The Effects of Mindfulness Versus Distraction During Exercise:

Examining Strategies to Improve Affective Response to Cardiovascular Exercise and Promote Exercise Behavior

by

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Thesis directed by Professor Angela D. Bryan

The majority of American adults are insufficiently physically active, and variation in affective response to exercise partially explains levels of inactivity. Examining ways to improve affective response to physical activity is therefore an important direction for research aiming to promote exercise behavior. Two potential strategies that individuals might use to improve subjective response to exercise are mindfulness and distraction. This is the first study to directly compare the effects of each of these strategies on psychological response to exercise.

A sample of 54 insufficiently active individuals aged 18-40 were randomly assigned to one of three conditions: 1) mindfulness, 2) distraction, or 3) associative attentional focus. The study was divided into two phases, a laboratory session in which participants learned their assigned strategy and completed a 30-minute supervised exercise bout, and a two-week at-home intervention in which participants used their assigned strategy on their own while exercising for two weeks. At the end of the two-week period, participants completed a follow-up survey.

The central hypotheses were partially supported. Participants in both the mindfulness and distraction conditions generally had more positive subjective response to exercise compared to participants in the associative focus active control condition. However, contrary to hypotheses, participants in the distraction condition had more positive subjective responses compared to those in the mindfulness condition.

These findings suggest that individuals wishing to increase their cardiovascular exercise behavior would likely do well to find a method of distracting themselves while exercising to

make the experience subjectively less difficult and more affectively pleasant. More research is needed in order to confidently recommend mindfulness as a strategy for managing exercise-related affect and improving maintenance of exercise behavior over time.

Dedication

This thesis is dedicated to Sean Hudson.

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Introduction

Physical inactivity is a well-known risk factor for a wide range of negative health outcomes and noncommunicable diseases, including obesity, coronary heart disease, breast cancer, colon cancer, type 2 diabetes, and early death caused by these conditions (Heyward & Gibson, 2014; Ogden, Carroll, Kit, & Flegal, 2014; Torre et al., 2015; Warburton, Nicol, & Bredin, 2006). Lack of sufficient physical activity is a widespread, global problem; survey data collected from 122 countries found that 31% of the global adult population is physically inactive (Heyward & Gibson, 2014), and the World Health Organization names physical inactivity as the fourth leading risk factor for global mortality, causing 3.2 million deaths annually (World Health Organization, 2017). The economic burden of these health consequences is stark; a recent study quantified the global cost of the outcomes of inactivity at $67.5 billion annually (Ding et al., 2016). Besides the amelioration of negative health consequences, regular physical activity has many benefits in and of itself, including improving mental health and mood, increasing energy, promoting better sleep, and maintaining quality of life and functionality with age (Mayo Clinic, 2016; CDC, 2015).

Both the World Health Organization and the American College of Sports Medicine recommend that adults aged 18-64 do at minimum 150 minutes of moderate-intensity aerobic physical activity per week or at least 75 minutes of vigorous-intensity exercise (or an equivalent combination thereof; Garber et al., 2011; World Health Organization, 2017). Notably, as a general rule, the relationship between physical activity and health outcomes is linear; health status is simply better the more physically fit one is (Warburton et al., 2006). Yet, only 49% of American adults meet *minimum* recommendations for weekly aerobic exercise (Carlson, Fulton, Schoenborn, & Loustalot, 2010; Centers for Disease Control and Prevention/ National Center for Health Statistics, 2015; Tucker, Welk, & Beyler, 2011).

A myriad of features of modern life contribute to this lack of physical activity, including technological advances (such as passive modes of transportation), environmental factors (such as increased urbanization leading to a lack of parks and walking trails), or socioeconomic factors (such as lack of leisure time for physical activity, or lack of access to fitness facilities) (CDC, 2011). Without major policy shifts, these barriers to physical activity are difficult to change. However, it is notable from a health behavior intervention standpoint that some of the most common reasons adults cite for not exercising enough are psychological factors; including a lack of self-motivation, low self-efficacy for physical activity, lack of self-regulation skills for physical activity, and the fact that they find exercise boring or unenjoyable (Sallis & Hovell, 1990). Thus, finding ways to intervene on these individual-level psychological factors is an important direction for research to promote physical activity and improve national and global health.

Physical Activity and Affect

One important psychological predictor of physical activity engagement is exercise-related affect. Simply put, people are more likely to exercise if they feel good while they are doing it. For example, in a study by Williams and colleagues, affective valence measured during a treadmill walk, but not during a cool-down period, was both cross-sectionally and longitudinally associated with minutes per week of physical activity (Williams, Dunsiger, Jennings, & Marcus, 2012). Another study by Kwan and Bryan (2010) found that increases in positive affect over the course of an exercise bout were associated with more frequent exercise participation at follow-up, as were increases in feelings of tranquility and decreases in fatigue post-exercise. This research suggests that individual differences in the degree to which one experiences positive affect when exercising is related to greater levels of exercise overall. Evidence suggests that the reverse pattern of influence occurs as well, such that greater exercise leads to more positive affect. A study by Magnan, Kwan, and Bryan (2013) showed that more active individuals experienced higher positive affect and lower negative affect and fatigue during exercise. This experienced affect contributes to individuals' overall attitudes, self-efficacy, and intentions about exercise behavior (Kwan & Bryan, 2010b), which inform future decisions to exercise. A meta-analysis by Rhodes, Fiala and Conner (2009) found that affective judgments related to exercise behavior (for example, the degree to which people state that they enjoy exercise) are correlated with reported exercise behavior with a medium effect size.

While affective response to exercise seems to vary in part due to individual differences, it is also clearly related to exercise intensity. Researchers have identified the ventilatory threshold (VT; or the point where the activity becomes more anaerobic than aerobic, i.e., breathing becomes labored and lactic acid accumulates) as the physiological marker of a "turning point" for affective response during exercise. Specifically, affect tends to be positive on average during exercise at intensities below VT, but as intensity approaches VT, there is individual variability in the degree to which exercise feels positive versus negative; finally, affective response tends to be nearly universally negative at intensities that exceed VT (Ekkekakis, Hargreaves, & Parfitt, 2013; Ekkekakis, Parfitt, & Petruzzello, 2011). Some health researchers (e.g., Ekkekakis & Petruzzello, 1999) conclude from these findings that efforts to promote maintenance of exercise behavior should be focused solely on low-to-moderate intensity exercise.

However, there are reasons that more vigorous-intensity activity should not be discouraged altogether. First, people commonly cite that one of the reasons they do not exercise is that they do not have enough time. As WHO and ACSM guidelines suggest, vigorous-intensity exercise gives people more ‘bang for their buck’ in terms of health benefits for time spent exercising—to meet minimum recommendations for health, one can spend half the time exercising at a vigorous intensity compared to a moderate intensity (75 minutes versus 150 minutes). For example, a growing body of evidence suggests that short bouts of vigorous intensity exercise (e.g., high-intensity interval training) can induce positive physiological adaptations comparable or even superior to longer bouts of lower-intensity endurance exercise (Gibala, Little, MacDonald, & Hawley, 2012; Gibala & McGee, 2008). In addition, there is some evidence suggesting that vigorous intensity exercise in particular is associated with improved cardiorespiratory fitness, which is more strongly associated with lower risk for all-cause mortality than is general level of exercise participation (Wen et al., 2011). Thus, there seems to be good reason to argue that, despite potential negative affective consequences, promoting vigorous-intensity exercise may be worth “a little pain for a lot of gain” (Gibala & McGee, 2008). Finally, some people simply wish to engage in forms of exercise which are inherently higher intensity activities. For example, someone might find personal satisfaction in setting and achieving a challenging goal pace while running a long-distance race, enjoy the social aspect of taking a spin class with a friend, or appreciate the muscle-building benefits of difficult circuit training workouts, even if those activities are acutely unpleasant.

Thus, because 1) there are individual differences in the degree to which people experience exercise as pleasant versus unpleasant (and those who do not exercise enough are most likely to find exercise to be unpleasant), and 2) vigorous intensity exercise, which may be most beneficial in terms of health, is nearly universally unpleasant, research that illuminates ways to help individuals manage, or even decrease, their in-the-moment negative affective responses to more vigorous-intensity exercise can help to promote higher levels of exercise behavior.

Given the strong literature base demonstrating the relationship between exercise-related affect and future exercise behavior, it is surprising that relatively few studies have attempted to change experienced affect during exercise (Rhodes, Fiala, & Conner, 2009; Rhodes & Kates, 2015). One recent study found that manipulating positive expectancies about exercise-related affect led to more positive experienced affect while exercising (Kwan, Stevens, & Bryan, 2017). Several studies have also found that listening to music and/or watching music videos is associated with more positive affect while exercising at high intensities compared to control conditions (Bird, Hall, Arnold, Karageorghis, & Hussein, 2016; Hutchinson, Karageorghis, & Jones, 2015; Jones, Leighton, & Ekkekakis, 2014). Others have found that exercising outdoors, rather than indoors, was associated with more positive affect during exercise (Focht, 2009; Lacharité-Lemieux, Brunelle, & Dionne, 2015). Further research examining additional ways to change in-task affect during exercise, and especially exercise at higher intensities, is needed; in a meta-analysis on the relationship between affective response to exercise and future behavior, Rhodes and Kates note that "interventions with sustained attempts to improve in-task exercise… should be an aim of future research" (2015).

To help address this gap in the literature, this dissertation will examine two cognitive strategies to make experienced affect during exercise more positive, as improving exercise-related affect should have downstream consequences of increasing attitudes, self-efficacy and intentions to exercise (Kwan & Bryan, 2010b) and eventually promoting exercise behavior. The first strategy is the practice of mindfulness, a technique in which an individual continuously monitors their present-moment experience, including physical sensations, thoughts, and emotions/affect, while maintaining a sense of acceptance and nonjudgment of that experience (Arch & Craske, 2006; Brown & Ryan, 2003). The second strategy is distraction, in which the individual consciously directs their attention to something unrelated to the exercise experience in an attempt to disengage from it. Here, I will review the evidence supporting the potential merits of each strategy and how this evidence motivates the current study.

Mindfulness Overview

In recent years, the concept of *mindfulness* has been introduced and promoted as a strategy for individuals to reduce negative affect across many contexts. While mindfulness is not always consistently defined throughout the literature, it is commonly discussed as a state of enhanced attention, awareness, and non-judging acceptance of one's current experience in the present moment (and this is the definition of mindfulness that guides the current discussion) (Arch & Craske, 2006; Brown & Ryan, 2003). In introducing the concept of mindfulness, it may help to characterize it in terms of what a mindful state is *not*. Brown, Ryan, and Creswell (2007) discuss that typically, an object of perception is only briefly held in focal attention before a cognitive or emotional reaction to that object is made. As such, "concepts, labels, ideas, and judgments are often imposed, often automatically, on everything that is encountered…sensory objects are rarely seen impartially, as they truly are, but rather through the filters of self-centered thought and prior conditioning, thereby running the risk of furnishing superficial, incomplete, or distorted pictures of reality" (Brown, Ryan, & Creswell, 2007, p. 212).

In contrast, a mindful state of processing contains six important characteristics, as outlined by Brown, Ryan, and Creswell (2007). The first is *clarity of awareness* of both internal states and external experiences. The second is *nonconceptual, nondiscriminatory awareness*, that is, awareness without judgment, categorization, or evaluation; the individual recognizes "thoughts as thoughts" without imposing greater meaning on them. The third characteristic is *flexibility of awareness and attention*: attention can be focused both on a specific sensation as well as the "bigger picture." The fourth is an *empirical stance toward reality*, in which the mindful individual is acting as a gatherer of information, attempting to be as objective as possible without judgment. Fifth is *present-oriented consciousness*, or attention and awareness that is focused on the present moment (compared to the past or future), although this is not meant to imply that one is "living in the present," which may imply hedonism or impulsivity. Finally, the sixth characteristic of mindfulness is *stability or continuity of attention or awareness*; being fully mindful is not a fleeting or infrequent state, but instead, a continuous state of being. Somewhat paradoxically, being continuously mindful includes the idea that the individual recognizes when attention has drifted away from the present moment and into past experiences or planning for the future, and consciously returns attention to the present moment. Such recognition is seen to be an instance of mindfulness itself (Brown & Ryan, 2003; Brown, Ryan, & Creswell, 2007; Dutton, 2008).

As above, mindfulness is typically conceived of as a *state*, wherein an individual can be mindful at some times but less mindful at other times (e.g. being on "autopilot"). However, individuals can also vary in their tendencies to be more or less mindful on average (trait mindfulness; Brown & Ryan, 2003).

Mindfulness and Affect

One of the frequently-touted benefits of mindfulness is its relationship with emotion regulation. Specifically, mindfulness seems to be associated with increases in positive emotions and decreases in the strength of negative emotions. A large body of research has shown that both state and trait level mindfulness are associated with greater pleasant affect and less unpleasant affect (Brown & Ryan, 2003). Additionally, interventions that teach individuals to be more mindful in the longer-term [e.g. mindfulness-based cognitive therapy (MBCT; D. Morgan, 2003) or acceptance and commitment therapy (ACT; Hayes, Strosahl, & Wilson, 1999)] have demonstrated success in clinical and non-clinical populations for improving a large range of negative outcomes, including depression, anxiety, stress, and mood disturbance (Brown & Ryan, 2003).

Short-term interventions that manipulate or induce mindful states also seem to promote the regulation of negative affect. For example, one study found that a mindfulness meditation helped participants recover more quickly from an induced negative mood compared to both distraction and rumination conditions (Broderick, 2005). A similar study found improvements in both implicit and explicit affect after a mindfulness exercise following an induced negative mood (Remmers, Topolinski, & Koole, 2016). Notably however, in this study, a distraction condition also showed similar improvements compared to the rumination condition.

Researchers have put forth several hypotheses as to *why* mindfulness might help increase positive affect (or similarly, better regulate negative affect). The first involves the way that mindfulness might change the perspective from which an individual views their inner emotional experience. Shapiro and colleagues (Shapiro, Carlson, Astin, & Freedman, 2006) propose that three qualities or “axioms” of mindfulness, specifically, 1) paying attention, 2) on purpose or with intention, 3) with the particular mindful “attitude” of compassion and nonjudgment leads to a significant shift in perspective, which they term “reperceiving”, wherein an individual engaging in mindfulness distances themself from the contents of their thoughts which allows them to view their experience with greater clarity and objectivity. Others have referred to this phenomenon as “decentering” or “metacognitive awareness,” alternatively defined as the ability to view ones' thoughts and emotions as passing mental events rather than to identify with them (Keng, Smoski, & Robins, 2011). As an example, mindfulness may help an individual recognize that distressing thoughts are not necessarily accurate representations of reality (Coffey & Hartman, 2008). Similarly, in a paper proposing a "Buddhist psychological model" of the mechanisms of mindfulness, Grabovac, Lau, and Willett (2011) suggest that mindfulness practices improve well-being (of which improving positive affect/reducing negative affect would be a component) by decreasing attachment and aversion to feelings, which in turn leads to decreased mental proliferation when those feelings are experienced. The social psychological literature makes reference to a similar concept, psychological distancing, in which an individual can choose to view their inner experience from a "third party" perspective (Ayduk & Kross, 2010). For example, in one study, Ayduk and Kross (2010) found that viewing a negative interpersonal emotional experience from this third party perspective reduced negative emotions when participants reflected on negative past emotional experiences or current conflict with a romantic partner.

