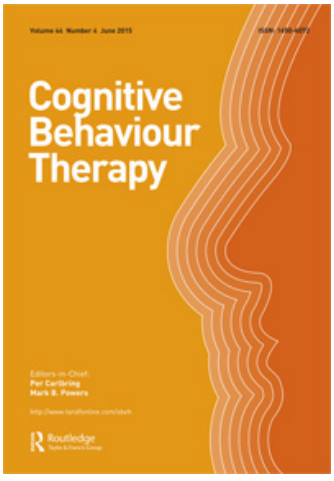

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Running as Interoceptive Exposure for Decreasing Anxiety Sensitivity: Replication and Extension

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Running as Interoceptive Exposure for Decreasing Anxiety Sensitivity: Replication and Extension

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Abstract. A brief, group cognitive behavioural therapy with running as the interoceptive exposure (IE; exposure to physiological sensations) component was effective in decreasing anxiety sensitivity (AS; fear of arousal sensations) levels in female undergraduates (Watt et al., *Anxiety and Substance Use Disorders: The Vicious Cycle of Comorbidity*, 201–219, 2008). Additionally, repeated exposure to running resulted in decreases in cognitive (i.e., catastrophic thoughts) and affective (i.e., feelings of anxiety) reactions to running over time for high AS, but not low AS, participants (Sabourin et al., "Physical exercise as interoceptive exposure within a brief cognitive-behavioral treatment for anxiety-sensitive women", *Journal of Cognitive Psychotherapy*, 22:302–320, 2008). A follow-up study including the above-mentioned intervention with an expanded IE component also resulted in decreases in AS levels (Sabourin et al., under review). The goals of the present process study were (1) to replicate the original process study, with the expanded IE component, and (2) to determine whether decreases in cognitive, affective, and/or somatic (physiological sensations) reactions to running would be related to decreases in AS. Eighteen high AS and 10 low AS participants completed 20 IE running trials following the 3-day group intervention. As predicted, high AS participants, but not low AS participants, experienced decreases in cognitive, affective, and somatic reactions to running over time. Furthermore, decreases in cognitive and affective, but not in somatic, reactions to running were related to decreases in AS levels. These results suggest that the therapeutic effects of repeated exposure to running in decreasing sensitivity to anxiety-related sensations are not related to decreasing the experience of somatic sensations themselves. Rather, they are related to altering the cognitive and affective reactions to these sensations. *Key words: brief intervention; cognitive behaviour therapy; physical exercise; interoceptive exposure.*

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Anxiety sensitivity (AS; fear of arousal-related sensations) is a well-documented risk factor for anxiety and other related disorders (Naragon-Gainey, 2010; Schmidt, Zvolensky, & Maner, 2006). Individuals with high levels of AS are inclined to catastrophize about the possible consequences of arousal-related sensations (e.g., public ridicule, heart attack, going crazy), causing the sensations to spiral, and leading to a vicious cycle of heightened fear and amplified anxiety-related physiological symptoms. As such, AS has been described as both a cognitive (i.e., beliefs) and an affective (i.e., fear) construct (McNally, 1999).

Previous research supports cognitive behaviour therapy's (CBT) efficacy in decreasing AS levels in both clinical populations and in at-risk high AS individuals (for review, see Smits, Berry, Tart, & Powers, 2008). CBT interventions for AS commonly incorporate an interoceptive exposure (IE; exposure to physiological sensations) component (e.g.,

Carter, Sbrocco, Gore, Marin, & Lewis, 2003; Craske, Lang, Aikins, & Mystkowski, 2005; Olthuis, Watt, MacKinnon, & Stewart, 2014).

In addition to demonstrating an intervention's efficacy, there is increasing emphasis on elucidating the processes through which an intervention exerts its therapeutic benefits (e.g., Meuret, Rosenfield, Seidel, Bhaskara, & Hofmann, 2010; Smits, Rosenfield, McDonald, & Telch, 2006). In the case of IE for AS and associated conditions, theoretically, repeated exposure to physiological arousal should lead to a decrease in fearful responding by way of at least two separate mechanisms.

