorders. In this chapter, we review cross-sectional, longitudinal, and randomized studies that highlight the interplay between PA and anxiety and its disorders. Our aim is to summarize what is known about the PA–anxiety relation with the intent to guide future directions for research in this area.

## Physical activity is associated with reduced anxiety in population-based studies

A number of population-based studies support the association between PA and reduced levels of mood and anxiety symptoms (Goodwin, 2003; Hassmen, Koivula, & Uutela, 2000; Stephens, 1988). In a pooled, representative sample of U.S. and Canadian individuals aged 10 to 74 ($N$ = 55,979), PA was associated with improved mental health, including fewer symptoms of depression and anxiety, even after controlling for education, social economic status, and physical illness. The link between PA and mental health was strongest among those who were over 40 and female (Stephens, 1988). In another study, Goodwin (2003) examined data from approximately 6,000 individuals (aged 15–54) in the National Comorbidity Survey. The study compared the 12-month prevalence of DSM diagnoses among persons who indicated that they exercised "regularly" (60.3%) to those who exercised occasionally, rarely, or never. Individuals who reported regular PA were significantly less likely to be diagnosed with panic, agoraphobia, social phobia, generalized anxiety disorder (GAD), or specific phobias. These associations did not vary by gender or age and remained significant after controlling for comorbid physical illness and demographic variables.

Ströhle and colleagues (2007) found evidence suggesting that PA may offer protective effects against the onset of anxiety disorders. They assessed a cohort of 2,458 individuals (aged 14–24) for DSM-IV anxiety disorders over a span of four years. Cross-sectional results indicated that those individuals who engaged in regular PA were less likely to meet criteria for DSM-IV psychiatric disorders (particularly anxiety disorders) and less likely to have comorbid conditions compared to those who were inactive (OR = 0.70). Similarly, the longitudinal data showed that participants engaging in regular PA had a lower incidence rate of anxiety disorders compared to

those who were inactive (OR = 0.52). This study provides correlational evidence indicating that PA may prospectively reduce the incidence of anxiety disorders.

The hypothesis that PA directly confers protective effects against anxiety disorders was challenged in a population-based study from the Netherlands. De Moor and colleagues (2008) examined leisure time PA and levels of anxiety and depression in a sample of twins ($N$ = 5,952), additional siblings ($N$ =1,249), and parents ($N$ = 1,249). Cross-sectional and longitudinal results revealed a negative association between PA and anxiety in twins. However, when examining the relationship in the context of genetic and environmental factors, genetic correlations were significant, whereas environmental correlations were not, thus suggesting that the association between PA and anxiety disorders may be best explained by overlapping genetic factors. Indeed, heritable tendencies toward avoidance appear to play a role in the onset of anxiety disorders (Arnold, Zai, & Richter, 2004) and may also reduce the likelihood of voluntary leisure time PA (see our discussion of these factors below). Hence, lower rates of PA among those with anxiety disorders may be the result of genetically linked avoidance tendencies. Despite the role of genetics in both lower PA and anxiety, there is good evidence to suggest that programmed exercise can reduce both risk factors for the development of anxiety disorders and anxiety severity once these disorders are developed. Nonetheless, prior to reviewing this evidence, it is important to note that genetic influences may moderate the degree of benefit of these interventions. For example, in a longitudinal study of adolescent girls, PA was protective against depression only for those girls with a genetic variation in brain-derived neurotrophic factor (BDNF; Mata, Thompson, & Gotlib, 2010). More specifically, this genetic variation (Val66Met polymorphism in the BDNF gene) is associated with lower BDNF, and exercise is known to increase BDNF levels (Egan et al., 2003). BDNF is important for brain plasticity, neurogenesis, neuronal survival, and hippocampal function (Egan et al., 2003). Moreover, reduced levels of BDNF are associated with depressed mood, reduced response to CBT, and disturbances in memory (Egan et al., 2003; Lu, 2003). Hence, the Met allele may identify those individuals most likely to achieve affective benefits from PA-related BDNF stimulation (Mata et al., 2010). As such, the role of genetic variants in the effects of exercise on anxiety and mood requires additional study.