Others highlight emotional reappraisal (Holzel et al., 2011) as well as extinction or exposure (Holzel et al., 2011; Keng et al., 2011) as additional mechanisms for how mindfulness improves emotion regulation specifically. In their review on the mechanisms of mindfulness practice, Holzel and colleagues review studies wherein improved emotional reappraisal through mindfulness meditation practice has been conceptualized as both "positive reappraisal," wherein mindfulness leads individuals to consciously reconstrue stressful events as positive, as well as "nonappraisal" in which emotional stimuli are perceived in a "bottom-up" manner and with less "top-down" control, which would be expected if individuals are truly accepting an experience without judgment as is typically instructed in mindfulness training (Holzel et al., 2011). They also review studies that support extinction as a mechanism of the beneficial effects of mindfulness on emotion regulation (largely in the anxiety literature); these studies support the idea that if mindfulness practitioners allow themselves to meet negative emotional experiences “head on”, then the strength of those experiences will decrease over time, a process well-established in the classical conditioning literature (Holzel et al., 2011).

Relatedly, Arch and Craske hypothesize that mindfulness reduces negative affect by increasing willingness to tolerate uncomfortable sensations or emotions, increasing acceptance of negative emotions, and decreasing the time needed to regulate uncomfortable events (Arch & Craske, 2006). For example, they found that participants who received a focused breathing induction showed less negative affective responses to emotionally valenced stimuli and greater willingness to view highly negative photographs compared to participants in unfocused attention and worry induction conditions (2006).

In addition to the apparent benefits of mindfulness in helping individuals decrease negative emotional mood states (and increase positive ones), mindfulness appears to have additional benefits to physical health. Brown and Ryan (2003) found that individuals higher on trait mindfulness reported having fewer physical health symptoms and fewer medical visits. In addition, mindfulness has been associated with positive physical health outcomes in numerous studies (Creswell, 2015). The *mindfulness stress-buffering hypothesis* put forth by Creswell (2015) suggests that mindfulness’s effects on physical health are at least partly, if not completely, explained by mindfulness’s mitigation of stress appraisals and stress reactivity. Such a reduced stress response would have clear direct effects on physical health, but may also impact health somewhat more indirectly by increasing self-regulatory abilities or resources (Masicampo & Baumeister, 2007), potentially reducing engagement in health-risk behaviors and increasing engagement in health-protective behaviors. For example, Leary and Tate (2007) suggest that bringing present-focused attention to a self-regulatory challenge may help individuals succeed at self-control by helping them to disengage from thoughts about the task or preoccupation with other concerns that can interfere with successful performance, and by reducing anxiety and other emotions that can disrupt performance.

At the same time, Brown and colleagues (Brown et al., 2007) note that there are some situations where mindfulness may not be beneficial—specifically, the context of pain has been noted as an exception to the near-exclusive positive effects of mindfulness as a regulatory strategy. With regards to mindfulness and pain, research has demonstrated that the direction of attention to physical discomfort and pain may heighten the experience of the symptom, and instead, behavioral health researchers and practitioners have argued that distraction, avoidance, or other attention diversion strategies are more beneficial when coping with large amounts of pain or discomfort (Brown et al., 2007). As such, these authors argue that mindfulness in the context of regulation of pain or physical discomfort is best suited to more mild or acute conditions (Brown et al., 2007).

Taken together, the current theoretical and experimental literature on mindfulness supports the idea that mindfulness increases positive affect and decreases negative affect overall. Some studies have directly compared mindfulness to alternative regulatory strategies, such as distraction, and while the evidence is somewhat mixed as to the relative benefits of mindfulness (e.g., in the realm of pain management), it is clear that in many situations, mindfulness is beneficial. The current dissertation expands upon this strong literature base supporting the benefits of mindfulness for affect regulation and examines its potential effects in the context of exercise behavior specifically.

With regards to exercise, based upon the general mindfulness literature, it seems reasonable to predict that being mindful while engaging in physical activity could improve affective response during exercise. Specifically, it is possible that engaging in mindfulness could help individuals cope with unpleasant sensations that accompany increases in exercise intensity, both by increasing willingness to experience these negative sensations as well as increasing acceptance of discomfort or distress (e.g., as in Arch & Craske, 2006). In addition, intentional exposure to negative sensations may cause them to decrease in valence over time due to extinction, and/or mindfulness might change the individuals' appraisal of negative feelings during exercise (Holzel et al., 2011). Finally, the decentering aspect of mindfulness may help individuals create distance between themselves and the negative affective experience of exercise, making them less likely to identify with and succumb to negative feelings that arise during exercise (and which may lead to stopping the activity) (Keng et al., 2011; Shapiro et al., 2006).

Thus, through these hypothesized mechanisms, using mindfulness to draw present-moment attention to exercise-related sensations and face them with acceptance and nonjudgment may in fact reduce their negative valence, promoting greater maintenance of exercise behavior in the long term. On the other hand, the literature on mindfulness and pain also suggests that distraction techniques may also be a viable alternative toward managing negative exercise-related affect. That is, in cases where pain is experienced during exercise, rather than purposefully drawing attention toward negative sensations, it may instead be best to ignore them as best as possible. Note that pain in this context refers to muscle soreness or shortness of breath as occurs when one is beginning an exercise program or increasing the intensity of an existing regimen. It does not refer to pain as the result of injury. The following sections will explore the known and potential benefits and pitfalls of each of these cognitive strategies in the context of exercise research.

Mindfulness and Exercise

Some studies have shown that mindfulness, both cross-sectionally and experimentally, is associated with better health outcomes, including engagement in physical activity, providing some initial support for the hypothesis that mindfulness may be beneficial for exercise behavior.

Correlational findings: trait mindfulness and exercise behavior. Much of this literature focuses on the relationship between trait-level mindfulness and the enactment of health behaviors or the frequency of engagement in health behavior. For example, Gilbert and Waltz (2010) examined cross-sectional relationships between mindfulness and multiple health behaviors, and found that trait mindfulness predicted exercise behavior, fat intake, fruit and vegetable intake, and self-efficacy. Specifically, in this study, mindfulness was measured using the Five Factor Mindfulness Questionnaire (FFMQ; Baer et al., 2006), which measures trait mindfulness in terms of five subfactors: Observe, Describe, Act with Awareness, Nonjudging, and Nonreactivity. The authors found that the “Observe” subscale of mindfulness was most robustly correlated with physical activity behavior. Another cross-sectional study found associations between the FFMQ and physical activity, and also found that this relationship was partially statistically mediated by stress, such that mindfulness may reduce stress, which leads to more positive health behaviors (Roberts & Danoff-Burg, 2010). Similarly, Kangasniemi and colleagues found that mindfulness was associated with objectively measured time spent in moderate to vigorous physical activity (Kangasniemi, Lappalainen, Kankaanpää, & Tammelin, 2014). Multiple studies specific to exercise behavior have also found that more dispositionally-mindful participants were more successful at maintaining an exercise program (Blair Kennedy &

Resnick, 2015). For example, Ulmer, Stetson, and Salmon (2010) surveyed YMCA exercisers to examine the relationship between mindfulness, acceptance (versus avoidance), and suppression and maintenance of exercise behavior. Participants who were more successful at maintaining exercise behavior tended to have higher scores on mindfulness and acceptance and lower scores on suppression, supporting the idea that mindfulness and related constructs may help individuals regulate negative affective experiences associated with exercise behavior.

In terms of a potential explanation for the positive relationship between mindfulness and exercise behavior, some correlational work suggests that being higher on trait mindfulness seems to be associated with greater enjoyment of (and, perhaps subsequently, motivation for) exercise. Several studies with athletes have shown that more mindful athletes report a greater tendency toward "flow" states during their sport, a state associated with better performance and more inherent enjoyment of the activity (Pineau, Glass, & Kaufman, 2014). Relatedly, a cross-sectional study by Ruffault and colleagues found that trait mindfulness was positively associated with intrinsic motivation for exercise (2016). In addition, trait mindfulness moderated the relationship between intrinsic motivation and physical activity, such that the relationship between intrinsic motivation for physical activity and physical activity behavior was stronger for more mindful individuals, perhaps suggesting that mindfulness helps people recognize their own internal motivations to exercise and enact consistent behavior. Finally, Kang and colleagues examined the role of trait mindfulness in an intervention where participants reporting insufficient exercise receive potentially threatening health messages (Kang, O'Donnell, Strecher, & Falk, 2016). In this study, trait mindfulness was associated with greater self-reported vigorous activity at baseline (though not physical activity as measured by accelerometer, which is arguably a better, more objective measure of physical activity). Additionally, greater mindfulness predicted larger increases in exercise motivation after receiving the intervention; this increase in motivation was mediated by lower negative affect and shame in response to the threatening messages.

These studies demonstrate a correlational link between trait mindfulness and exercise behavior; more mindful individuals seem to exercise more than less mindful individuals. Further, there is some suggestive evidence that this relationship may be at least partially explained by the fact that mindful individuals may have a more positive affective experience during exercise, though more research is needed examining this question.

Exercise after mindfulness training. Studies that have used interventions to increase mindfulness suggest similar positive relationships between mindfulness and exercise behavior. One study examined the role of a voluntary 8-week mindfulness-based stress reduction program on health behaviors including exercise in an adult sample and observed decreases in sedentary behavior and increases in strength and flexibility over time (but no increase in self-reported minutes of physical activity; Salmoirago-Blotcher, Hunsinger, Morgan, Fischer, & Carmody, 2013). A different intervention in a group of obese women binge-eaters found that weekly yoga sessions (a form of physical activity where mindfulness is typically a key component) with instructions for home practice increased self-reported physical activity after the intervention and at follow-up compared with the control group (McIver, O'Halloran, & McGartland, 2009). Another randomized controlled trial (RCT) found that a mindfulness-based intervention for weight loss consisting of four two-hour mindfulness workshops increased physical activity in women compared to a control group (Tapper et al., 2009). A meta-analysis of the effects of mindfulness on obesity-related health behaviors in overweight and obese adults found a small to medium effect of mindfulness on baseline to post-intervention changes in physical activity behavior across four RCTs with a combined 222 participants (Ruffault et al., 2016). Relatedly, mindfulness training programs have been shown to enhance sports performance; some of the examined mediators of this effect include the reduction of sports-related anxiety and enhancing athletes' abilities to achieve flow states (Pineau, Glass, & Kaufman, 2014). Interestingly, while these studies all suggest the expected directional relationship such that increased mindfulness leads to greater physical activity engagement, one study found a relationship in the reverse causal direction; a randomized controlled trial in men found that dispositional mindfulness increased in an aerobic exercise training condition but not a relaxation condition or waitlist control group (Mothes, Klaperski, Seelig, Schmidt, & Fuchs, 2014).

The above studies do not give explicit insight into the mechanisms behind why these mindfulness interventions may have led to increased exercise behavior. To shed some light on this, therapeutic interventions that contain components of mindfulness (but are not purely mindfulness interventions, per se) have been found to relate to exercise behavior in some studies. One of these is Acceptance and Commitment Therapy (ACT), an empirically-supported behavioral treatment approach that seeks to help individuals work toward creating a life consistent with their values while accepting painful and uncomfortable experiences (Hayes, 2004; Hayes, Luoma, Bond, & Masuda, 2006). ACT contains components of mindfulness among its core principals, and individuals undergoing ACT are taught to remain in the present moment, be open to experience aversive sensations in order to further long-term goals or support their most important values, and use cognitive defusion, or psychological distancing, as a strategy to regulate thoughts and emotions (Hayes et al., 2006).

A few studies have looked at the effects of ACT to increase exercise behavior as well as examined potential mechanisms for its effectiveness. One pilot study which used an ACT intervention to increase physical activity found that participants in the ACT condition visited a university athletic center more than those in a control condition (Butryn, Forman, Hoffman, Shaw, & Juarascio, 2011). Another study found that a brief ACT intervention increased the amount of time low-active women were willing to exercise to exhaustion during a high-intensity cycling test, decreased perceived exertion during the test, and increased reports of post-exercise enjoyment relative to the control condition; interestingly, participants in the ACT condition did not report more positive affect *during* the cycling test compared to control (Ivanova et al., 2015). Finally, one study found that participants assigned to an ACT intervention condition for exercise behavior exercised more during the intervention period; importantly, participants in the ACT condition also improved more on a measure of experiential acceptance during exercise compared to two control conditions, and scores on this measure predicted greater exercise behavior at follow-up (Stevens, 2016). Together, these studies provide experimental evidence that ACT interventions delivered by trained clinicians may help individuals tolerate discomfort and other negative affective experiences during exercise, which in turn may help them to exercise more in the future.

State mindfulness and physical activity. Relatively fewer studies have examined relationships between being in a mindful *state* on psychological or physiological response to an exercise bout.

A recent cross sectional study by Tsafou and colleagues (K.-E. Tsafou, Lacroix, van Ee, Vinkers, & De Ridder, 2016) examined relationships between mindfulness during exercise and satisfaction with exercise. Specifically, the authors proposed that greater awareness during physical activity might help participants notice positive responses to physical activity, thus increasing satisfaction with physical activity and leading to greater maintenance of physical activity behavior over time. The authors measured state mindfulness during physical activity using a retrospective questionnaire, and found that state mindfulness was positively associated with physical activity behavior as measured in metabolic equivalents (METs; a measure of exercise that takes intensity into account); they found that this effect was statistically mediated by reports of satisfaction with physical activity. Finally, trait mindfulness significantly predicted state mindfulness during physical activity. Another cross-sectional study by the same authors observed the same mediational relationship between state mindfulness, satisfaction with physical activity, and physical activity behavior; they also examined moderation of the relationship between mindfulness and physical activity behavior by the strength of physical activity habit (K. E. Tsafou, De Ridder, van Ee, & Lacroix, 2015). They found that mindfulness was related to physical activity levels only for individuals without strong habits for physical activity.

In a prospective study by Cox and colleagues, individuals registered for a yoga class at a university were followed for one semester (Cox, Ullrich-French, Cole, & D'Hondt-Taylor, 2016). A survey assessing state mindfulness of the mind and body was administered immediately after participants practiced yoga on the second day of class. State mindfulness during yoga was measured with the State Mindfulness Scale for Physical Activity (SMS-PA) developed by the study authors, which includes items such as "I noticed pleasant and unpleasant thoughts" and "I felt present in my body" (Cox, Ullrich-French, & French, 2016). They found that greater mindfulness of the body predicted an increase in more intrinsic reasons for exercise over the course of the semester; specifically, participants were more likely to report exercising for health and fitness or mood and enjoyment. In this paper, the authors concluded that "mindfulness appears to be a beneficial state during exercise, therefore future research studies should examine mindfulness during different types of exercise and design intentional interventions to optimize mindfulness during exercise."

Finally, a recent study by Cox and colleagues (Cox, Roberts, Cates, & McMahon, 2018) examined the effects of a mindfulness manipulation on affective response during treadmill walking in low-active individuals. As far as we know, this is the first study that has manipulated mindfulness during cardiovascular exercise. The authors found that, relative to a control bout of walking, listening to a mindfulness meditation audio track during ten minutes of moderate-intensity treadmill walking was associated with more positive affect during exercise. This study supports the idea that mindfulness may be a useful strategy for regulating exercise-related affect during cardiovascular exercise, though it remains to be seen whether this is true for longer bouts of higher-intensity cardiovascular exercise.

While few researchers have tested the relationship between state mindfulness and psychological response to physical activity, this paper is not the first to suggest that this relationship may be important. In a review paper by Salmon, Hanneman, and Harwood, the authors propose potential avenues for research in this domain; specifically, they state that mindfulness may influence perceived exertion during exercise, stating that "sensitivity to inner states would almost surely impact ratings of effort or intensity…However, currently there is a dearth of research involving mindfulness and attention allocation in the context of physical exertion…we are confident that the near future will see increasing applications of mindfulness-based research in exercise science, as has been the case in clinical psychology and behavioral medicine" (Salmon, Hanneman, & Harwood, 2010). The proposed research addresses this call for further research in this area, and also includes an expansion to psychological constructs other than, but related to, perceived exertion (e.g., affect).