First, from a cognitive perspective, arousal or anxiety-related sensations are misinterpreted as signifying imminent danger. Exposure to the feared sensations without the accompanying feared consequences, therefore, might lead to a re-evaluation of the *meaning* of arousal sensations as less threatening (Chambless & Goldstein, 1981). Second, from a learning perspective, fear of physiological arousal (the conditioned stimulus [CS]), arises due to a learned association with a feared consequence, such as an unexpected panic attack or public humiliation (the unconditioned stimulus [US]). IE exercises act to present the CS repeatedly in the absence of the US, such that new learning occurs accompanied by a reduction in the affective reaction to (i.e., fear of) the CS (Bouton, 2004), resulting in what has been called *extinction learning* (Moscovitch, Antony, & Swinson, 2009).

Anxiety sensitivity and physical exercise

High AS is associated with lower levels of physical exercise and physical fitness (Goodin et al., 2009; Sabourin, Hilchey, Lefaivre, Watt, & Stewart, 2011; Smits & Zvolensky, 2006). Perhaps, high AS individuals avoid physical exercise due to fears of the associated physiological sensations. Alternatively, the limited exposure to arousal-related sensations in individuals who do not engage in physical exercise might contribute to elevated AS levels. These two mechanisms may also work in conjunction in maintaining both exercise avoidance and high AS levels.

Aerobic exercise is a promising treatment for improving mental health, including risk factors such as AS levels (Broman-Fulks & Storey, 2008; Smits et al., 2008; for review see Stathopoulou, Powers, Berry, Smits, & Otto, 2006). Because aerobic exercise induces physiological sensations that are similar to those experienced while anxious (e.g., racing heart, perspiration), aerobic exercise can in fact be considered as an alternate form of IE.

Running as interoceptive exposure

A recent study by Watt and colleagues (Watt, Stewart, Conrod, & Schmidt, 2008) pioneered the use of combining a brief group-based CBT with an IE component comprised of aerobic exercise (i.e., running) in the treatment of high AS. Female undergraduate participants attended three 1-h group sessions on three consecutive days. The program, which included psychoeducation, cognitive restructuring, and the running IE component, was designed by Watt and colleagues based on a manual originally developed by Conrod et al. (2000). Following the three group sessions, participants were instructed to complete ten 10-min running trials individually during the following 10 weeks. Following every running trial, participants completed a measure assessing cognitive (i.e., catastrophic thoughts), affective (i.e., feelings of anxiety), and somatic (i.e., physiological sensations) reactions during running.

The intervention was successful in decreasing AS levels (Watt et al., 2008), as well as cognitive and affective reactions to the running (Sabourin et al., 2008) in high AS, but not low AS women. On the other hand, somatic reactions decreased for both the high and low AS women. Because decreases in cognitive and affective reactions, as well as in AS levels, were unique to high AS individuals, both a cognitive and affective mechanism of action could be postulated for the intervention's therapeutic effects (Stewart & Watt, 2008). Although the study found decreases in both responsivity to the IE trials and in AS levels, the study did not assess whether these changes were in fact related.

The present study

The present process study was a part of a larger outcome study (Sabourin, Stewart, Watt, & Krigolson, under review) that sought to replicate and extend results from the previous Watt et al. (2008) study. The larger

outcome study's intervention remained unchanged from the original study. Because of the theoretical importance of IE in decreasing AS levels, however, we postulated that a more extensive running IE homework would help maintain gains and enhance the intervention's efficacy. The IE portion was therefore expanded from 10 to 42 running trials. High AS female undergraduates who participated in the CBT plus IE intervention arm had higher initial levels of AS, stress, depression, and anxiety symptoms than their low AS counterparts, and experienced decreases in all symptoms from the intervention (Sabourin et al., under review).