## Physical activity reduces anxiety reactivity to stressors

Stress has been implicated in the development and maintenance of anxiety disorders (Last, Barlow, & O'Brien, 1984; Kessler, Davis, & Kendler, 1997). Many studies indicate that PA may prepare the body to handle stressors by improving its ability to adapt to such demands (e.g., Brownley et al., 2003; Sothman et al., 1996; Steptoe, Kimbell, & Basford, 1998). For example, Throne and colleagues (2000) randomly assigned firefighters to either a 16-week exercise program (rowing machine for 40 minutes four times per week) or their own continued PA routine (control condition) following initial measurements of heart rate, blood pressure, anxiety, and mood in a simulated fire drill. Following the intervention, the firefighters repeated the simulated fire drill. Those who completed the rowing program showed significantly lower heart rate, blood pressure, state anxiety, and negative affect compared to those in the control condition.

With respect to reducing reactivity to anxiety disorder-relevant stressors, growing evidence suggests that PA offers protective effects (Esquivel, Schruers, Kuipers, & Griez, 2002; Esquivel et al., 2008; Rejeski, Thompson, Brubaker, & Miller, 1992; Smits et al., 2009, 2011; Strohle et al., 2005, 2009). For example, Rejeski and colleagues (1992) compared the effects of a 40-minute bout of aerobic exercise to 40 minutes of quiet rest on responses to psychosocial stress (i.e., interpersonal threat) in low to moderately physically fit women. Participants were counter-balanced to experience both conditions and results suggested that both blood pressure and

self-reported anxiety were significantly lower following the psychosocial stressor when participants had engaged in exercise prior to the stressor (Rejeski et al., 1992). Similarly, Esquivel and colleagues (2002) examined the effects of exercise compared to minimal activity prior to a single vital capacity inhalation of 35% $CO_2$ in healthy adults. Participants who exercised reported significantly fewer panic symptoms compared to those in the minimal activity condition. Consistent with these findings, Smits and colleagues (2009) found less anxious responding among participants who exercised prior to a single vital capacity inhalation of 35% $CO_2$ compared to those in a quiet rest control condition. Importantly, these effects remained significant after controlling for negative affect and anxiety sensitivity (AS), an established cognitive risk factor for panic and related disorders, as well as fearful responding to $CO_2$ challenge (McNally, 2002). In a recent follow-up study, these findings were extended to show that the relation between regular exercise and reduced fearful responding to $CO_2$-enriched air is stronger among individuals with elevated AS than among individuals with normative AS levels, suggesting that the protective effects of regular PA with respect to anxiety vulnerability may be particularly applicable to persons at risk – i.e., those who have elevated AS (Smits et al., 2011).

More relevant to PA as a treatment for anxiety are studies that demonstrate the effects of PA as a buffer to stress in individuals diagnosed with anxiety disorders (Esquivel et al., 2008; Strohle et al., 2009). For example, Strohle and colleagues (2009) examined the effects of 30 minutes of aerobic exercise compared to 30 minutes of rest on panic attacks induced by cholecystokinin tetrapeptide ($CCK_4$) in individuals with panic disorder and healthy controls. Panic disordered individuals showed increases in somatic symptoms following exercise, but no increases in anxiety compared to control participants. Additionally, those participants with panic disorder who underwent exercise before the $CCK_4$ challenge were significantly less likely to have a panic attack compared to those who did not exercise (Strohle et al., 2009).