Attentional Focus and Exercise

Associative versus dissociative attentional focus defined. While the mindfulness literature suggests that engaging in mindfulness during exercise could improve acute and long-term psychological response to exercise, a separate body of literature on attentional focus during exercise complicates this theory. Attentional focus during exercise was originally described by Morgan and Pollock (W. Morgan & Pollock, 1977), who studied thought patterns of distance runners. They identified two different attentional focus strategies: 1) association, in which the runner focuses' attention on physical bodily sensations, usually related to performance, or 2) dissociation, in which the runner actively and purposefully blocks out sensations related to physical effort (Lind, Welch, & Ekkekakis, 2009; W. Morgan, Horstman, Cymerman, & Stokes, 1983; W. P. Morgan & Pollock, 1977). Other scholars have defined or characterized these dimensions as task-related thoughts (associative) compared to task-unrelated thoughts (dissociative) (Balagué et al., 2015).

Given these original definitions, one might initially note the parallels between an associative strategy and mindfulness (though with the key difference that such attentional monitoring of sensations does not necessarily come with the "mindful" qualities of acceptance and non-judgment of these sensations; in fact, the intention of maintaining an associative attentional focus is often *to* judge the incoming sensations and adjust exercise performance accordingly), but that dissociation is essentially quite opposite from mindfulness. However, given the extensive body of research on attentional focus and exercise, it is important to further explicate how researchers have defined association and dissociation as they have been studied in the context of exercise behavior. As noted by Lind and colleagues (2009), "the lack of consistency in operational definitions has been one of the major obstacles in consolidating the research on A/D [associative/dissociative] strategies," thus, this section will attempt to parse these inconsistent definitions as best as possible. Several review papers have been written about attentional focus during exercise (see Brick, MacIntyre, & Campbell, 2014; Lind, Welch, & Ekkekakis, 2009; Salmon, Hanneman, & Harwood, 2010), thus, this is not a comprehensive review but an attempt to integrate these definitions as they are relevant in the current context.

Since Morgan and Pollock's separation of cognitions during exercise into the associative-dissociative dichotomy, other researchers have further expanded the attentional focus spectrum to include multiple dimensions. First, Schomer (1986) proposed a two-dimensional classification system after characterizing verbalizations of thoughts during a run in a sample of marathon runners. In this model, thoughts are classified as falling within four quadrants comprised of broad/narrow width and internal/external focus. According to this classification system, thoughts (or verbalizations) related to affect, feelings, and body monitoring reflect an *internal/narrow* attentional focus; thoughts related to personal reflection, problem solving, or one's career fall within the *internal/broad* focus, thoughts pertaining to pace monitoring reflect an *external/narrow* focus, and thoughts related to running course information and other "talk and chatter" would reflect *external/broad* attentional focus (Lind et al., 2009; Schomer, 1986).

Later, Stevinson and Biddle (Stevinson & Biddle, 1998) similarly attempted to classify thought patterns as varying along two dimensions of task-relevancy (task-related versus task-unrelated, as above, analogous to association/dissociation) and whether focal awareness was directed internally versus externally. Thus, four different categories of thoughts can be categorized using this model; internal, task-relevant/associative focus (focus on breathing or muscle fatigue), internal, task-irrelevant/dissociative focus (daydreams, mental math, imagining music), external, task-relevant/associative focus (strategy, split times, mile markers), and external, task-irrelevant/dissociative focus (unimportant scenery, spectators or other competitors) (Lind et al., 2009; Stevinson & Biddle, 1998).

In a recent review paper, Brick, Macintyre, and Campbell (2014) propose an extension to Stevinson and Biddle's model. Specifically, they propose that the internal, task-relevant dimension be further classified to distinguish between internal sensory monitoring and active self-regulation—that is, one can simply (or passively) monitor their breathing or other sensations, or they can employ "active" strategies in an effort to control associated thoughts or feelings (Brick et al., 2014). Examples of such active regulation strategies given by the authors include purposefully focusing on technique, cadence, pacing, or active relaxation strategies. It might seem reasonable to think that purposefully engaging in mindfulness techniques could also fall into this category of internal attention (though the authors do not mention mindfulness in their review). Additionally, Brick and colleagues suggest that rather than distinguish between internal versus external dissociation (which may not be meaningfully different), it may be best to classify dissociation techniques as either active distraction or involuntary distraction. That is, in active distraction, the individual effortfully directs their thoughts toward a distraction, such as mental puzzles or another intentional distraction, whereas in involuntary distraction, the distracting thoughts, such as thinking about unimportant (non-course-related) scenery or self-reflecting, come more naturally (Brick et al., 2014).

Importantly, much of the association/dissociation literature describe these categories of attention as types of thoughts that occur spontaneously doing exercise, and characterizes relationships between individual differences in these thought patterns and exercise-related outcomes such as perceived exertion or exercise performance. However, others have focused on outcomes when each type of focus is used as a *strategy* (connoting planned, rather than passively occurring thoughts). For example, Tenenbaum and Hutchinson (2007) include association and dissociation when discussing strategies for coping with physical effort or stress, and distinguish between active versus passive strategies. They note that external or dissociative strategies are used when attention is intentionally shifted toward external events in order to reduce perceived exertion signals, and internal associative strategies are used when individuals attempt to cope directly with feelings of fatigue and effort during exercise through "fighting" against them. They contrast these dissociative and associative strategies with "a passive form of coping with effort," which is when an individual does not try to do anything to help them better tolerate uncomfortable sensory experiences during exercise.

How attentional focus strategies influence the exercise experience. Research in this area typically finds that, while elite athletes on average *perform* better through associative strategies, non-elite or recreational exercisers (i.e., the population for which exercise adherence is arguably most important) benefit from dissociating during exercise, which has been found to decrease perceived exertion (W. Morgan et al., 1983) and improve endurance (Padgett & Hill, 1989; Salmon et al., 2010). For example, Masters and Ogles (1998) found that elite runners who engage in associative strategies have faster running times. On the other hand, in their review paper, Lind and colleagues note a passage in a book for fitness professionals stating that "focusing on the physical activity serves to remind us of feelings of fatigue and make the effort feel more of a chore" (Lind et al., 2009)

Schucker and colleagues manipulated attentional focus in untrained runners, using a breathing-focused condition and a running movement focused condition to manipulate associative focus, a video condition to manipulate dissociative focus (the video was of a runner running through an outdoor scene and was intended to mimic running outdoors and paying attention to scenery), and a no instruction condition. Participants completed all four conditions. They found that participants' running economy was better (i.e., lower rate of oxygen consumption) in the video condition relative to the other conditions, but found no differences in perceived exertion between conditions (Schücker, Schmeing, & Hagemann, 2016).

Another study found that listening to motivational music while walking, compared to listening to either no music or "relaxation" music, led to a more positive affective response during exercise in patients with cystic fibrosis (Calik-Kutukcu et al., 2016).

A study with obese children found that a condition using virtual reality to help children (10-15 year olds) dissociate during exercise (treadmill walking) was successful in helping children shift attention toward the (virtual) external environment and away from bodily sensations. While in this study they did not observe condition differences in Feeling Scale ratings or RPE, children reported increased enjoyment in the VR condition, and children reported that they preferred using the virtual environments while exercising (Baños et al., 2016).

In their recent review paper on attentional focus during exercise, however, Brick, MacIntyre, and Campbell (2014) note that while some studies find increased effort perception with an associative focus, others do not. They also note distinctions between studies that examine outcomes based on attentional strategies versus spontaneous attentional focus. For example, they note that involuntary distraction relates to improved exercise adherence, greater enjoyment and less boredom, reduced effort perceptions, and more feelings of tranquility and positive mood change; while studies imposing active distraction techniques indicate either reduced or relatively unaffected effort perceptions during activity. Of course, since studies examining outcomes related to involuntary distraction are necessarily correlational (since they are observing natural fluctuations in distracting thoughts), these studies do not tell us whether distraction is causing better outcomes during exercise, or what is an equally or perhaps more plausible outcome, that individuals engaging in more pleasant or lighter intensity exercise are more prone to have distracting thoughts. With regards to dissociative strategies, however, Brick and colleagues note that, in terms of the most promising outcomes, "distractive techniques appear most effective to reduce effort perceptions during endurance activity and to enhance mood states post-exercise" (pg. 114), rather than improving objective exercise performance (e.g. pace).

Lind and colleagues note that ratings of perceived exertion (RPE) are the most widely studied outcome in studies comparing associative and dissociative focus strategies, and that theoretically, it is expected that association should result in consistently higher perceived exertion ratings as it should amplify physical sensations, while dissociation should attenuate physical sensations and result in lower ratings of perceived exertion (Lind et al., 2009). Notably, while they are often considered separate outcomes (and affect is often not examined at all in the sport psychology literature in which much of this work is completed), negative affect during exercise and perceived exertion are related; Brick and colleagues note that increasing negative affective states may elevate effort perception during endurance activity (Brick et al., 2014).

For the current research, the relationship between associative/dissociative strategies and affect is of greatest interest. However, Lind and colleagues note that affect is one of the lesser-studied outcomes in this domain, and the limited findings are mixed; both associative and dissociative focus during exercise have been found to be associated with reductions in pleasure over time. However, while findings on general affective response (valence) are mixed, dissociative focus has been consistently related to more positive *specific* feeling states, including revitalization, positive engagement, and tranquility (Lind et al., 2009). They also note one study

(Masters, 1992) showing that the "runner's high" was more commonly experienced by runners who used dissociative strategies. Finally, Lind et al. discuss some relationships between associative/dissociative focus and broad mood states during exercise; specifically, associative focus is related to worsening mood states, while dissociative focus seems to have no effect or a positive effect in some studies.

Integrating Mindfulness with Theories of Attentional Focus in Exercise

Thus, in large part this work suggests that teaching recreational exercisers to dissociate during exercise (a strategy that is essentially the opposite of mindfulness) may be a useful strategy to improve physical activity outcomes. In a sense, it seems that these findings conflict with what a theory of mindfulness during exercise should suggest. However, there are some important points to note here. First, while conceptually there is some overlap between mindfulness and descriptions of associative attentional focus, these two concepts have not been discussed extensively in conjunction with one another. While some work comparing dissociative with associative cognitive strategies during exercise may provide some insight into the question of how distraction techniques might compare to a mindful approach, the conceptual overlap is not entirely clear. In fact, mindfulness falls into somewhat of a gray area theoretically in terms of recent extensions to the dimensions of attentional focus during exercise. For example, Stevinson and Biddle proposed distinguishing between active regulation versus passive monitoring *within* the internal, task-relevant/associative quadrant of their model. However, mindfulness, in a sense, falls in between these two distinctions—one is essentially *actively* choosing to *passively* monitor their present moment experience. Thus, while mindfulness shares qualities with associative attentional focus, the current literature does not speak to how the nuances of a truly mindful approach to exercise behavior might lead to different psychological outcomes when compared to both the more traditional conception of associative focus and dissociative attentional focus during exercise.

Theoretical Moderators of the Effectiveness of Cognitive Strategies During Exercise

Importantly, it is quite possible that the "best" cognitive strategy to use to promote positive affect during exercise (here, we mainly focus on mindfulness compared to distraction) depends on a variety of factors. Specifically, we will focus here on exercise intensity and an individual's experience with exercise as the most relevant moderators.

Perhaps the most important moderator to consider is exercise intensity. Importantly, as previously discussed, exercise intensity and affect are strongly related, such that at higher intensities (i.e., those above VT), affective response sharply declines. In addition, cognitions during exercise are also related to exercise intensity. Specifically, above a certain exercise intensity, research shows that task-related (associative) thoughts will eventually take over, even if an individual is attempting to maintain task-unrelated thoughts (Balagué, Hristovski, Aragonés, & Tenenbaum, 2012; Hutchinson & Tenenbaum, 2007). That is, it may not even be possible for individuals to remain focused on a distraction if exercise is particularly intense. Thus, for individuals who wish to better tolerate high-intensity exercise, it is possible that mindfulness is a preferable strategy.

Also potentially important to consider is the level of physical fitness or exercise experience of the target of the cognitive strategy. Here, the literature on associative versus dissociative attentional focus discussed above is relevant—in general, it seems most likely that dissociative cognitive strategies are most useful for inexperienced exercisers, while associative strategies may improve performance in more experienced athletes. In addition, the work on mindfulness in sports performance suggests that mindfulness interventions may help athletes improve their performance, and that a possible mediator of this effect is the reduction of negative affect (stress) associated with sports performance. Taken together, it seems likely that a mindful approach to exercise behavior would be beneficial to experienced athletes. On the other hand, the hypothesis is less clear for individuals with less exercise experience. It is possible that for individuals just beginning an exercise program, using distraction strategies may be a useful way to "get over the hump" of beginning a difficult exercise routine, by helping individuals draw their attention away from (rather than toward) unpleasant sensations, and that mindfulness may be more beneficial later, once the exercise becomes more regular. Alternatively, it is possible that a mindful approach from the start would offer greater benefits, such as increasing an individual's ability to tolerate unpleasant sensations or even causing them to dissipate over time through extinction.

Theoretical Proposal: Mindfulness Over Distraction

All together, the literature supports the idea that mindfulness and distraction may each have merits as strategies to improve affect during exercise, and thus, promote maintenance of exercise behavior over time, dependent on possible moderating factors. However, based on the current synthesis of the literature, I propose that recommending a mindful approach to exercise behavior may prove to be the best overall strategy.

First, mindfulness has components of both associative and dissociative attentional focus that have been supported in the literature as beneficial to exercisers in some way. The monitoring of sensations in the body involved in both mindfulness and attentional focus have been shown to improve exercise performance, and while improving performance may not necessarily be the most important component of promoting exercise behavior for most individuals, it is likely that better performance would increase perceived self-efficacy for exercise behavior, which, of course, relates to maintenance of behavior over time. In addition, paying closer attention to bodily sensations and feelings during exercise might also help individuals newer to exercise prevent poor form that may lead to injury or overexertion. At the same time, the mindfulness approach to viewing ones' bodily experience with acceptance, nonjudgment, and defusion aligns more with a dissociative approach to exercise, which it would appear has experiential benefits for nonathletes and leads to greater maintenance of exercise behavior over time. Thus, mindfulness may be thought to combine the "best of both worlds" of associative and dissociative focus and be a better overall approach than a purely dissociative strategy.

The literature on mindfulness reviewed earlier strongly links being mindful with increases in positive affect. While it has not been extensively tested in an exercise context, being mindful during exercise should increase positive affect through the same mechanisms that it does in other contexts: by increasing willingness to experience and acceptance of negative sensations (i.e., improving distress tolerance), and decreasing the valence of these sensations through psychological distancing and extinction. On the other hand, literature relating distraction during exercise with positive affect specifically is more limited (Lind et al., 2009). Subsequently, improving affect during exercise through mindfulness should directly and indirectly lead to maintenance of exercise behavior. Affect during exercise has been directly related to frequency of exercise behavior (Magnan et al., 2013; Williams et al., 2012). In addition, affect is related to psychosocial constructs (i.e., those outlined in the Theory of Planned Behavior; Ajzen & Madden, 1986) that play an important role in motivation to maintain exercise, including attitudes, self-efficacy, and intentions to exercise in the future (Kwan & Bryan, 2010b). Paying close attention to ones' present moment affective experience during exercise over time may also affect these motivational factors in a slightly different way. That is, along with possible direct improvements in affect, perhaps engaging in mindfulness may also help inexperienced exercisers notice that exercise feels less difficult or negative as time goes on, realize that they can handle negative sensations in the short-term for a long-term benefit, or notice that exercising regularly improves their overall mood and health even when they are not exercising. Each of these “side-effects” of mindfulness should increase motivation to exercise through these same psychological factors—individuals would likely have more positive attitudes about exercise, feel more efficacious, and intend to exercise more in the future.

The Current Research

This review has provided a theoretical overview of mindfulness and distraction (dissociative focus) during exercise and has discussed the research that supports the potential merits of each as a cognitive strategy to improve affective response during exercise, concluding overall that mindfulness may be the best strategy to recommend. The missing piece, of course, is that no study has directly compared these strategies with one another and examined their effects on psychological response to exercise, either acutely or over the longer term.