The present study aimed to replicate and extend findings of changes in cognitive and affective reactions to running specifically for high AS participants using results from the additional running trials. Second, we aimed to discover whether changes in reactions to running, particularly affective and cognitive changes, were related to changes in AS levels. It was hypothesized that high AS, as compared with low AS, participants, would exhibit more pronounced initial reactions to the running. Decreases over time in affective and cognitive reactions to the IE trials were also hypothesized for high AS, but not low AS, participants. Indeed, we expected that affective and cognitive scores for the low AS group would start low and remain low across trials. Both high and low AS participants were expected to experience changes in somatic sensations as a result of repeated exposure to running. Finally, it was expected that decreases in both affective and cognitive reactions to the IE exercises would be correlated with decreases in AS over the same timeframe. However, decreases in somatic reactions to IE were not expected to be correlated with these decreases in AS.

Method

Participants

A total of 154 female undergraduate students from three eastern Canadian universities participated in the larger outcome study (Sabourin et al., under review). Only women were recruited for participation to control for sex effects, for replication purposes (Sabourin et al., 2008), and because women have been found to have higher AS levels than men (Stewart, Taylor, & Baker, 1997). Participants were recruited based on scoring one standard deviation (SD) above or below the mean score for university women (i.e., $18 +/- 7$; see Watt et al., 2008) on the Anxiety Sensitivity Index (ASI; Peterson & Reiss, 1992), a widely used measure of AS. The ASI was completed as part of a screening battery during an introductory psychology course. Any potential participants with health conditions (e.g., a heart condition or asthma) that might contraindicate running were excluded. Participants were told that they would be randomly assigned to either a CBT intervention, where they would receive training in anxiety management, or a health education control (HEC) condition, where they would learn about health behaviours. These assignments resulted in four separate groups: high AS/CBT ($n = 44$), high AS/HEC ($n = 37$), low AS/CBT ($n = 39$), low AS/HEC ($n = 34$).

Measures

Anxiety Sensitivity Index (ASI; Peterson & Reiss, 1992). The ASI is a widely used measure assessing fear of arousal sensations. It consists of 16-items (e.g., "It scares me when my heart beats rapidly"), each scored on a 5-point Likert scale ranging from "very little" (scored as 0) to "very much" (scored as 4). The ASI has shown excellent psychometric properties (Peterson & Reiss, 1992). Pre-intervention internal consistency was high in the current study ($\alpha = .93$).

Depression Anxiety Stress Scales – 21 (DASS-21; Lovibond & Lovibond, 1995). The DASS-21 is a 21-item self-report measure that assesses the extent of psychological distress over the previous seven days on a 4-point scale (scored as 0–3). The scale possesses good internal consistency and convergent and discriminant validity (Lovibond & Lovibond, 1995). The 7-item depression subscale was used for the current study. Pre-intervention internal consistency was high in the current study's sample ($\alpha = .93$).

Hyperventilation Questionnaire-Brief (HVQ-B; Sabourin, Stewart, Watt, & MacDonald, 2013). The HVQ-B is an eighteen item measure that assesses reactions to physiological arousal. It consists of three separate subscales: (1) cognitive (e.g., "worried about damaging health"), (2) affective (e.g., "anxiety"), and (3) somatic (e.g., "dizziness"). Each item is rated on a 4-point scale ranging

from "not at all" (scored as 0) to "markedly" (scored as 3). The HVQ-B is a brief version derived from the HVQ (Rapee & Medoro, 1994). Both scales have shown strong psychometric properties in university samples, including strong internal consistency, test-retest reliability, and construct validity (Rapee & Medoro, 1994; Sabourin et al., 2013). Internal consistency as assessed during the first running trial was high with alpha coefficients of .84 for the cognitive subscale, .83 for the affective subscale, and .89 for the somatic subscale.