Additional evidence for the anti-panic effects of PA comes from the study of exercise as an intervention for reducing (instead of modulating the effects of) AS (Smits, Berry, Tart, & Powers, 2008b). Specifically, Broman-Fulks and colleagues (2004) randomly assigned participants with high levels of AS (measured with the Anxiety Sensitivity Index; Reiss, Peterson, Gursky, & McNally, 1986) to either six 20-minute high-intensity (60–90% max HR) or six 20-minute low-intensity (below 60% of max HR) exercise sessions. Results revealed that the high-intensity intervention was associated with significantly greater reductions in AS compared to the low-intensity intervention. In a follow-up study, Broman-Fulks and Storey (2008) observed significant reductions in AS following six sessions of aerobic exercise compared to a no-exercise control in participants with high AS. Later work used a similar protocol comparing six 20-minute high-intensity exercise sessions to six sessions of exercise plus cognitive restructuring and a waitlist control in participants with high AS (Smits et al., 2008a). Both exercise conditions were equally efficacious in reducing AS compared to the waitlist condition, suggesting that guiding participants through threat reappraisal may not add to the efficacy of aerobic exercise.

## Acute physical activity is followed by reduced anxiety

Research on the effects of acute bouts of PA on anxiety indicates differential effects for aerobic compared to anaerobic (i.e., resistance training) activity. Reductions in state anxiety appear evident immediately and up to 120 minutes following aerobic activity (Bahrke & Morgan, 1978; Hale & Raglin, 2002; Raglin & Wilson, 1996). However, anaerobic activity, especially at high intensities, appears to temporarily increase state anxiety during or immediately following the activity, followed by a slow return to baseline (or lower) over a period of 20 to 60 minutes (Bibeau, Moore, Mitchell, Vargas-Tonsing, & Bartholomew, 2010; Raglin, Turner, & Eksten, 1993).

More recently, research on the acute anxiolytic affects of PA has expanded to include examination of the effect of prescribed versus self-selected intensities for aerobic and anaerobic activity (Focht, 2002; Knapen et al., 2009). Overall, self-selected PA intensity appears as efficacious in reducing anxiety as prescribed intensities; in a qualitative review, Ekkekakis and colleagues (2011) found that acute bouts of exercise, particularly at intensities chosen by participants, are associated with significant reductions in state anxiety (Ekkekakis, Parfitt, & Petruzello, 2011). Knapen and colleagues (2009) examined the effects of 20 minutes of prescribed versus self-selected aerobic exercise in individuals with anxiety and depressive disorders (Knapen et al., 2009). Participants completed three exercise conditions: (1) 50% of maximum heart rate; (2) self-selected intensity with heart rate feedback; and (3) self-selected intensity without heart rate feedback. All three conditions showed pre- to post-exercise reductions in state anxiety and negative affect; heart rate feedback did not influence the response. Additionally, self-selected intensity exercise, regardless of heart rate feedback, resulted in significant increases in well-being and decreases in fatigue. A similar study examining the effects of prescribed versus self-selected resistance exercise or resting condition found comparable results (Focht, 2002). State anxiety was reduced in both the prescribed and self-selected conditions at 5, 20, 60, and 120 minutes following acute exercise in those participants classified as high-state anxiety individuals, while reductions in state anxiety were only seen at 60 and 120 minutes following exercise in the low-state anxiety group (Focht, 2002). Additionally, all participants had significantly higher ratings of perceived exertion in the prescribed exercise condition, compared to the self-selected condition. These findings parallel other work suggesting that exercise (particularly self-selected compared to prescribed intensities) is associated with positive affect (Ekkekakis & Petruzello, 1999) and also extend the literature by providing some insight into the timing of anxiety reduction in high versus low anxious individuals during self-selected intensities. Specifically, the anxiolytic effects of anaerobic PA are greater for persons with higher levels of baseline anxiety compared to those with low levels (Hale & Raglin, 2002); however, individuals with low baseline anxiety show significant anxiety reduction following acute anaerobic activity when the exercise is self-selected and after a considerable post-exercise period (60–120 minutes; Focht, 2002).

Together, these findings suggest that acute bouts of PA are associated with reductions in anxiety, if not immediately, very shortly following the conclusion of activity. However, control groups were not employed in all studies, limiting causal conclusions. Additionally, it remains unclear whether these effects vary as a function of other person variables such as age or gender, or different types of anxiety.