In the current study, we attempt to disentangle this important question and examine which cognitive strategy better helps individuals manage unpleasant affect associated with exercise, to the ultimate end of increasing rates of exercise behavior and improving health overall. Importantly, as the literatures on mindfulness and associative/dissociative focus have been almost entirely separate up to this point, this study also includes an associative focus condition, in order to maintain continuity with the established literature on associative/dissociative focus, as well as to test whether mindfulness, with its qualities of defusion, nonjudgment, and acceptance of the present moment experience, is truly a separate construct from associative attentional focus, which focuses on monitoring the present-moment experience but without emphasizing these important elements. Thus, this study involves random assignment to one of three experimental "cognitive strategy" conditions: 1) Mindfulness; 2) Distraction (no different theoretically from Dissociative Attentional Focus, but called Distraction hereforth); 3) Associative Focus. As such, the proposed dissertation study has three primary aims:

1. **Specific Aim 1:** To test the effect of the three strategies on acute affective response to exercise and perceived difficulty of exercise during a 30-minute bout of moderate-to-vigorous intensity cardiorespiratory exercise.
   - **Hypothesis 1:** Participants in both the mindfulness and distraction conditions will report more positive affective valence, lower felt arousal, and lower perceived exertion (RPE) than the associative condition during exercise just below ventilatory threshold (VT).
   - **Hypothesis 2:** In addition, participants in the mindfulness condition will report more positive affective valence, lower felt arousal, and lower RPE than those in distraction condition during exercise just below VT.
2. **Specific Aim 2:** To test the longer-term effect of three cognitive strategy conditions on affective response to exercise, RPE, and exercise volume during a two-week, self-guided, at-home exercise intervention with daily reporting.
   - **Hypothesis 3:** Participants in the mindfulness and distraction conditions will exercise for more minutes, experience more positive affect, and report lower RPE over the 2-week intervention than the associative condition.

- **Hypothesis 4:** Additionally, participants in the mindfulness condition will exercise more and report more positive affect and lower RPE compared to the distraction condition.

3. **Exploratory Aim 3:** To test the effect of the three strategies on psychological predictors of exercise behavior, including TPB predictors (attitudes, norms, self-efficacy, and intentions to exercise) and other correlates of exercise behavior (e.g., state mindfulness, distress tolerance) AFTER learning the cognitive strategy and using it when they exercise on their own for two weeks.

   - **Hypothesis 5:** Mindful participants will experience greater change from baseline to post-intervention in attitudes, norms, self-efficacy, and intentions to exercise in the future than participants in either of the other two groups, and will improve in their state mindfulness and ability to tolerate distress over time compared to the other two conditions.

Methods

Design

This study was a randomized experiment with two phases. In the first phase, participants came into the lab, completed baseline measures and a fitness test, and were randomly assigned to one of three between-subjects conditions: mindfulness, distraction, or associative focus. We examined acute psychological response to a 30-minute bout of cardiorespiratory exercise after participants were trained to utilize their assigned strategy. In the second phase, participants completed a two-week at-home self-directed exercise intervention (using the same assigned strategy on their own) and reported their exercise behavior and psychological response via online daily diary measures. On the last day of the two-week exercise intervention, participants completed a larger battery of measures of psychological predictors of future exercise behavior.

Participants

54 participants were recruited from the greater Boulder community through flyers, online advertisements, and word-of-mouth. On average, participants were 25.06 years of age (SD=5.76) and were 71.7% female. Participants were 75.9% White, 11.1% Asian, 0.02% Black, 0.02% Hispanic or Latino, and 0.09% Mixed Race. Participants were recruited primarily on the basis that they had been engaging in insufficient cardiovascular exercise for the past three months, as recommended by American College of Sports Medicine (ACSM) guidelines, as reported to us on an online study screening measure. ACSM guidelines recommend that adults participate in, at minimum, 150 minutes of moderate-intensity exercise or 75 minutes of vigorous-intensity exercise per week (ACSM, 2013). The participants in this study reported that they had engaged in an average of 71.48 minutes of moderate-intensity exercise (SD=52.61) per week for the past three months. Additional inclusion criteria were that participants were 18-40 years of age,

physically capable of and willing to engage in moderate-vigorous intensity exercise (specifically running, jogging, walking, or hiking), willing to fill out online survey measures for two weeks after the intervention, willing to accept random assignment to condition, and have a smartphone or comparable mobile device that could be used to play podcasts (should they be assigned to the distraction condition). Exclusion criteria for this study were health contraindications for safe engagement in moderate-vigorous intensity exercise (e.g., diabetic, pregnant, family history of cardiovascular disease, etc.). Table 1 shows demographic and baseline characteristics of the sample, on average and by condition.

Table 1. *Participant Baseline Demographics*

	Overall (N=54) *M (SD)*	Min	Max	Mindfulness (n=17) *M (SD)*	Distraction (n=18) *M (SD)*	Self Monitoring (n=19) *M (SD)*	Test Statistic for Condition Differences	p
Gender (% Female)	72%			81%	72%	63%	$\chi^2(2) = 1.4$	.495
Race/Ethnicity (% White)	76%			71%	83%	74%	$\chi^2(8) = 8.14$	.420
Age (years)	25.06 (5.76)	18	39	26.24 (6.86)	24.56 (4.27)	24.44 (6.08)	$F_{2, 50}$=0.52	.604
BMI (kg/m^2)	23.94 (4.46)	18.54	40.23	23.4 (4.04)	22.8 (3.38)	25.51 (5.39)	$F_{2, 51}$=1.96	.152
Mod-vig intensity exercise minutes[1]	71.48 (52.62)	0	190[4]	72.06 (54.86)	83.33 (51.88)	59.74 (51.46)	$F_{2, 51}$=0.93	.402
AUDIT Score[2]	4.33 (4.19)	0	20	4.41 (3.62)	4 (3.99)	4.58 (4.99)	$F_{2, 51}$=0.09	.915
Cannabis Use Frequency[3]	1.56 (2.33)	0	8	1.94 (2.51)	1.89 (2.7)	0.89 (1.66)	$F_{2, 51}$=1.19	.312

Note. Table presents descriptive statistics for demographic variables, both overall and by condition. 1. Moderate-vigorous intensity exercise minutes were computed by adding reported moderate intensity minutes and 2X reported vigorous intensity minutes. 2. Total Alcohol Use Disorders Identification Test (AUDIT; Saunders, Aasland, & Babor, 1993) score. A score of 8 or more is associated with harmful or hazardous drinking. 3. Scores from one item on the cannabis use measure assessing frequency of cannabis use in the last month, where 0=Never and 8=Every Day. 4. Five individuals reported more minutes of moderate-vigorous intensity exercise at the baseline session than they did in the screening measure for the study, where eligibility criteria for the baseline visit included that potential participants were participating in less than or equal to 150 minutes of moderate-vigorous intensity exercise per week. These participants are still included in all analyses.

Power analysis. Power was estimated using G*Power, based on the analysis to address Specific Aim 1, which involves a within-between repeated measures analysis comparing group means on repeated measures of psychological constructs during the 30-minute exercise bout.

Power was estimated using standard procedures following Cohen (1988). We estimated the power to detect a small to moderate effect (f=.20) with alpha of .05 and power of .95 for the difference between three groups (mindfulness/distraction/associative) using 4 repeated measurements during the exercise bout and estimating a correlation of .5 between repeated measures. With our sample of 54 participants, our power to detect these effects is .88.

Measures

Screening. During the online eligibility screening, participants completed the Physical Activity Readiness Questionnaire (PAR-Q; Thomas, Reading, & Shephard, 1992), which assessed health risks for exercise behavior (e.g., chest pain while exercising, dizziness, cardiac symptoms, etc.). Participants also responded to measures assessing their eligibility in terms of the inclusion criteria outlined above. To assess current physical activity levels, we first defined moderate and vigorous intensity exercise. We then asked individuals to report how many minutes of moderate and vigorous intensity exercise they had engaged in per week on average for the past 3 months. We used the ACSM's rule of thumb that 1 minute of moderate intensity exercise is equivalent to 2 minutes of vigorous intensity exercise. Thus, if total minutes of moderate intensity exercise and total minutes of vigorous intensity exercise (multiplied by 2) per week was greater than 150, callers were not eligible for study inclusion.

Baseline and follow-up survey measures. Study data were collected and managed using REDCap electronic data capture tools hosted at the University of Colorado (Harris et al., 2009). Participants completed the following measures via REDCap at baseline and (except for Demographics measures) on the last day of the two-week at-home intervention. Participants completed baseline measures in the lab at the beginning of their study appointment, and completed follow-up measures online at home.

Demographics. Participants responded to questions indicating their gender, age, height and weight, ethnicity, race, relationship status, level of education, employment status, and income.

Frequency and correlates of exercise behavior. Participants completed the following self-report measures of exercise frequency and psychological or behavioral correlates of exercise behavior:

The Godin Leisure-Time Exercise Questionnaire (GLTEQ). The GLTEQ (Godin & Shephard, 1985) is a self-report assessment of the quantity, frequency, and intensity of exercise participation for a participants's average week. Participants reported both the number of exercise sessions per week and minutes per week of mild, moderate, and vigorous intensity exercise.

Aerobic Exercise Questionnaire (AEQ). The AEQ (Bryan & Rocheleau, 2002) measures frequency of aerobic exercise behavior over the past three months and one week.

Stanford Leisure-Time Activity Categorical Item (L-Cat). The L-Cat (Kiernan et al., 2013) is a single-item categorical measure comprised of six descriptive categories ranging from inactive to very active that has been shown to be sensitive to changes in physical activity.

Theory of Planned Behavior (TPB) exercise measures. The TPB measures (Ajzen & Madden, 1986; Bryan & Rocheleau, 2002) include four separate constructs: intentions, subjective norms, perceived behavioral control (PBC)/ self-efficacy, and attitudes. The intentions construct (α=.92) measures participants' intentions for aerobic exercise within the next month via three items with seven point Likert scales (1=Not at all likely, 7= very likely) for each item (example item: "I intend to do at least 150 minutes of moderate-intensity activity per week in the next month"); the subjective norms construct (α=.77) measures participants' perception of social norms for aerobic exercise via eight items with seven point Likert scale (1= Strongly disagree, 7= Strongly agree) ratings for each item (example item: "My friends think that I should engage in weekly cardiorespiratory exercise of at least moderate intensity") ; the PBC/self-efficacy construct (α=.83) measures the degree to which participants feel they are capable of aerobic exercise via nine items with seven point Likert scale ratings (1= Strongly disagree, 7= Strongly agree) for each item (example item: "I could do cardiorespiratory exercise of at least moderate intensity even if I was very busy"); and the attitudes construct (α=.85) measures participants' attitudes towards exercising via twelve items with eleven-point semantic differential scales for each item (example item: "For me, engaging in regular cardiorespiratory exercise would be: very calming/very revitalizing").

Alcohol use. The AUDIT (Saunders et al., 1993) is used to detect problems associated with alcohol consumption and addresses both current problems (problems within the last 3 months) and problems across an individual's lifetime. The AUDIT consists of ten questions that cover such domains as alcohol consumption, drinking behavior, adverse psychological reactions, and alcohol-related problems.

Cannabis use. These scales were created for the purpose of our laboratory's studies to assess the frequency with which participants use cannabis and other questions surrounding cannabis use. Participants were first asked if they had ever used cannabis (marijuana) in any form; if they responded they had not, they skipped the rest of the questions. If they responded they had, they were asked a series of questions about their frequency of use, methods of use (e.g., edibles, smoking, etc.), and estimated percentages of various cannabinoids (e.g., THC, CBD) in the cannabis that they use. For the purposes of assessing baseline cannabis use frequency in this sample (e.g., Table 1), we examined one item assessing "In the last six months, how often did you use cannabis?" rated on a Likert Scale (0=Never, 8=Every Day). If participants had never used cannabis, they also received a 0 on this item.

Cigarette and e-cigarette use measures. These scales were created for the purpose of our laboratory's studies to assess the frequency with which participants use cigarettes and electronic cigarettes, or e-cigarettes.

Positive and Negative Affect Schedule (PANAS). The PANAS (Watson, Clark, & Tellegen, 1988) is a brief measure of mood. Participants rate emotional state descriptors on a 5-point Likert scale (1=Very slightly or not at all, 5=Extremely), and items are averaged to create a positive affect subscale (α=.91) and negative affect subscale (α=.70).

Discomfort Intolerance Scale (DIS). The DIS (Schmidt, Richey, & Fitzpatrick, 2006) is a brief, 7-item, measure assessing participants' general difficulty managing and regulating physical distress and discomfort. The DIS is measured on a 7-point Likert scale (1= Not at all like me, 7= Very much like me) and includes items such as "I take extreme measures to avoid feeling physically uncomfortable" (α=.82).

Five Facet Mindfulness Questionnaire. The FFMQ (Baer, Smith, Hopkins, Krietemeyer, & Toney, 2006) assesses 5 subscales of mindfulness: observe (α=.79), describe (α=.91), act with awareness (α=.88), nonjudge (α=.93), and nonreact (α=.86). The FFMQ is measured on a 5-point Likert Scale (1=Never or very rarely true, 5=Very often or always true) and includes items such as "When I'm walking, I deliberately notice the sensations of my body moving."

Philadelphia Mindfulness Scale (PHLMS). The Philadelphia Mindfulness Scale (PHLMS; Cardaciotto, Herbert, Forman, Moitra, & Farrow, 2008), is a 20-item bidimensional measure of mindfulness that measures the degree to which participants express present-moment awareness (α=.84) and acceptance (α=.87).

Mindful Attention and Awareness Scale (MAAS). The MAAS (Brown & Ryan, 2003) is a 15-item measure assessing attention to and awareness across several domains of experience. The MAAS is measured on a 6-point scale (1=Almost Always, 6=Almost Never) and includes items such as "I find it difficult to stay focused on what's happening in the present" (α=.85).

Study feedback measures (follow-up survey only). These questions asked about participants' experience in the study, and include Likert Scale measures and one open-ended question. These items assessed participants' subjective experience with using their assigned strategy, and included the following three items: "Using my assigned strategy made exercise feel better"; "Using my assigned strategy helped me exercise more"; "In the future, I will use my assigned strategy when I exercise", rated on a 7-point Likert scale (1=Strongly disagree, 7=Strongly agree). We also asked participants to describe their experience with one open-ended question: "We are interested in your feedback on how this strategy worked for you while exercising. Please tell us anything you'd like about your experience using your assigned strategy."

Acute exercise measures. Participants first responded to these measures during the exercise bout that included the Talk Test (before randomization). Thus, the baseline acute exercise measures were completed after exercising for five minutes after the appropriate heart rate range as determined by the Talk Test (see Table 2 below). During the experimental exercise bout, participants responded to these measures at 10-minute intervals: at 0 minutes (that is, when participants reached the appropriate heart rate range after the warm-up and 30-minute timing began), 10 minutes, 20 minutes, and 30 minutes. For the baseline measure at the conclusion of the Talk Test, participants rated how they felt in the past five minutes. For the experimental bout, participants rated how they felt in the past 10 minutes.

Feeling Scale (FS). The FS (Hardy & Rejeski, 1989) was used to measure affective valence during exercise, the first dimension of a circumplex model of affect, which characterizes core affect on dimensions of valence and activation or arousal (Panteleimon Ekkekakis, Parfitt, & Petruzzello, 2011a; Russell & Feldman Barrett, 1999). Participants were asked to "Please choose the number that best describes how you were feeling on average in the past (five/ten) minutes". This single item, 11-point measure ranges from - 5 to + 5, with verbal anchors at all odd integers and at the zero point (+5 = very good, 3 = good, 1 = fairly good, 0 = neutral, -1 = fairly bad, - 3 = bad, - 5 = very bad).