Procedure

Consistent with the protocol used in the Watt et al. (2008) study, participants in the CBT plus IE condition participated in three 1-h interactive group sessions on three consecutive days. The first day consisted of psychoeducation, focusing on learning about anxiety, AS, panic, and the anxiety cycle. On day two, participants acquired cognitive restructuring skills to better deal with anxiety sensations, consistent with established cognitive treatment for panic disorder (Craske & Barlow, 2001). On day three, participants engaged in a 10-min group run. They were instructed to run at an intensity that induced physiological arousal sensations (e.g., rapid breathing, increased heart rate), to focus on these sensations while running, and to compare these to anxiety-related sensations. Following the group run, participants completed the HVQ-B and then discussed how running sensations were similar to anxiety-related sensations. Participants were then instructed to run on their own, three times per week until they reached 42 running trials, and to complete the HVQ-B after each running trial. Prior to taking part in the intervention, all participants read and signed informed consent forms and completed baseline measures. They completed outcome measures again at a 10-week follow-up. Participants received university credit in a psychology course and a small honorarium for participating in the study. The study was approved by the research ethics boards of all three participating universities.

Data analytic strategy

Given that specific a priori hypotheses had been postulated, data were analyzed via planned comparisons and trend analyses using SPSS 15 (see Field, 2013; Tabachnick & Fidell, 2013). Only data from completers (defined as those who completed at least 20 IE running trials) were used so as to assess the effects of the running intervention on individuals who actually engaged in a significant number of running trials. First, between-group *t*-tests were conducted to assess for any initial group differences. Next, within-subject contrasts examined whether or not there was a linear or quadratic trend present in the data over days of measurement (i.e., a significant linear decrease would suggest improvement/learning over time). Finally, to determine if changes in cognitive, affective, and somatic reactions to running corresponded to changes in ASI scores over the same interval, three separate HVQ-B subscale residual change scores and an ASI residual change score were computed, and their inter-correlations were then examined.

Results

Participants in the two conditions (CBT, HEC) did not differ significantly in pre-intervention AS level, race, or age (see Sabourin et al., under review). A total of 125 (63 in the CBT and 62 in the HEC conditions) participants completed all 3 days of the interventions (i.e., 81% completion rate). There were no differences between participants who completed the 3-day intervention ($N = 125$) and those who did not ($N = 29$) on initial ASI scores, F (1,148) = 0.10, p = NS, age, F (1,150) = 3.55, p = NS, or race (i.e., Caucasian vs. Other), χ^2 (1) = 0.10, p = NS.

Participants in the CBT group, but not in the control group, who attended day three of the intervention ($N = 63$) were instructed to engage in the IE running trials. Participants handed in completed HVQ-Bs for a mean (SD) of 17.4 (16.5) running trials. Ten participants handed in completed HVQ-Bs for all 42 trials. A visual inspection of the HVQ-B revealed that minimal decreases in scores occurred after the first 20 trials. Because nearly all of the benefits from IE occurred during the first 20 trials, few participants completed all 42 trials, and 20 trials represented twice the amount from the previous Sabourin et al. (2008) study, treatment completion for the current process study was defined as having completed at least 20 running trials.

A total of 28 participants (10 low AS and 18 high AS) completed at least 20 running trials; these were the participants for the current process study. Participants ranged in age from 17–23 years ($M = 18.89$, SD = 1.59). Most (82.1%) were Caucasian. Mean (SD) pre-treatment ASI scores were 8.50 (3.89) for low AS participants and 35.00 (5.60) for high AS participants.