## Anxiety symptoms decrease with physical activity training programs

Several recent meta-analyses suggest medium effect sizes for PA interventions in the reduction of anxiety (Conn, 2010; Long & van Stavel, 1995; Petruzello, Landers, Hatfield, Kubitz, & Salazar, 1991; Wipfli, Rethorst & Landers, 2008). For example, Wipfli and colleagues (2008) found that PA outperformed other active treatments (e.g., CBT, pharmacotherapy) and no-treatment control groups in the treatment of anxiety ($d$ = .48 and $d$ = .19 respectively). Additionally, Long and van Stavel (1995) found that several factors influenced the relationship between PA and anxiety reduction. First, interventions focusing only on PA were significantly more effective in anxiety reduction ($d$ = .45) than those attempting to change other behaviors as well ($d$ = .01). Second, supervised PA ($d$ = .47) outperformed non-supervised ($d$ = .09) interventions. Finally, effect sizes for studies using high-stressed samples (e.g., work, school, social) were significantly larger than those using low-stressed samples ($d$ =.51 and .28, respectively; Long & van Stavel, 1995).

With regard to the influence of specific PA parameters, longer duration of the intervention is generally associated with greater reductions in trait anxiety, with the largest effects for those programs that are at least 16 weeks in length ($d$ = .90; Petruzzello et al., 1991). Similarly, sessions lasting 21 to 30 minutes provide the most anxiety reduction ($d$ = .41; Petruzzello et al., 1991). Analysis of the effect of frequency of PA on anxiety reductions indicates that engaging in PA three to four times per week elicits significantly larger effects than one to two or more than five times per week (Wipfli et al., 2008). Moreover, as indicated in the previous section, the intensity of PA is associated with changes in *positive* affect during and immediately following acute activity, where higher intensities are associated with reduced positive affect (Ekkekakis & Petruzzello, 1999). In non-clinical samples, higher intensity activity relates to greater anxiety reduction in fit compared to unfit individuals, indicating that degree of benefit from high-intensity programs may be moderated by fitness (Ekekkakis & Petruzzello, 1999).

In contrast to findings for acute PA, aerobic and anaerobic training programs appear to yield comparable patterns of anxiety reduction immediately following intervention. Specifically, in healthy adults, both aerobic and anaerobic programs elicit changes in state and trait anxiety immediately following long-term programs, which often range from 10 to 24 weeks in length (Blumenthal, Williams, Needles, & Wallace, 1982; DiLorenzo et al., 1999; Tsutsumi, Don, Zaichowsky, & Delizonna, 1997; Cassilhas, Antunes, Tufik, & de Mello, 2010). Additionally, aerobic programs demonstrate maintenance of anxiety reductions up to 12 months following the intervention (DiLorenzo et al., 1999). Interestingly, a longer-term program (12 weeks) of yoga/tai chi, characterized as an aerobic activity, was associated with significant reductions in trait anxiety and exhaustion and greater improvements in tranquility and revitalization compared to a metabolically matched walking program (Streeter et al., 2010). Thus, both longer-term aerobic and anaerobic programs invoke change in anxiety immediately following the intervention in non-clinical populations, while aerobic programs demonstrate their efficacy up to a year post-program. Importantly, more research is needed to determine the long-term effects of anaerobic activity in clinical and non-clinical populations. Additionally, the beneficial impact of yoga on anxiety and mood symptoms is important for the continued development of PA interventions, as it offers an alternative for individuals who may not be willing or capable of more vigorous or high-impact aerobic exercise.