Felt Arousal Scale (FAS). The FAS was used to measure affective arousal during exercise, which the second component of a circumplex model of affect (Panteleimon Ekkekakis et al., 2011a; Russell & Feldman Barrett, 1999). Participants were asked to "Please indicate how aroused ("worked up") you felt on average in the past (five/ten) minutes. This single item measure ranges from 1 to 6 (1= Low arousal, 6=high arousal; Svebak & Murgatroyd, 1985).

Rate of Perceived Exertion (RPE). Lastly, participants rated the average perceived intensity of the exercise for the past five/ten minutes. Ratings were reported on a scale from 6 (no exertion) to 20 (maximal exertion), from Borg (1973).

Supervised exercise manipulation check. After the supervised exercise session, participants self-reported their agreement with the statements, "I observed the exercise experience closely"; "I paid close attention to the physical sensations caused by exercise"; "I tried to stay focused on something other than my exercise experience" and "I concentrated on other things rather than the exercise experience" on a 7-point Likert scale from 1 (Never did that) to 7 (Always did that). These items were adapted from Arch and colleagues (Arch et al., 2016).

Daily exercise diary measures. Participants responded to the following measures every day for the 14 days following the baseline appointment.

Exercise behavior and minutes. For the daily exercise measures, participants were first asked if they exercised that day. If participants did not exercise that day, then they skipped all questions specific to the day's exercise. If participants did exercise that day, they were asked how many minutes they exercised, and what type of exercise they did (walking, jogging, hiking, running, or other), to ensure they were following instructions.

Exercise-related affect measures. Participants reported their affective valence before, during, and after they exercised using the FS (as described above).

RPE. Participants rated the average intensity of their exercise session using the RPE scale (as described above).

Substance use measures. In order to account for substance use, which may have affected exercise behavior in ways unrelated to the intervention, participants reported the number of alcoholic beverages they had that day as well as whether or not they had used cannabis.

Sleep. As sleep may have also affected exercise behavior, participants reported the number of hours they had slept the previous night.

Daily manipulation check. Participants were asked to "Estimate the percentage of the total time exercising you spent using your assigned strategy, [Mindfulness/Distraction/Self-Monitoring], while you were exercising today." Participants also rated how easy or difficult it was to use their strategy on a Likert scale. Additionally, participants in the distraction condition were asked to check which type of distraction(s) they used during that exercise session (podcast, audiobook, book or magazine, TV, or other [describe]), to ensure they were following instructions or note if participants had chosen to use a different distraction.

Procedures

Table 2 summarizes study appointments and procedures.

Table 2. *Schedule of Assessments*

Visit	Duration	Includes
Online Screening	5 minutes	- PAR-Q - Other eligibility screening measures
Laboratory Session	2 hours	- Baseline questionnaire (demographics, exercise frequency measures, TPB, distress tolerance, and trait mindfulness) - Talk Test protocol + collect baseline FS, FAS, RPE - Random Assignment - Intervention workshop - 30-minute exercise bout with FS, FAS, and RPE at 10-minute intervals - Explanation of two-week at home intervention
Two-Week At-Home Intervention	Exercise goal: 150 minutes per week, 5-minute daily surveys	- Self-guided exercise - Short daily diary measures completed online
Follow-Up Survey	20 minutes	- Follow-up questionnaire (exercise frequency measures, TPB, distress tolerance, and trait mindfulness, intervention feedback), completed online

Recruitment and screening. Recruitment materials for the study described the opportunity for participants to participate a study titled “Strategies to Enhance the Experience of Exercise,” a research study examining strategies people can use to change their experience of cardiovascular exercise. The advertisements noted main eligibility criteria, a summary of the assessments involved in study participation, and the opportunity to earn up to $29 for participation.

Advertisements directed interested individuals to contact the researcher via email or go directly to the online screening form, administered via REDCap, to determine their eligibility for participation. The screening form also contained a more detailed description of study procedures and the time commitment involved. If participants were eligible to participate in the study, they were contacted by the researcher via email to schedule their study appointment.

Laboratory session. In order to reduce experimenter demand, all study procedures for the laboratory appointment were fully scripted, standardized, and administered by trained research assistants blind to the study's hypotheses. Pre-randomization, the same script was used for all participants (for the informed consent, baseline survey, and Talk Test procedures). Post-randomization, the research assistant used a script for the assigned intervention condition. The content of these scripts can be found in Appendices A, B, C, and D.

At the beginning of the laboratory session, participants completed informed consent. Next, they completed the baseline survey measures on a laboratory computer.

Talk Test. After completing the baseline measures, participants were prepared for the exercise bout. Participants were fitted with a heart rate monitor, and then underwent a Talk Test in order to determine exercise intensity. The goal of the Talk Test was to determine an exercise intensity near the participant's ventilatory threshold (VT), as research has shown that affective response to exercise is variable between individuals at a level of intensity that is near VT (while affective response to exercise below VT tends to be nearly universally positive, and affective response to exercise at intensities above VT tend to be nearly universally negative; Ekkekakis, Hall, & Petruzzello, 2008). Thus, having participants exercise near their VT allowed for greater power for our manipulations to change affective response to exercise. The Talk Test has been shown to reliably approximate VT across several studies (Foster et al., 2008; Lee, Emerson, & Williams, 2016; Persinger et al., 2004; Woltmann et al., 2015). A masters-level exercise physiologist trained research assistants to administer the Talk Test protocol. The Talk Test procedures as well as the Feeling Scale, Felt Arousal Scale, and RPE scale were explained to participants before the test began.

The Talk Test, from Foster et al. (2008) was a graded exercise test (GXT) on a treadmill, where exercise intensity was increased at regular intervals. The first stage was 4 minutes in duration with 0% grade to define a comfortable treadmill speed. The following stages were 2 minutes each, and the grade increased 2% per stage while the speed remains constant. Heart rate was recorded during the final 10 seconds of every 2-minute stage. During the final 30 seconds of each stage, the participant was asked to recite the Pledge of Allegiance (a paragraph generally familiar to most Americans, but supported by cue cards if necessary). After participants recited the Pledge, they were asked, “Were you able to speak comfortably?” and asked to respond “yes,” “not sure,” or “no.” The point at which the participant first provides an equivocal (“not sure” or similar) response to the Talk Test has been shown to be “almost exactly equivalent to ventilatory threshold” in one study (Persinger et al., 2004). Thus, the participant’s heart rate at their first equivocal response was recorded as the heart rate range for their in-session exercise bout, and the treadmill speed and incline were also recorded so that the exercise bout could be completed under these parameters.

After giving an equivocal response, participants were told that they were at the appropriate intensity level, and that they would exercise for five minutes at that intensity. The research assistant ensured that participants remained at an intensity within +/- 5 beats of the recorded heart rate during that time. After five minutes, the research assistant showed participants cue cards for the FS, FAS, and RPE measures, and recorded their responses. These responses provided a baseline, pre-intervention measure of participants’ response to these constructs at this intensity of exercise. At this point, the treadmill was stopped and participants were offered water before beginning the intervention/cognitive strategy training session.

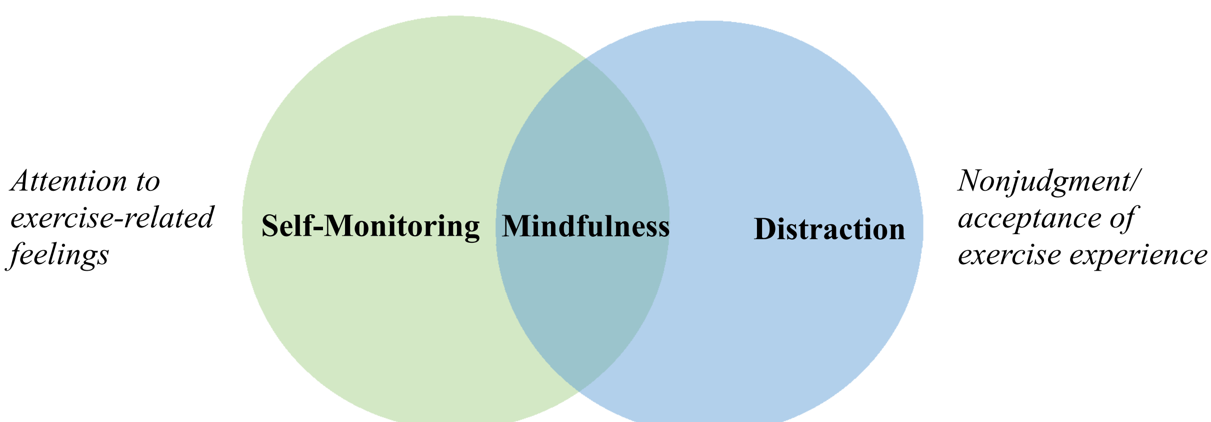
Randomization and intervention outline. After the Talk Test, the research assistant consulted a random numbers list to assign the participant to their study condition, and switched to the corresponding script for the assigned condition. The general text and outline of the scripted procedures were the same across intervention conditions, except for the specifics of the strategies to be used, which are described in the subsections below.

First, participants were told that they had just been randomly assigned to condition. Participants in each condition were told that their condition was a "technique for improving our emotional response to everyday life experiences that we are examining as a strategy to enhance the experience of exercise." Participants were told that when people exercise at a moderate-to-vigorous intensity, their internal experience might feel unpleasant, and that their assigned strategy would be used to address that feeling.

Next, the skills the participants were to use under each condition were explained. Participants were given specific examples of the types of negative thoughts or feelings that might come up while exercising, told how they might apply their assigned strategy when these thoughts arise. These skills were practiced with a demonstrative exercise, developed for an ACT exercise intervention and modified for each condition in the current study (Stevens, 2016). Participants were asked to hold their legs out in front of them, and not put them down until they were told that they could (about 60 seconds). The research assistant then guided the participant toward applying their assigned strategy to the experience of holding their legs out, as a parallel to negative sensations one might experience during cardiovascular exercise. At the end of this brief intervention, participants were told that they would apply the strategy they just learned while exercising for 30 minutes.

Mindfulness condition. In the mindfulness condition, participants were told to bring their attention to the present moment while exercising, including noticing how their body feels, focusing on their breathing, or being aware of the thoughts that arise. Participants were told to do their best to experience these sensations and feelings without judging them, through the process of observing their thoughts with distance while exercising rather than distracting away from them. They were taught that they could label their thoughts, feelings, and sensations while exercising, (i.e., “Part of me is noticing the urge to slow down”). During the “legs up” exercise, participants were guided to notice their thoughts, sensations, and urges. It was emphasized that having similar negative thoughts and sensations while exercising was normal, but that it does not mean that one has to stop exercising. Thus, the goal of the mindfulness intervention condition was to train participants to 1) bring their attention *toward* feelings and sensations experienced while exercising; and 2) *accept* the exercise experience with *nonjudgment* (See Figure 1).

Figure 1. *Conceptual overlap and distinctions between the three study conditions*



Distraction condition. In the distraction condition, participants were told that their strategy was to bring their attention *away* from their experience while exercising, and that they would be doing so by listening to podcasts while exercising[1]. Podcasts were chosen as a method of distraction for this study because they are portable with a mobile device and therefore could be used while exercising both indoors or outdoors (compared, for example, to watching television, which one can only do if one is exercising in a gym), as well as free to access (compared, for example, to audiobooks). Participants were told that if they begin to feel fatigued during exercise, they should remind themselves to focus on the distraction instead. During the "legs up" demonstration, the research assistant played a song on a study iPod, and told the participant to pay attention to the song, and focus their attention away from the experience of holding out their legs. At the end of this intervention condition, participants were asked to choose from one of three pre-selected podcast episodes on the study iPod to listen to while exercising. Summaries of the episode content were provided to participants. The episode choices (*Science Vs.:* "Forensic Science"; *Reply All:* "Is Facebook Spying on You?"; *How I Built This*: "John Zimmer: Lyft") were selected on the basis that they were approximately 30 minutes in length, of subject matter with wide appeal, and interesting enough to be distracting while at the same time not especially affectively-laden (such that the affective content of the episode would not be transferred to exercise-related affect). Thus, the goal of the distraction intervention condition was to train participants to 1) bring their attention *away* from feelings and sensations

[1] Importantly, for this study, we chose not to use music as distraction while exercising. A great deal of research examines how listening to music affects the exercise experience (Bird et al., 2016; Calik-Kutukcu et al., 2016; Chow & Etnier, 2017; Elliott, Carr, & Orme, 2005; Hutchinson et al., 2015; Karageorghis & Jones, 2014; Potteiger, Schroeder, & Goff, 2000). Importantly, this literature finds that music is motivational during exercise; however, it seems unclear whether music is effective in enhancing the exercise experience because it is a *distraction* from exercise, or because it helps individuals tune in with biological factors during exercise as well (i.e., feeling their heartbeat sync up to the beat of the music, or running to the pace of the music), or both. Given that, it is difficult to think of music as a pure "distraction" from exercise; thus, to not confound these factors (and to test the effectiveness of other distractions besides music), we will request participants use other forms of distraction for this study.

experienced while exercising; and 2) (by doing so) *refrain from judging* the experience (see Figure 1).

Associative focus condition. Participants were told that the name of the strategy for associative focus condition was “Self Monitoring”. Similar to the mindfulness condition, participants in the associative focus condition were told to bring their attention to their experience while exercising. However, in contrast to the mindfulness condition, participants in this condition were not taught strategies to refrain from judging their affective experience or act as a distant observer of the experience. Instead, in this condition we encouraged participants to judge and ruminate on their affect experience, in order to provide a strong juxtaposition to the mindfulness condition. Participants were told to “turn up [their] internal monologue of sensations and desires” while exercising, including saying to themselves “I want to stop” or “My legs are burning” if fatigue sets in during exercise. Thus, the goal of the associative focus intervention condition was to train participants to 1) bring their attention *toward* feelings and sensations experienced while exercising; and 2) *judge and/or ruminate* on the experience (see Figure 1).

Exercise bout. Once participants finished their assigned intervention, they began the 30-minute exercise bout. While still wearing their heart rate monitor, participants warmed up on the treadmill at the same speed and incline as the last stage of their Talk Test until they reached the heart rate that was determined during the test. The point at which they reached this heart rate was designated as minute 0 and the 30-minute timing began. Responses to the FS, FAS, and RPE scales were recorded at 0, 10, 20, and 30 minutes. In addition, participants were given scripted reminders to use their strategy at specific intervals during the bout (at 5, 15, 25 minutes). Participants’ heart rates were monitored during the bout and speed and incline were adjusted if needed to ensure that their heart rates remained in the prescribed range. At the 30-minute mark, final measures were taken, and participants were told that the exercise bout was over, and that they could cool down for a few minutes as desired.