A 2 (AS group: high AS, low AS) × 2 (completed 20 trials: yes, no) between-subjects ANOVA performed on pre-intervention ASI scores revealed a main effect of AS group, $F(1,56) = 385.51$, $p < .001$, but no significant main effect of completion, $F(1,56) = 0.12$, $p =$ NS, and no significant interaction, $F(1,56) = 0.12$, $p =$ NS. Thus, there were no differences in initial ASI scores between participants who completed all 20 trials and those who did not. Another 2 (AS group: high AS, low AS) × 2 (completed 20 trials: yes, no) between-subjects ANOVA was performed on participant age. There were no significant main effects or interaction (*p*s = NS), demonstrating that there were no age differences between groups. A 2 (race: Caucasian, other) × 4 (groups: high AS/completed 20 trials, low AS/completed 20 trials, high AS/did not complete 20 trials, low AS/did not complete 20 trials) chi-square analysis confirmed that race did not differ between groups, $\chi^2(3) = 6.12$, $p =$ NS.

Decreases in AS levels

Scores on the ASI collected prior to the intervention and 10-weeks following the 3-day intervention were analyzed separately for high and low AS participants using paired-sample *t*-tests. As expected, high AS participants experienced a significant decrease in ASI scores, $t(17) = 2.25$, $p < .05$. Low AS participants, on the other hand, did not experience a significant decrease in ASI scores, $t(9) = 1.71$, $p =$ NS.

Changes in reactions to IE running trials

To confirm that there was a difference in initial responses to the running trials between high AS and low AS participants, planned comparisons using between subjects t-tests were performed on reaction scores from the first IE homework trial for each subscale. As expected, high AS participants had higher initial reactions than low AS participants for the HVQ-B cognitive subscale, $t(26) = 2.99$, $p < .01$ [M (SD) = 2.67 (2.91) Range = 2–15 vs. 0.22 (0.43) 0–1], the affective subscale, $t(26) = 3.26$, $p < .005$ [M (SD) = 2.87 (2.94) Range = 0–10 vs. 0.67 (1.28) 0–5], and the somatic subscale, $t(26) = 2.70$, $p = .01$ [M (SD) = 7.00 (3.80) Range 2–15 vs. 3.78 (2.80) 0–12] (see Figure 1, trial 1 scores).

Within subject contrasts were conducted separately for high and low AS participants for the three HVQ-B subscales. Results indicated that high AS participants experienced a linear decrease in cognitive reactions to running over time, as reflected by a significant linear effect of time on the cognitive subscale, $F(1,17) = 9.90$, $p < .01$, $\eta_p^2 = .37$. Conversely, cognitive reactions did not decrease over time for low AS participants, as reflected by a non-significant linear effect of time on the cognitive subscale, $F(1,9) = 0.14$, $p =$ NS (see Figure 1A). High AS participants also experienced a linear decrease in affective reactions to running over time, as reflected by a significant linear effect of time on the affective subscale, $F(1,17) = 4.67$, $p < .05$, $\eta_p^2 = .22$. Low AS participants also did not experience a decrease in affective reactions over time, as reflected by a non-significant linear effect of time on the affective subscale, $F(1,9) = 4.81$, $p =$ NS (see Figure 1B). High AS participants experienced a linear decrease in somatic reactions over the 20 trials, as reflected by a linear effect of time on the somatic subscale, $F(1,17) = 9.12$, $p < .01$, $\eta_p^2 = .35$. The linear effect of time on the somatic subscale was non-significant for low AS participants, $F(1,9) = 3.57$, $p =$ NS, indicating that low AS participants did not experience a decrease in somatic reactions over time (see Figure 1C).

Changes in reactions to IE running trials and in AS levels

In order to determine whether changes in HVQ-B subscales were related to changes in ASI scores over the same interval, three separate HVQ-B subscale residual change scores and an ASI residual change score were computed. First, HVQ-B scores from the first three running trials were combined as an index of early scores, and scores from the last three