## Clinical trials of physical activity for anxiety disorders are limited in number

Overall, the evidence base for PA as an intervention for anxiety is less developed than that for depression (Stathopoulou, Powers, Berry, Smits, & Otto, 2006). To date, randomized controlled trials investigating the effects of PA interventions in patients with anxiety disorders have included panic disorder, social phobia, and generalized anxiety disorder (GAD; Broocks et al., 1998; Herring, Jacob, Suveg, Dishman, & O'Connor, 2012; Martinsen, Raglin, Hoffart, & Friis, 1998). Open trials have examined PA for obsessive-compulsive disorder (OCD) and post-traumatic stress disorder (PTSD; Brown et al., 2007; Manger & Motta, 2005). In general, evidence suggests that PA is associated with significant reductions in specific anxiety disorder symptoms, as well as more general anxiety. For example, Broocks and colleagues (1998) examined the efficacy of aerobic exercise relative to clomipramine and pill placebo in patients with panic disorder. Patients randomized to the exercise condition engaged in a 10-week aerobic endurance-training program. Results suggested that clomipramine was significantly more effective at reducing anxiety symptoms after four weeks of treatment compared to placebo, while exercise was significantly more effective than placebo after 10 weeks. Both treatments resulted in equal reductions in

anxiety and outperformed placebo at post-treatment; however, clomipramine yielded greater changes in global improvement ratings compared to exercise.

Examining a broader range of disorders, Martinsen and colleagues (1998) compared an aerobic exercise condition to an anaerobic exercise condition among in-patient participants with panic disorder with agoraphobia, social phobia, or GAD. Both eight-week exercise conditions showed similar post-treatment improvements in anxiety, while only aerobic exercise was associated with greater improvements in physical fitness (Martinsen et al., 1998). This indicates that cardiorespiratory fitness may not account for the effectiveness of exercise programs in reducing pathological anxiety. Similarly, exercise (150 minutes of moderate intensity per week), in combination with group CBT, resulted in significantly reduced symptoms of depression, stress, and anxiety among patients with panic disorder, social phobia, and GAD, compared to group CBT alone (Merom et al., 2008). Likewise, in a small feasibility study, patients with GAD achieved significantly greater reductions in worry symptoms following six weeks of resistance or aerobic exercise training as compared to a wait list control (Herring et al., 2012).

PA interventions have also gained some support for their beneficial impact on symptoms of OCD and PTSD. For example, patients with OCD who engaged in a 12-week moderate-intensity aerobic group program in conjunction with regular care showed significant reductions in Y-BOCS scores from pre- to post-treatment and at a 6-month follow-up (Brown et al., 2007). Moreover, clinically meaningful changes were observed for 69% and 50% of patients at post-treatment and six-month follow up, respectively. Patients also reported improvement in overall sense of well-being after the 12-week intervention (Brown et al., 2007). Additional analyses to determine the acute effects of exercise on symptoms of anxiety, obsessions, and compulsions suggested medium to large effects for reductions in pre- to post-exercise on all three variables at week one and small effects for all three factors at week 12 (Abrantes et al., 2009). These findings suggest that exercise provided the greatest reductions in symptoms earlier in treatment, offering initial support for the utility of exercise as an inexpensive and effective brief treatment for anxiety.

Similarly, exercise interventions may be useful for reduction of PTSD symptoms (Diaz & Motta, 2008; Manger & Motta, 2005; Newman & Motta, 2007). A study investigating the effects of five weeks of speed walking on symptoms of anxiety and PTSD in a sample of adolescents suggested that over 90% of participants reported significant reductions in PTSD immediately following the intervention and at one month follow-up (Diaz & Motta, 2008). Additionally, over 50% of participants reported significant reductions in general anxiety. Although these early findings are promising, the lack of a control group makes solid conclusions difficult to draw.

Further investigation is needed to determine the level of benefit for specific anxiety disorders, including PTSD and OCD. This additional research may also help to clarify the mechanisms through which PA reduces anxiety. Additionally, more work needs to be done to clarify potential moderators of the relationship between PA and anxiety reduction. That is, does the efficacy of PA for anxiety disorders vary as a function of certain dispositional variables such as genetic factors, as discussed earlier, or dispositional variables such as cardiorespiratory fitness, gender, and age? Similarly, future work investigating the timing of treatment effects (i.e., when changes actually occur) will lend insight into development of interventions that provide optimal effects in the most efficient manner.