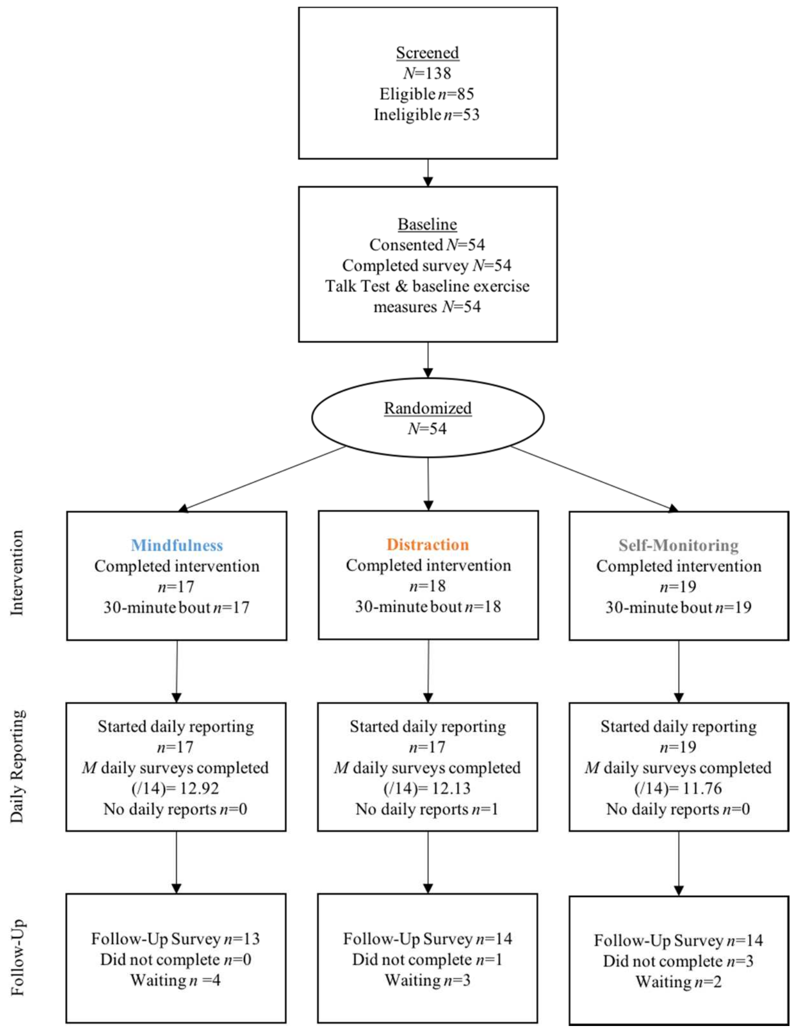
Manipulation check. After participants were finished cooling down from the exercise session, they completed the manipulation check items.

Explanation of two-week intervention. The laboratory session ended with an explanation of the two-week self-administered exercise "assignment". Participants were all given the same instructions, except those specific to their condition assignment. Participants were told that they should try to exercise 150 minute per week for the next two weeks. They were told that this specific minutes-per-week goal was chosen because it represents national guidelines for minimum cardiovascular exercise engagement. Participants were told to try and exercise at the same intensity as they did during their exercise session in the lab, and that they could think of the Talk Test as a guideline for determining intensity. In addition, to keep their form of exercise consistent with their supervised exercise session in the lab, participants were told that they should walk, jog, run, or hike as exercise. Participants in the mindfulness and associative focus conditions were told to avoid distractions like music, podcasts, or television while exercising, while participants in the distraction condition were told to listen to a podcast every time they exercised for the next two weeks.

Two-week intervention period. During the two-week intervention, at 6am each morning, participants were sent a short email with a reminder and tip about using their assigned strategy if they exercise that day. This email also included a link to the daily survey measure and instructed participants to fill it out after they exercise that day (if they were planning on exercising), but they were also told to fill out the survey even if they did not exercise. On the last day of the two-week period, participants were also sent a separate email with a link to the follow-up survey.

Figure 2 represents the flow of participants across the study phases. Of the 54 participants who came in for the study visit, 41 had completed the daily reporting and follow-up survey at the time of analysis.

Figure 2. *CONSORT Diagram: Flow of participants across study phases*



Note. This diagram depicts participant flow across study phases. At the time of analysis, 54 participants began the study and started daily reporting. Means for daily surveys completed are calculated using only the participants who had finished the 14-day period. Participants listed as “Waiting” for follow-up had not yet reached the end of the 14-day follow-up period at the time of analysis.

Results

Baseline Characteristics

We first examined whether any of the psychosocial predictors of exercise behavior (i.e., TPB measures, distress tolerance, and trait mindfulness measures) differed by condition at baseline. Baseline descriptive statistics for these measures and *F*-tests for condition differences are presented in Table 3 (below). There were no significant differences on the baseline survey measures by condition (all p's >.15).

Talk Test and Baseline Affect

The average heart rate range determined by the Talk Test was 145.17 beats per minute (bpm) (*SD*=21.22). Thus, at the mean level, participants were exercising in a heart rate range corresponding to the lower end of vigorous intensity exercise for this age group. Predicted maximum heart rate for the average age in the sample is 195 bpm (using the formula 220-age to estimate maximum heart rate), and moderate-intensity exercise corresponds to 50-70% of maximum heart rate, or 97.5-136.5 bpm, while vigorous-intensity exercise corresponds to 70-80% of maximum heart rate, or 136.5 to 165.75 bpm (CDC, 2015). Thus, using the Talk Test method to approximate VT led participants to exercise in the intensity range of interest to the current study. However, the standard deviation of 21.61 does demonstrate a decent amount of variability in the intensities that participants were exercising at, spanning both moderate and vigorous intensities across participants, and importantly, as exercise intensity increases from more moderate to more vigorous, the literature shows that subjective response to exercise also changes, such that exercise feels more difficult and affect is worse (Panteleimon Ekkekakis, Hall, & Petruzzello, 2008b; Panteleimon Ekkekakis, Parfitt, & Petruzzello, 2011b). For this reason, in some of the subsequent analyses examining response to the 30-minute exercise bout, we include heart rate as a covariate, as we were interested in variation in *subjective* response to physical activity as the result of our manipulations, *holding objective intensity constant*.

In order to check that exercise intensity as determined by the Talk Test did not differ across condition, we conducted a one-way ANOVA with Talk Test heart rate as the dependent variable and condition as the independent variable. We observed no significant differences in heart rate by condition, $F_{2, 51}$=0.33, p=.72. We also observed no significant condition differences in the subjective response measures (FS, FAS, and RPE) measured after the Talk Test, before randomization to condition (FS: $F_{2, 51}$=0.99, p=.38, FAS: $F_{2, 51}$=0.91, p=.40, RPE: $F_{2, 51}$=0.87, p=.42).

Manipulation Check

In order to examine whether participants complied with instructions regarding the strategies they were taught, we examined responses to the manipulation check. We first computed an average for the first two items of the manipulation check to create an average "observed" score, where higher scores represent that participants responded that they were attending to the feelings and sensations caused by exercise. We also computed an average for the second two items of the manipulation check to create an average "distracted" score, where higher scores represent that participants responded that they attended to something other than exercise. We then examined differences in these two averages by condition, in two one-way ANOVA models. As expected, we found that participants in the mindfulness and self-monitoring conditions reported that they observed the exercise experience significantly more, $t(51)=5.57$, $p<.001$, and distracted significantly less, $t(51)=-7.53$, $p<.001$, than those in the distraction condition (see Figure 3).

Figure 3. *Manipulation Check Results*

Note. Bars represent means for the manipulation check scales by condition with standard error bars. The "observed" subscale is created with the average of the items "I observed the exercise experience closely" and "I paid close attention to the physical sensations caused by exercise", scored on a Likert scale from 1 to 7. The "distracted" subscale is created with the average of the items "I tried to stay focused on something other than my exercise experience" and "I concentrated on other things rather than the exercise experience", scored on a Likert scale from 1 to 7.

Planned Analyses to Address Aim 1: Acute Exercise Response during Laboratory Session

The first aim of the study was to examine the effect of the three conditions on affect, arousal, and RPE during the acute exercise bout. These analyses involved one within-subjects factor (**time**: 4 repeated measures of affect, arousal, or RPE within each session) and one between-subjects factor (condition). We conducted these analyses using three mixed effects models (one for each dependent variable), examining 1) average levels of the dependent variable; 2) linear change of the dependent variable over the course of the session; 3) quadratic change of the dependent variable over the course of the session; and 4) the interactions of these within-subjects factors with condition, which was contrast coded to compare a) first, the mindfulness and distraction conditions to the associative focus condition (to address **Hypothesis 1**, that FS scores would be higher and FAS/RPE scores would be lower for the mindfulness and distraction conditions compared to the self-monitoring condition); and b) second, the mindfulness and distraction groups to each other (to address **Hypothesis 2**, that FS scores would be higher and

FAS/RPE scores would be lower for the mindfulness compared to the distraction condition). We also included heart rate (mean-centered) during the exercise session as a covariate in these models. We note where significance values change notably if heart rate is not included in the model.

Also to address the first aim, we examined the effect of the three conditions on affect, arousal, and RPE during the acute exercise bout, *relative to* each participant's baseline scores on affect, arousal, and RPE during the Talk Test. To do this, we computed change scores representing each participant's average change on each dependent variable relative to their Talk Test score by subtracting their Talk Test score for the dependent variable from the average of their scores at minutes 0, 10, 20, and 30 during the 30-minute bout. We then conducted one-way ANOVAs examining the change scores as a function of condition. Results from these planned analyses are presented below.

30-minute bout.

Affective Valence: FS. Figure 4 presents means for the FS during the bout by condition. In the mixed effects model predicting FS scores throughout the 30-minute exercise bout from linear and quadratic time, condition, and their interactions, controlling for heart rate, we found a trend toward a linear effect for time, such that affective valence decreased throughout the course of the bout across conditions, $t(51)=1.75$, $p=.09$. There was not a significant quadratic effect of time, $t(51)=1.22$, $p=.23$.

We also observed an overall condition difference for average affective valence throughout the bout; the contrast comparing the mindfulness and distraction conditions to the self-monitoring condition was marginally significant $t(50)=1.98$, $p=.053$[2], such that affective

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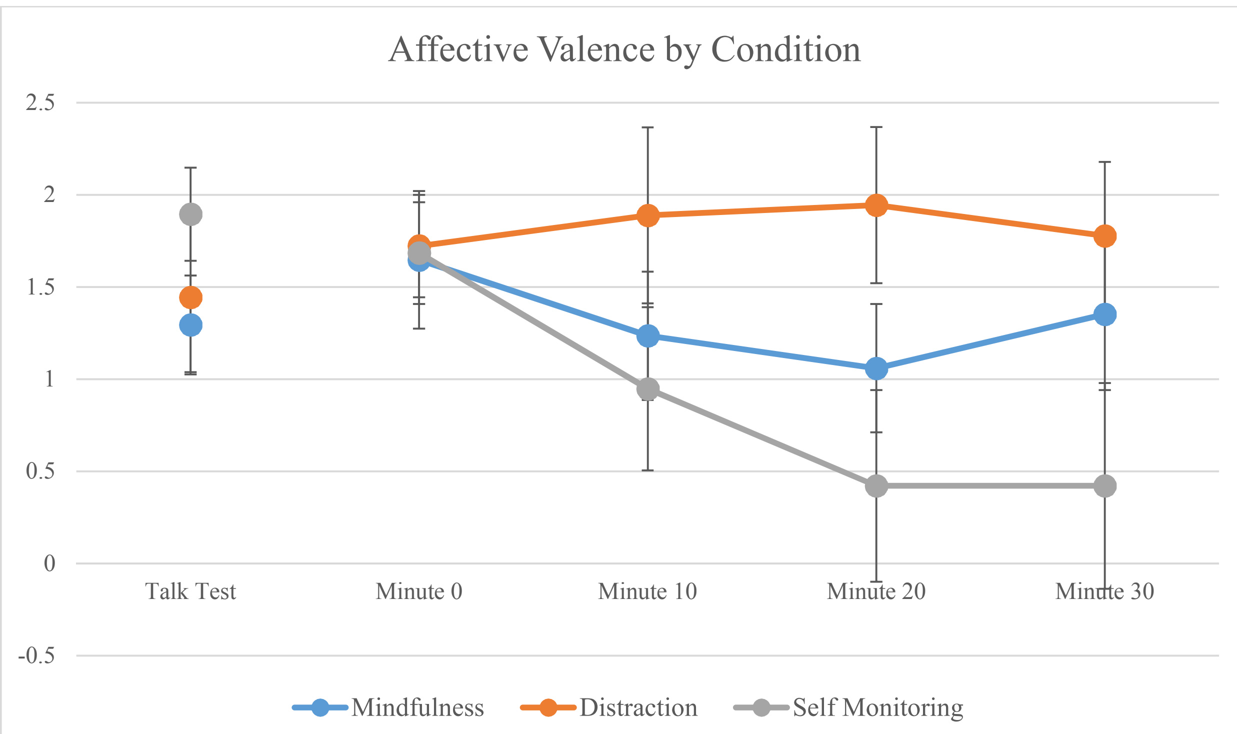
[2] When heart rate is not controlled, this effect moves from marginally significant to trending, p=.08.

valence was higher overall in the mindfulness and distraction conditions. The mindfulness and distraction conditions were not significantly different from each other $t(50)=1.19$, $p=.24$.

There was one marginally significant condition by time interaction in this model: the linear slope of affect was less negative in the mindfulness and distraction conditions compared to the self-monitoring condition $t(51)=1.90$, $p=.063$.

The covariate, heart rate, was marginally significant in this model, such that as heart rate increased, affect was lower throughout the bout $t(50)=1.91$, $p=.061$.

Figure 4. *Affective valence as measured by the Feeling Scale (FS) by condition*

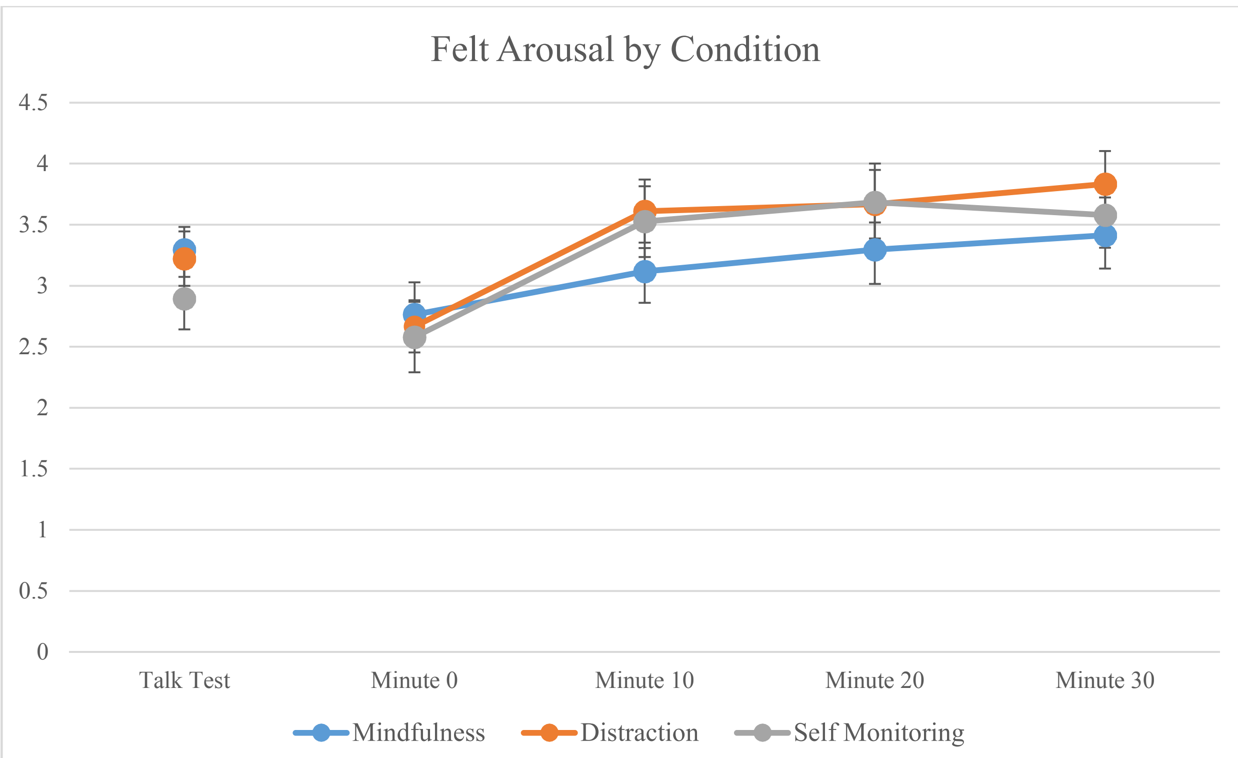


Note. Affective valence as measured by the Feeling Scale (FS) means by condition with standard error bars. The first point represents baseline FS responses by condition, after participants exercised for 5 minutes at the intensity determined by the Talk Test. The intervention took place in between the Talk Test and Minute 0.