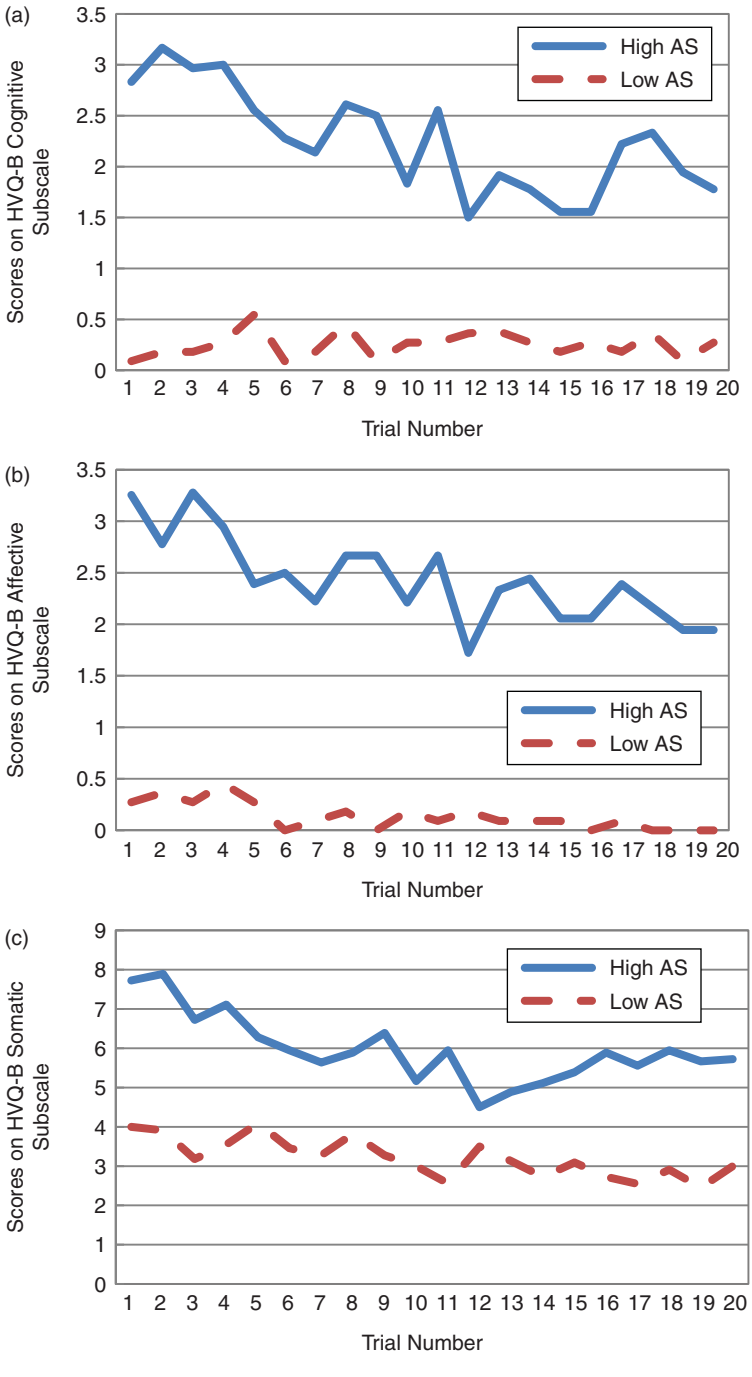

Figure 1. HVQ-B cognitive (A), affective (B), and somatic (C) subscale scores over time. AS = anxiety sensitivity; HVQ-B = Hyperventilation Questionnaire-Brief.

trials (i.e., trials 18–20) were combined as an index of later scores. These combinations also helped correct for potential random variability arising from any one particular running trial. The latter scores were then regressed from the earlier scores, and the standardized residuals