There also remains a paucity of research on the dose-response relationship of PA and anxiety reduction. One criticism of PA research is that no studies have examined the *combined* effect of varying intensity, duration, and frequency of exercise (Dunn, Trivedi, & O'Neal, 2001). Most research comes from quantitative analyses of numerous studies providing some information, yet a clear picture of a dose-response relationship is still lacking. When looking at the available research, it seems that consistent exercise, in line with current public health recommendations

(USDHHS, 2008), seems to be a good starting point. This type of long-term exercise will likely be beneficial for reductions in overall stress and anxiety over time, while more intense interventions, using PA as an interoceptive technique (e.g., Smits et al., 2008a), may be necessary to drive changes in more specific symptoms, such as those associated with panic disorder (i.e., AS). Ekkekakis and colleagues (2011) further highlighted that intensity of exercise was inversely related to affective response, such that higher intensity produces more negative affect. Given the promising findings on the use of self-selected intensity activity, additional research on this topic will likely provide useful information on whether a dose-response relationship is indeed present, or whether reductions in anxiety are moderated by other variables (e.g., level of anxiety, fitness level, health-related factors such as body mass index (BMI)). Together, such research will help determine the clinical utility of PA interventions for the anxiety disorders.

## Anxiety may result in physical *in*activity

Thus far, we have reviewed data suggesting that PA may prevent or reduce symptoms of anxiety. We now turn to work indicating that anxiety may reduce PA. Anxiety may contribute to physical inactivity through several proposed mechanisms. First, individuals with significant anxiety, particularly AS, generally find PA aversive. One theory attempting to explain variability in affective responses to PA is the dual-mode theory, which posits that two factors, cognitive appraisals and interoceptive cues, interact to generate an affective response (Ekkakakis, 2003). Specifically, when individuals exercise at intensities at or around their ventilatory threshold (VT) or lactate threshold (LT), the affective response is thought to be driven mainly by cognitive appraisals of the exercise experience, whereas exercise that exceeds one's VT/LT, by definition being much more strenuous, will be driven more by interoceptive cues (e.g., racing heart, trouble breathing), resulting in more negative affect, especially for individuals with heightened sensitivity to these cues (e.g., high AS). Research examining affective states during exercise supports these hypotheses (Lind, Joens-Matre, & Ekkekakis, 2005; Parfitt, Rose, & Burgess, 2006; Rose & Parfitt, 2007, 2008). For example, in a study comparing affective responses to exercise at intensities below LT, above LT, and self-selected intensity, affect was least positive in the above LT condition and most positive in the low LT and self-selected conditions (Rose & Parfitt, 2007). Moreover, perceptions of exercise ability, interpretation of exercise intensity, and perceptions of control influenced positive affective responses (Rose & Parfitt, 2007).

Additional research suggests that individuals choose to exercise at intensities around or at their VT/LT, and the intensity is increased over the duration of the exercise session, while affective responses remain stable and positive (Lind et al., 2005; Rose & Parfitt, 2007, 2008). Data also support a decline in affect during exercise above VT, which may be related to the experience of intense interoceptive cues, creating a negative affective message from the body (Ekkekakis, 2003; Rose & Parfitt, 2007). This decline in affect over VT threshold seems to be especially true among overweight/obese individuals (Ekkekakis, Lind, & Vazou, 2010). Interestingly, overweight individuals report more negative affect when exercise intensity is prescribed, rather than self-imposed, compared to normal-weight individuals. Obese individuals also tend to rate both perceived exertion and breathlessness intensity higher than those who are normal weight (Ekkekakis & Lind, 2006; Ofir et al., 2007). Thus, PA interventions, especially in individuals with intolerance for physiological sensations (i.e., high AS and panic disorder) as well as overweight/obese individuals, should work to reduce this intolerance during the early phase of exercise to improve the likelihood of positive affect during and immediately following exercise and ultimately facilitate the maintenance of a long-term PA program, similar to those interventions targeting anxiety sensitivity (Smits et al., 2008b).