Affective Arousal: FAS. Means for affective arousal (FAS) at each measured time point are presented in Figure 5. In the mixed effects model controlling for heart rate, we observed both linear and quadratic effects of time, such that arousal increased over the course of the bout across condition, $t(51)=5.66$, $p<.001$, and this linear increase was qualified by a significant quadratic effect such that this increase in arousal was higher in the middle of the bout, $t(51)=3.78$, $p<.001$.

We did not observe significant condition differences in average levels of felt arousal, nor did we observe any significant time by condition interactions for affective arousal. In this model, heart rate was not significantly associated with arousal, $t(50)=1.28$, $p=.20$.

Figure 5. *Affective arousal as measured by the Felt Arousal Scale (FAS) by condition*



Note. Affective arousal as measured by the Felt Arousal Scale (FAS) means by condition with standard error bars. The first point represents baseline FAS responses by condition, after participants exercised for 5 minutes at the intensity determined by the Talk Test. The intervention took place in between the Talk Test and Minute 0.

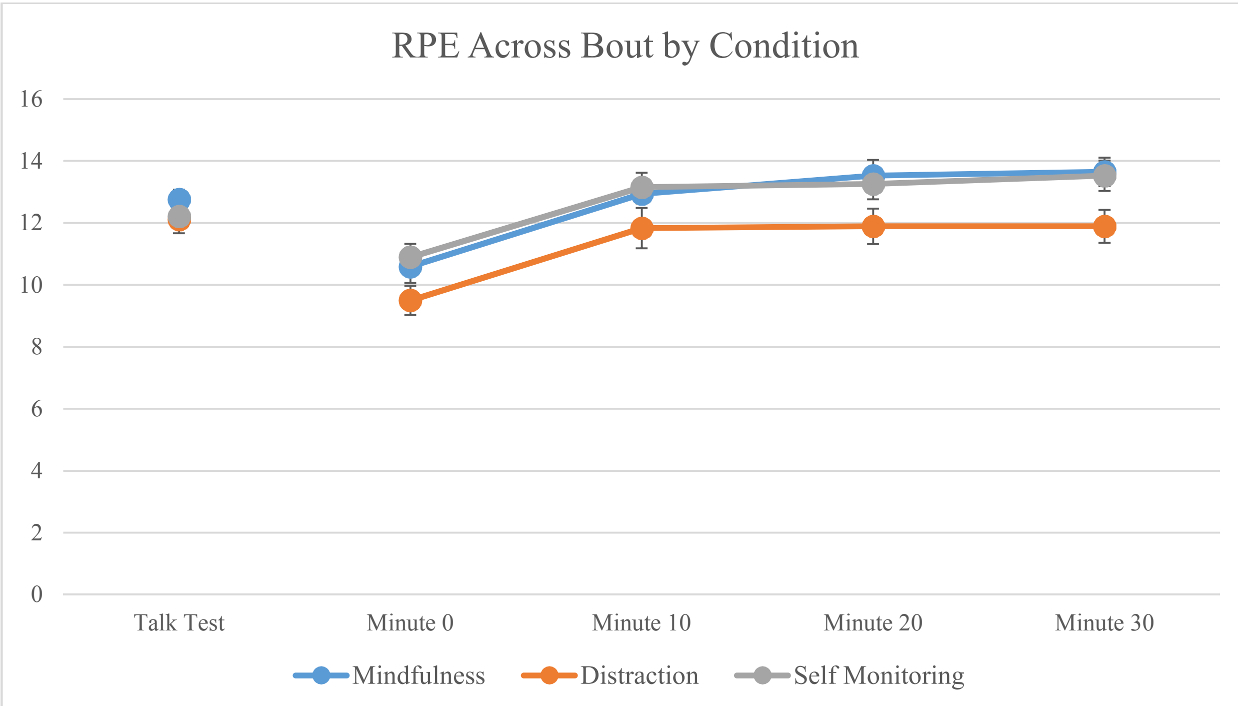
RPE. Means for perceived exertion across time are presented in Figure 6. The mixed effects model for RPE also controls for heart rate; thus, it allows us to look at changes in *perceived* or *subjective* exercise intensity or difficulty over time and by condition, while controlling for *objective* intensity of exercise. In this analysis, we found significant linear and quadratic effects of time, such that RPE increased significantly over the course of the 30-minute exercise bout, $t(51)=7.56$, $p<.001$, and this increase was larger from the beginning to the middle of the bout, $t(51)=6.27$, $p<.001$.

We also observed significant condition differences in perceived exertion. The contrast comparing the mindfulness and distraction groups to the self-monitoring group was significant, $t(50)=2.14$, $p=.04$[3], although this difference seems to have been driven by the relatively lower average perceived exertion in the distraction group relative to the other two groups. The contrast comparing the mindfulness to the distraction group was also significant, such that perceived exertion was higher in the mindfulness group compared to the distraction group, $t(50)=3.01$, $p=.004$. In a follow-up analysis comparing the mindfulness group to the self-monitoring group, we found that average RPE was not significantly different between these two groups, $t(50)=0.310$, $p=.76$.

We did not observe any significant condition by time interactions in this model. Heart rate did significantly predict RPE, such that higher heart rate was associated with greater perceived exertion, $t(50)=4.42$, $p<.001$.

[3] When heart rate is not included in the model, this effect becomes nonsignificant, p=.15.

Figure 6. *Perceived Exertion as measured by the Felt Arousal Scale (FAS) by condition*

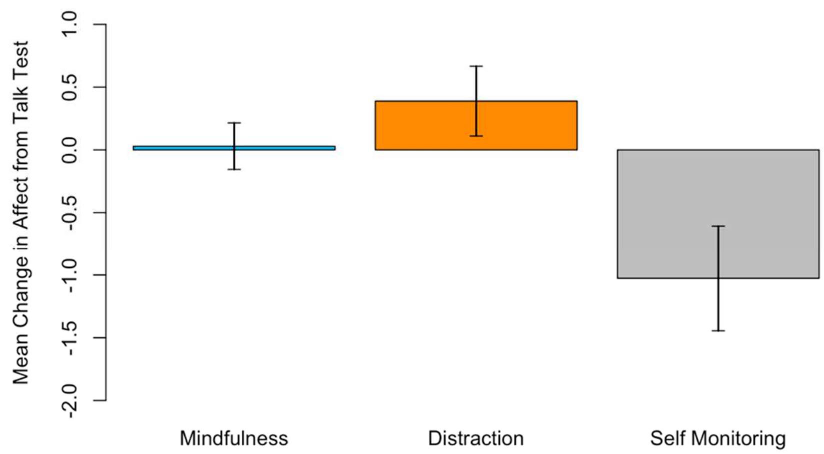


Note. Perceived Exertion as measured by the Rating of Perceived Exertion (RPE) scale means by condition with standard error bars. The first point represents baseline RPE responses by condition, after participants exercised for 5 minutes at the intensity determined by the Talk Test. The intervention took place in between the Talk Test and Minute 0.

Change from Talk Test.

FS. In the ANOVA examining average change in affect from baseline by condition, we observed a significant overall effect of condition, $F_{2, 51}$=5.51, p=.006, Multiple R^2=.18. The self-monitoring condition experienced a stronger decrease in affect from baseline, compared to both the mindfulness and self-monitoring conditions, t(51)=3.1, p=.002. Change in affect was not significantly different for the mindfulness compared to the distraction groups, t(51)=0.79, p=.43. These results are presented in Figure 7.

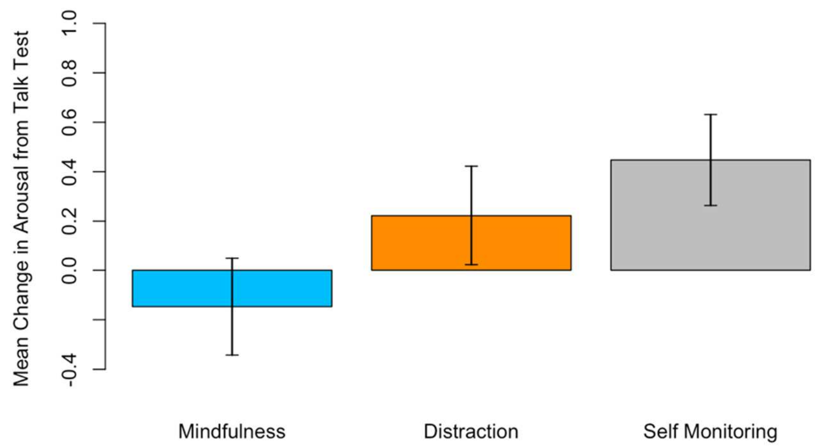
Figure 7. *Change in Affective Valence (FS) scores from baseline by condition*



Note. Change scores were calculating by subtracting baseline affective response as measured by the Feeling Scale (FS) measured after the Talk Test from the average FS across the four time points measured during the 30-minute bout. Mean change scores by condition are presented here, with standard error bars.

FAS. In the ANOVA examining average change in arousal from baseline by condition, there was a trending overall effect of condition, $F_{2, 51}$=2.39, *p*=.10, Multiple R^2=.09. We observed a trend such that the self-monitoring group increased in arousal relative to baseline more than the mindfulness and distraction groups, *t*(51)=1.76, p=.09. The mindfulness and distraction groups were not significantly different from one another, *t*(51)=1.33, p=.19. When examining pairwise group differences in arousal change, we did find that the mindfulness and self-monitoring groups were significantly different from one another, unadjusted *p*=.03. These results are presented in Figure 8.

Figure 8. *Change in affective arousal (FAS) scores from baseline by condition*



Note. Change scores were calculating by subtracting baseline affective arousal as measured by the Felt Arousal Scale (FAS) measured after the Talk Test from the average FAS across the four time points measured during the 30-minute bout. Mean change scores by condition are presented here, with standard error bars.

RPE. In the ANOVA examining average change in perceived exertion from baseline by condition, we observed a significant overall effect of condition, $F_{2, 51}$=4.67, *p*=.01, Multiple R^2=.15. The self-monitoring group increased in RPE from baseline more than both the mindfulness and distraction groups, *t*(51)=2.54, p=.01. There was also a trend such that the distraction group decreased in perceived exertion relative to the mindfulness group, *t*(51)=1.66, p=.10. See Figure 9 for a visualization of these results.

Figure 9. *Change in Perceived Exertion (RPE) scores from baseline by condition*

Note. Change scores were calculating by subtracting baseline perceived exertion as measured by the Rating of Perceived Exertion (RPE) scale measured after the Talk Test from the average RPE across the four time points measured during the 30-minute bout. Mean change scores by condition are presented here, with standard error bars.

Planned Analyses to Address Aim 2: Response Over the Two-Week Intervention

The second aim of the study was to assess the longer-term effect of three cognitive strategy conditions on affective response to exercise, RPE, and exercise volume during a two-week, self-guided, at-home exercise intervention. We specifically predicted that participants in the mindfulness and distraction conditions would exercise for more minutes, experience more positive affect, and report lower RPE over the 2-week intervention than the associative condition (**Hypothesis 3**), and that additionally, participants in the mindfulness condition would exercise more and report more positive affect and lower RPE compared to the distraction condition (**Hypothesis 4**). We again used mixed effects models to address this aim, using exercise volume and frequency, remembered affective response during exercise, and remembered RPE as dependent variables, including a within-subjects factor coding the linear day effect, and between-subjects contrasts (as above) coding condition. With these models, we were able to examine: 1) average levels of the dependent variables, 2) linear trends of the dependent variable over time, and 3) interactions of the linear time effect for the dependent variable with condition[4].

All participants who completed some of the daily measures were included in analyses. Nine participants had not completed all 14 days of reporting at the time of analysis, and thus have missing data for the end of the reporting period. For all participants who had completed the 14-day reporting period, if the participant did not complete the survey on a particular day, for the exercise behavior measures (frequency and minutes of exercise), we made the assumption that the participant had not exercised that day, and coded their behavior as zero.

Behavior Covariates. Alcohol use, cannabis use, and hours of sleep the previous night were included in the daily surveys as potential covariates in these analyses, as each might affect exercise behavior engagement on a particular day. We examined whether this was the case in two mixed effects models, with our exercise behavior measures as dependent variables and alcohol use, cannabis use, and sleep as independent variables.

The number of minutes exercised on a particular day were not associated with that day's alcohol use, cannabis use, or previous night's hours of sleep (all *p*'s >.26). However, in a model examining the binary outcome of whether or not an individual had exercised on a particular day, we found a significant association such that, controlling for alcohol use and hours of sleep, if a participant reported having used cannabis, they were less likely to have exercised that day (z=-2.01, p=.04. Therefore, in the subsequent analysis examining exercise frequency as a dependent variable, we examined our effects of interest both with and without controlling for cannabis use.

[4] We also ran models that included a quadratic day effect, as we anticipated that the effect of our manipulation might have more than just a linear effect over time. However, no quadratic effects or quadratic time by condition interactions were significant, and leaving them out of the models did not change any of our results. Thus, for simplicity's sake, we present models examining only linear effects of time and linear time by condition interactions.

Dependent variable: exercise frequency. Our first primary outcome of interest was the frequency of exercise behavior over the 2-week at-home exercise intervention. This dependent variable was coded as 0 if the participant did not exercise and 1 if the participant did exercise on a particular day. We then examined this outcome variable as a function of condition and linear day using a mixed effects logistic regression model.

There was no significant effect of time in this model; participants across condition did not exercise more over time. While at a mean level, participants in the mindfulness and distraction conditions exercised more often than those in the self-monitoring condition (M=53.0% of days for the mindfulness condition and M=51.2% of days for the distraction condition compared to M=42.74% of days for the self monitoring condition), this difference was not significant, z=1.26, p=.21. There was no difference in exercise frequency between the mindfulness and distraction conditions, z=.36, p=.71. The condition by time interactions were not significant.

Controlling for cannabis use in this model did not meaningfully change our results.

Dependent variable: minutes of exercise. Our second outcome of interest was exercise behavior measured in the number of minutes exercised per day. In the linear mixed effects model with minutes of exercise as a dependent variable, we found that across conditions, participants did not exercise for more minutes per day over time, $t(47.81)=0.85$, p=.40. We also observed no condition differences in the average minutes exercised (mindfulness/distraction vs. self-monitoring $t(49.33)=.776$, p=.44; mindfulness vs. distraction $t(50.02)=.415$, p=.68) and no condition by time interactions. On average, across condition and time, the model estimated intercept for minutes exercised per day was 21.09 minutes, corresponding to 147.63 minutes per week, just under the intervention's stated "goal" number of minutes of 150 minutes per week.

Dependent variable: remembered affect during exercise (FS). We also examined whether participants' remembered affect during exercise changed over time and/or as a result of condition. There was no significant linear effect of time on affect during exercise, $t(23.73)=0.66$, $p=.51$, nor were there condition effects on average remembered affective response during exercise throughout the 2-week intervention (mindfulness/distraction vs. self-monitoring $t(39.67)=.51$, $p=.61$; mindfulness vs. distraction $t(39.83)=.35$, $p=.73$). Finally, condition was not related to whether or not affect changed over time throughout the intervention.

Dependent variable: RPE during exercise. Finally, we were interested in the effects of our conditions on perceived exertion during exercise, both on average and over time. In the model predicting RPE from condition, time, and their interaction, we found a significant linear effect of day, such that participants reported that exercise felt significantly *more* difficult over time, $t(31.56)=3.06$, $p=.005$. On average, RPE in the mindfulness and distraction conditions was not significantly different from RPE in the self-monitoring condition, $t(45.00)=.52$, $p=.60$. However, average RPE in the mindfulness condition was significantly higher than RPE in the distraction condition, $t(45.13)=2.03$, $p=.048$. The condition by time interactions were not significant in this model, however, we did observe a trend such that the linear day slope was stronger in the mindfulness condition compared to the distraction condition, $t(31.25)=1.44$, $p= 0.16$, or in other words, exercise felt more difficult over time more steeply in the mindfulness versus distraction condition.