were retained as change scores. The 20th running trial was performed between 28 and 78 days following day three of the intervention, with a mean of 49 ($SD = 13$) days. Next, 10-week follow-up ASI scores, which were collected between 67 and 77 days following day three of the intervention, were regressed from pre-treatment ASI scores and these standardized residuals were retained as change scores. Ten-week ASI scores were used for the current analyses as they were the first ASI assessment following the 20th running trial and thus captured change over a similar timeframe. Because exercise is commonly used as behavioural activation for depression (Stathopoulou et al., 2006), residual depression change scores were used as a covariate in all correlations. HVQ-B cognitive change scores and affective change scores were both significantly associated with ASI change scores, even after controlling for depression change scores. On the other hand, HVQ-B somatic change scores were not associated with ASI change scores either before or after controlling for depression change scores (see Table 1). Furthermore, cognitive and affective residual change scores were strongly related with a correlation of $r = .71$, much higher than correlations between these two domains and the somatic domain. These results indicate that decreases in cognitive and affective, but not in somatic, reactions are indeed associated with decreases in AS. Nonetheless, the affective and cognitive residual change scores were not so highly correlated so as to suggest that they are redundant constructs (i.e., only 50% shared variance).

Discussion

The aim of the current study was to further explore the role of running as the IE component of a brief CBT for high AS women, by replicating and extending results from a previous intervention process study (Sabourin et al., 2008). As a result of repeated exposure to the running IE component of the intervention, high AS participants, but not low AS participants, experienced a decrease in catastrophic cognitions about the sensations associated with running and a decrease in fear of these arousal sensations. This result is consistent with results from our previous process study (Sabourin et al., 2008). As expected, high AS participants also experienced decreases in somatic reactions to running over time.

Contrary to predictions, however, the low AS group did not reveal a decline in somatic reactions to the running. This lack of finding may have resulted because the group size of only 10 participants was underpowered to detect significant changes in reactions to running. Low AS group participants may have found the intervention to be less personally relevant, and therefore less engaging, resulting in a greater attrition rate with this group. Unfortunately, we did not include a measure of credibility so as to assess "buy-in" by this group, but this would be recommended for future research. Moreover, a floor effect in the cognitive and affective reaction scores of this group cannot be ruled out. Low AS individuals experienced low cognitive and affective reactions to running at the first trial, leaving little room for further decreases over time.

Table 1. *Correlations between standardized residual change scores from the Hyperventilation Questionnaire-Brief (HVQ-B) and the ASI, controlling for standardized depression change scores*

	Cognitive change	Affective change	Somatic change
Cognitive change	–		
Affective change	.71*** (70***)	–	
Somatic change	.48** (.48**)	.45* (.47*)	–
ASI change	.53** (.51**)	46* (.40*)	.12 (.11)

Note. *ASI, Anxiety Sensitivity Index; cognitive, affective, and somatic change scores, Standardized residuals from regressing scores of the last three trials from the first three trials; ASI Change, Standardized residuals from regression ASI 10-week follow-up scores from pre-treatment scores. Partial correlations among variables after controlling for standardized residual for DASS-21 Depression subscale change scores (10-week follow-up from pre-treatment) are in parentheses.*
*p < .05; **p < .01; **p ≤ .001.

The current study also extended results from the previous study by revealing that changes in cognitive and affective responses to, but not in somatic sensations arising from, the IE exercises, were related to changes in AS over a similar timeframe. This result suggests that the therapeutic effects of repeated exposure to running in decreasing sensitivity to anxiety-related sensations are not related to decreasing the experience of somatic sensations themselves. Rather, they are related to altering the meaning of (i.e., cognitive) and emotional reaction to (i.e., affective) these sensations.

Taken together, results from the current study and the Watt et al. (2008) and Sabourin et al., 2008) studies lend further support to the possibility that repeated exposure to physiological sensations may result in decreases in AS through two possible mechanisms. First, decreases in cognitive catastrophizing related to arousal sensations may drive AS reduction. Second, the repeated exposure itself may lead to a decrease in fear, through a process of extinction learning. These two mechanisms are not mutually exclusive, and could in fact be operating in tandem. Alternatively, there might be two distinct types of high AS individuals who experience the therapeutic benefits of exposure through different processes. Future research with a larger sample could further examine these alternative explanations.