Research examining physical inactivity and AS has expanded to determine whether other factors, such as BMI, may play a role in this relationship. Specifically, when examining the relationship between AS, BMI, and exercise following randomization to either a 20-minute bout of aerobic exercise or 20 minutes of quiet rest, results indicated that fear was highest among individuals with high BMIs, but only when they also had elevated AS (Smits, Tart, Presnell, Rosenfield, & Otto, 2010). Moreover, the relationship between BMI and AS did not predict levels of fear in those individuals in the quiet rest condition (Smits et al., 2010). Overall, these findings suggest that elevated AS may play an essential role in physical inactivity in those who are more likely to experience exertion-related symptoms as a result of excessive weight.

In addition to AS, social physique anxiety (SPA), described as an individual's anxiety regarding others' evaluation of physical appearance (Hart, Leary, Rejeski, 1989), may influence the relationship between PA and anxiety. High SPA is associated with reduced PA (e.g., Atalay & Gençöz, 2008; Lantz, Hardy, & Ainsworth, 1997), is more common among adolescent and young adult females (Hayes, Crocker & Kowalski, 1999; Hart et al., 1989), and correlates directly with body weight, such that overweight/obese individuals report higher levels of SPA (Spink, 1992). In a study examining the affective responses to increasing levels of exercise intensity in normal-weight, overweight, and obese women, Ekkekakis and colleagues (2010) found that SPA was negatively related to pleasure during exercise for obese women, but not for normal-weight or overweight women. Interestingly, this association was only significant at intensities near VT, not at low or maximal intensities. Given that individuals with high SPA may avoid exercise to avoid negative evaluation of their physical appearance, at low intensities, overweight/obese individuals may not have been concerned with evaluation from others because they were likely able to maintain their composure and pace, and at maximal intensity they may have been more concerned with the interoceptive cues of exercise, making SPA less salient. In an attempt to reduce SPA, Lindwall and Lindgren (2005) investigated changes in SPA over the course of a six-month exercise intervention compared to waitlist control among sedentary adolescent females. Following the intervention, those girls in the exercise condition demonstrated significant reductions in SPA compared to those in the control condition (Lindwall & Lindgren, 2005). Interestingly, SPA levels increased among those in the waitlist condition after the six-month timeframe.

## Conclusions and future directions

The literature examining the relationship between PA and anxiety and its disorders continues to expand. Overall, the findings are that PA is beneficial for most anxiety, most of the time. More specifically, PA reduces existing anxiety and appears to be associated with lower risk of developing an anxiety disorder. Conversely, anxiety disorders are associated with reduced PA, indicating that the PA–anxiety relation may be bidirectional.

There is still a relative dearth of research examining PA (aerobic or anaerobic) as an intervention for individuals with anxiety disorders. More research is also needed on the dose-response relationship between PA and anxiety. Here, it is important that the influence of exercise dose parameters (intensity, duration, frequency) or exercise modality on anxiety may very well vary by individual difference variables such as AS, SPA, and BMI (Ekkekakis & Lind, 2006; Ekkekakis et al., 2010; Smits et al., 2010).

Research also suggests there may be benefits of self-selected over prescribed exercise intensities in both anxiety reduction and PA adoption and maintenance. Recent work demonstrates that individuals typically pick intensities at or around their VT when given the opportunity to self-select and generally see higher levels of positive affect than those who are prescribed the same intensities (Rose & Parfitt, 2007, 2008). One course for additional research is to examine how

self-selected intensities endure in longer-term interventions, rather than acute exercise bouts. Moreover, work investigating the role of self-selected intensity in clinical anxiety populations needs to be established. Combining self-selected intensity research with research on frequency and duration of PA will provide more definitive answers to the dose-response question, providing information relevant to achieving maximal anxiety reduction and maintenance of PA. As discussed by Ekkekakis (in press), further elucidation of factors affecting the enjoyment of exercise, and applying this information to exercise prescriptions, represents a major growth area for exercise science.

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