Limitations and future directions

The current study's limitations included having participants complete the running IE component of the intervention unsupervised. Although participants were explicitly instructed to focus on the physiological sensations and to refrain from listening to music while engaging in the IE component, it is possible that they used some sort of distraction. Distractions, such as music, limit opportunities for learning that the sensations are in fact harmless (Foa & Kozak, 1986). In an effort to monitor the intensity of the running IE homework, participants were encouraged to wear heart rate monitors while running. It is possible, however, that some participants, especially high AS participants, engaged in subtle avoidance by running at an intensity that would not induce a sufficient level of physiological arousal to be effective exposure. Previous research has found that high AS individuals self-report less participation in moderate and vigorous exercise as compared to low AS individuals (Sabourin et al., 2011). Future research could have participants run supervised, using individualized measures of intensity (e.g., measures of ventilator or lactate threshold), in order to objectively assess physical exertion (e.g., Parfitt, Rose, & Burgess, 2006; Welch, Hulley, Ferguson, & Beauchamp, 2007).

A substantial number of participants either did not complete all homework IE trials or failed to submit their HVQ-B records. Perhaps more individualized contact, including supervised or group-based running trials, after the initial intervention, would have increased adherence to the homework portion of the study. Previous studies that have included an intervention consisting of unsupervised physical exercise have also experienced a significant amount of non-completion (e.g., Broocks et al., 1998). Although non-completers did not differ from participants who did complete the trials on initial ASI scores, age, or race, it is possible that they differed on other potentially theoretically relevant variables (e.g., social desirability, exercise self-efficacy) that were not assessed in the current study.

Participants were assigned 30 min of moderate/vigorous exercise per week as part of the current study's intervention. As this amount is substantially below recommended guidelines of 150 min per week (Canadian Society for Exercise Physiology, 2015), the therapeutic benefits observed in the current study would not be expected to result from participants' exercise participation, per se. However, the current study did not assess whether participants engaged in additional exercise over and above the assigned amount. Future research could assess participants' total exercise levels before, during, and following the intervention, via a daily diary for example. If participants were indeed engaging in additional bouts of exercise, other potential mechanisms of therapeutic benefits, such as improvements in sleep, self-efficacy, or distraction (Asmundson et al., 2013) could also be explored.

Future research could also objectively measure baseline and post-intervention fitness levels as an additional incentive for treatment completion and to test improvements in fitness levels as another potential mediator of change. Finally, future research

could expand on the current study by administering the ASI following every running trial to make use of more fine-grained process study analytic techniques (e.g., cross-lagged mediation analysis).

The current study's participants were a fairly homogeneous community sample of mostly young, Caucasian, female undergraduate students. Additionally, participants were excluded if they self-reported any potential health conditions that would contraindicate running (e.g., heart condition, asthma), potentially limiting generalizability of the findings. Future research could test the brief CBT plus IE intervention on diverse groups, including clinical populations, men, and individuals from other racial groups, and could use more objective medical assessments to exclude only those individuals for whom running would be unsafe. On the other hand, mean ASI scores for high AS participants in the current study at pre-treatment were comparable to scores of individuals with panic disorder (e.g., Meuret et al., 2010), suggesting that the AS levels of the high AS group can be considered clinically significant. Finally, the present study did not include a measure of body mass index (BMI). Although the BMI has been commonly used in exercise-based interventions, increasingly it is considered to be a good population measure but a poor measure of individual fitness (Ross & Janiszewski, 2008).

Conclusion

In conclusion, the current study's findings are consistent with previous studies demonstrating the efficacy of repeated, brief, physical exercise trials as an IE component of a brief group-based CBT for decreasing AS (Sabourin et al., 2008; Watt et al., 2008). Moreover, study findings suggest that decreases in maladaptive cognitions about the meaning of physiological arousal and extinction learning resulting from repeated exposure to physiological arousal, are both associated with decreasing aversion and sensitivity to arousal sensations.

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Disclosure statement

The authors have declared that no conflict of interest exists.

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