Additional analyses related to Aim 2. Two important questions, both practically (from an interventionist standpoint) and to further understand our effects, concerned whether participants 1) found a particular strategy more easy to use, as well as whether participants 2) used their assigned strategy relatively more or less during the at-home intervention depending on what the strategy was.

To examine the first question, we examined participants' responses to the daily survey question "How easy or difficult did you find it was for you to use your strategy today?" (rated on a Likert scale from 1=Very Difficult to 7=Very Easy) by condition, linear time, and their interaction. We found that on average, participants in both the mindfulness and distraction conditions reported that it was easier to use their strategy compared to the self-monitoring condition, $t(42.15)=2.75$, $p=.009$, but participants in the mindfulness condition found it more difficult to use their strategy compared to participants in the distraction condition, $t(42.24)=2.35$, $p=.02$. There was no significant effect of day on the ease of using the strategy (i.e., strategies did not become easier to use as time went by), and no significant time by condition interactions.

To examine the second question, we examined whether the percentage of time participants reported using their strategy during a particular day's exercise session was related to condition, time, or their interaction. Similarly as above, on average, participants in both the mindfulness and distraction conditions reported using their strategy during a larger percentage of the time exercising compared to the self-monitoring condition, $t(39.93)=3.00$, $p=.005$, and participants in the mindfulness condition used their strategy less of the time compared to participants in the distraction condition, $t(40.05)=4.02$, $p<.001$. Directionally, participants reported using their strategies more over time, however, this trend was not statistically significant, $t(26.74)=1.52$, $p=.14$, and did not differ by condition.

Planned Analyses to Address Aim 3: Change in Psychosocial Predictors of Exercise

The third aim, which was exploratory, was to examine whether the three strategies changed psychological predictors of exercise behavior, including TPB predictors (attitudes, norms, self-efficacy, and intentions to exercise) and other correlates of exercise behavior (e.g., distress tolerance) after the two-week exercise intervention. Specifically, we hypothesized that participants in the mindfulness condition would show significant increases in these psychological measures over time relative to the distraction condition (**Hypothesis 5**). To examine this question, we created change scores for the TPB predictors, distress tolerance, and mindfulness measures (follow-up scores minus baseline scores) and examined whether those change scores differed by condition using ANOVA models, with the same planned condition contrasts outlined above. Mean levels of change on these measures, overall and by condition, and results of the *F*-tests are presented in Table 3.

TPB predictors. Intentions to exercise did not change significantly from baseline to post-intervention, $t(39)=.05$, $p=.96$, and change in intentions did not differ by condition. Attitudes about exercise significantly increased from baseline to post-intervention, $t(39)=2.04$, $p=.048$; change in attitudes did not differ significantly by condition, though we did observe a trend such that change in attitudes was lower in the mindfulness versus distraction conditions $t(39)=1.45$, $p=.15$. There was a trend such that self-efficacy increased over time, $t(39)=1.82$, $p=.076$; this increase did not differ by condition. Finally, we also observed a trend such that norms increased over time, $t(39)=1.74$, $p=.09$, though this increase also did not differ by condition.

PANAS. Positive and negative affect subscales of the PANAS did not change from baseline to posttest, and change did not differ by condition.

Distress Tolerance (DIS). Scores on the DIS did not change from baseline to posttest, and change did not differ by condition.

State Mindfulness.

FFMQ. Scores on the observe and describe subscales of the FFMQ did not change over time nor by condition. Scores on the act with awareness subscale of the FFMQ decreased significantly over time, $t(38)=2.96$, $p=.005$, though this decrease did not differ by condition. There was a trend such that scores on the nonjudge subscale of the FFMQ increased over time, $t(36)=1.73$, $p=.09$, but did not differ by condition. Finally, we observed one time by condition interaction such that scores on the nonreact scale of the FFMQ decreased more over time for participants in the mindfulness condition relative to the distraction condition, $t(37)=1.83$, $p=.08$.

PHLMS. Scores on the awareness and acceptance subscales of the PHLMS did not change over time nor by condition.

MAAS. Finally, we found that participants in the mindfulness condition significantly *decreased* in their scores on the MAAS from baseline, relative to the distraction condition $t(37)=2.14$, $p=.04$.

Table 3. *Psychosocial Predictors of Exercise: Baseline and Change at Follow-Up*

	Baseline					Change from Baseline				
	Overall *M* (*SD*)	Mindfulness *M* (*SD*)	Distraction *M* (*SD*)	Self Monitoring *M* (*SD*)	*F* test for condition differences	Overall *M* (*SD*)	Mindfulness *M* (*SD*)	Distraction *M* (*SD*)	Self Monitoring *M* (*SD*)	*F* test for condition differences
Intentions	4.83 (1.42)	4.66 (1.51)	4.84 (1.50)	4.98 (1.31)	$F_{2,52} = 0.223$	0.01 (1.29)	0.05 (1.01)	-0.11 (1.36)	0.10 (1.49)	$F_{2,52} = 0.103$
Norms	5.08 (0.85)	5.03 (0.68)	5.01 (1.04)	5.19 (0.82)	$F_{2,52} = 0.232$	0.18 (0.68)	0.30^{+} (0.56)	0.10 (0.74)	0.16 (0.75)	$F_{2,52} = 0.307$
Attitudes	2.65 (1.08)	2.53 (1.08)	2.61 (0.82)	2.81 (1.30)	$F_{2,52} = 0.337$	0.34 (1.08)	0.14^{*} (1.29)	0.74 (1.14)	0.13 (0.73)	$F_{2,52} = 1.473$
Self-Efficacy/PBC	4.84 (1.07)	4.85 (0.92)	4.83 (0.89)	4.85 (1.37)	$F_{2,52} = 0.001$	0.26 (0.89)	0.23^{+} (1.14)	0.31 (0.79)	0.22 (0.78)	$F_{2,52} = 0.041$
PANAS Positive	25.24 (8.14)	24.65 (8.11)	25.44 (7.89)	25.58 (8.80)	$F_{2,52} = 0.065$	-0.9 (9.71)	-1.92 (11.93)	1.07 (8.77)	-1.87 (8.77)	$F_{2,52} = 0.423$
PANAS Negative	12.96 (3.05)	13.06 (3.27)	13.50 (3.76)	12.37 (1.98)	$F_{2,52} = 0.638$	0.52 (4.73)	1.08 (6.05)	0.64 (2.73)	-0.07 (5.15)	$F_{2,52} = 0.202$
DIS	3.08 (0.94)	3.18 (1.01)	2.99 (1.09)	3.08 (0.75)	$F_{2,52} = 0.162$	0.08 (0.75)	-0.08 (0.88)	0.21 (0.52)	0.08 (0.83)	$F_{2,52} = 0.499$
FFMQ: Observe	3.4 (0.66)	3.3 (0.78)	3.4 (0.54)	3.5 (0.66)	$F_{2,52} = 0.364$	0.04 (0.49)	0.06 (0.61)	0.04 (0.51)	0.01 (0.31)	$F_{2,52} = 0.026$
FFMQ: Describe	3.5 (0.81)	3.82 (0.51)	3.38 (0.88)	3.33 (0.93)	$F_{2,52} = 1.914$	-0.08 (0.55)	-0.09 (0.41)	-0.11 (0.59)	-0.06 (0.65)	$F_{2,52} = 0.026$
FFMQ: Awareness	3.44 (0.76)	3.51 (0.79)	3.46 (0.56)	3.35 (0.91)	$F_{2,52} = 0.204$	-0.3^{**} (0.65)	-0.50 (0.90)	-0.16 (0.45)	-0.24 (0.53)	$F_{2,52} = 0.991$
FFMQ: Nonjudge	3.46 (0.92)	3.51 (0.84)	3.49 (1.01)	3.37 (0.95)	$F_{2,52} = 0.122$	0.17^{+} (0.58)	0.19 (0.77)	0.16 (0.45)	0.15 (0.54)	$F_{2,52} = 0.020$
FFMQ: Nonreact	3.09 (0.68)	3.17 (0.78)	3.10 (0.56)	3.01 (0.72)	$F_{2,52} = 0.238$	-0.03 (0.51)	-0.27 (0.45)	0.07 (0.54)	0.10 (0.48)	$F_{2,52} = 2.350$
PHLMS: Aware	3.53 (0.61)	3.54 (0.70)	3.61 (0.47)	3.44 (0.65)	$F_{2,52} = 0.329$	-0.09 (0.46)	-0.15 (0.64)	-0.04 (0.36)	-0.07 (0.39)	$F_{2,52} = 0.197$
PHLMS: Accept	3.11 (0.73)	3.00 (0.70)	3.27 (0.79)	3.05 (0.69)	$F_{2,52} = 0.684$	-0.05 (0.46)	-0.14 (0.60)	0.01 (0.46)	-0.03 (0.31)	$F_{2,52} = 0.359$
MAAS	3.71 (0.7)	3.79 (0.6)	3.73 (0.7)	3.61 (0.8)	$F_{2,52} = 0.298$	-0.11 (0.61)	-0.43 (0.69)	0.05 (0.54)	0.00 (0.52)	$F_{2,52} = 2.66^{+}$

Note. $^{**}p<.01$, $^{*}p<.05$, $^{+}p<.10$. Symbols next to means in the "Overall" column for change scores indicate significant or trending change from baseline to post-test, across condition; symbols in the *F* test columns indicate significant condition differences.

Discussion

In this study, we examined strategies to improve people's subjective responses to moderate-to-vigorous intensity exercise, with the ultimate goal of identifying ways to help individuals increase and maintain their cardiovascular exercise behavior over the long term. We were specifically interested in comparing whether mindfulness versus distraction would lead to improvements in acute response to cardiovascular exercise during a supervised exercise session where subjective response was assessed several times throughout the bout, as well as longer-term response during a two-week at-home intervention. We also compared mindfulness and distraction to an associative or "self-monitoring" condition, in which participants monitored their present-moment experience while exercising, but without learning the fundamental mindfulness skills of acceptance and nonjudgment.

Overview of main outcomes

Overall, we hypothesized that, when comparing mindfulness and distraction to self-monitoring, both mindfulness and distraction would improve subjective response to exercise (both during the acute exercise bout and over the long-term) relative to self-monitoring, but that the mindfulness group would have better subjective response to exercise, as well as more exercise behavior during the two-week intervention, compared to the distraction group. Our hypotheses were partially supported.

The first set of hypotheses concerned **Study Aim 1**, which examined the effects of using one of the three strategies during a 30-minute supervised exercise bout where subjective response to exercise (affective valence as measured by the FS; affective arousal as measured by the FAS; and perceived exertion as measured by the RPE scale) was measured repeatedly throughout the bout. In terms of affective valence (FS), **Hypothesis 1** was supported in that participants in the mindfulness and distraction groups had more positive affect on average, and less of a decline in affect over time (both from baseline and throughout the bout), during the 30-minute exercise bout compared to the self-monitoring group. However, contrary to **Hypothesis 2**, we did not find that the mindfulness group had significantly more positive affect compared to the distraction group; in fact, at the mean level, the distraction group had higher positive affect than the mindfulness group, though these groups were not significantly different from one another. Additionally, we found that the three groups did not differ in their affective arousal throughout the 30-minute exercise bout, though we did find that, when examining change in affective arousal from baseline, there was a trend such that the self-monitoring group increased in arousal relative to both the mindfulness and distraction groups, and that pairwise, the mindfulness group (which slightly decreased in arousal over time) was different from the self-monitoring group (which increased in arousal over time), a finding that is in partial support of **Hypothesis 1.** Finally, concerning perceived difficulty during the exercise bout, we found that the distraction group reported lower perceived exertion compared to both the mindfulness and self-monitoring groups, a finding that is in partial support of **Hypothesis 1** but contrary to **Hypothesis 2**.

While these outcomes were contrary to our hypothesis that mindfulness would create the most subjective response to exercise, it is not surprising that distraction was an effective technique to improve subjective response to exercise in nonregular exercisers, as this has been previously demonstrated in the literature (Baños et al., 2016; Calik-Kutukcu et al., 2016; Lind et al., 2009; Masters, 1992; W. Morgan et al., 1983; Schücker et al., 2016). Additionally, while affective response to the exercise bout in the mindfulness condition was not significantly different, pairwise, from that in the self-monitoring condition in most cases, there was some evidence that mindfulness led to more positive affective response to exercise (i.e., less affective arousal compared to baseline, more positive affective valence, and less of a decline in affective valence over time) compared to self-monitoring. Perhaps especially noteworthy is the fact that the mindfulness and self-monitoring conditions did not differ nearly at all in their perceived exertion while exercising (see Figure 6), yet the mindfulness group's responses to the affective measures (FS, FAS) were slightly more positive from those in the self-monitoring condition, suggesting that the key aspects of mindfulness involving acceptance and nonjudgment of the present moment experience might help individuals reappraise or tolerate the discomfort associated with exercise, and thus experience it as less emotionally or affectively negative.

At the same time, distraction was the best strategy overall for improving subjective experience of exercise. It appears that directing one's attention from the sensations associated with exercise led individuals to perceive the exercise as less difficult or physically intense (even controlling for heart rate, i.e., holding objective intensity constant) and thus, less affectively negative. These findings fall in line with the literature on pain perception, which demonstrates that directing one's attention away from physical discomfort and pain is more beneficial than being mindful to it, which may heighten the experience of pain (Brown et al., 2007). While there was good basis in the literature for us to hypothesize that mindfulness might be a better technique for improving affective response to exercise given its positive relationship with affect and emotion regulation in other contexts (Arch & Craske, 2006; Brown & Ryan, 2003), and because one previous study has demonstrated mindfulness to improve affective response to walking relative to control (Cox et al., 2018), no other studies that we know of have examined mindfulness as a strategy to improve affective response to higher-intensity cardiovascular exercise (a less inherently positive affective experience than walking; Ekkekakis et al., 2011), nor has anyone else directly compared mindfulness to distraction as techniques to improve affective response to exercise.

Our second set of hypotheses concerned **Study Aim 2**, in which we examined the longer-term effects of the three strategies during a two-week at-home intervention where participants used mindfulness, distraction, or self-monitoring while exercising on their own. Contrary to both **Hypothesis 3** and **Hypothesis 4**, we found no condition differences on minutes exercised during the intervention, number of times exercised throughout the intervention, or daily remembered affective valence during exercise. In partial support of **Hypothesis 3**, but contrary to **Hypothesis 4**, we did find that participants in the distraction condition reported lower perceived exertion during their exercise sessions throughout the intervention compared to participants in the mindfulness condition. Notably, we did find that participants in the distraction condition reported that they used their strategy for a larger percentage of the time during each reported exercise session, and found it easier to use their strategy, compared to both the mindfulness and self-monitoring conditions.

The fact that we did not observe differences in exercise behavior across conditions could be explained by the fact that we gave our participants a specific goal to meet for their exercise behavior (150 minutes per week, minimum), and that participants, regardless of condition, apparently strove to meet that goal but not to exceed it. The fact that, on average and across condition, participants met this goal almost exactly (147.63 minutes per week) is consistent with this explanation. However, we did inform participants that this goal was intended to be a recommended *minimum* and that they could exceed it, so the opportunity was still there for condition differences to arise.

The fact that mindfulness did not improve subjective response to exercise during the two-week intervention was contrary to our expectations, particularly because we thought there was good reason to think that mindfulness might be a useful strategy, *especially* over the longer-term, as it might allow people to notice the nuances of their exercise experience and related thoughts (i.e., "That didn't feel as bad as I thought it might!") and thus facilitate more exercise behavior over time. However, it is also not entirely surprising that distraction was more effective in improving subjective response to exercise (specifically, lower perceived exertion) in this context as well, since as discussed above, there is a literature base demonstrating that dissociation is associated with more positive subjective response to physical activity, including lower RPE in nonregular exercisers (Brick, MacIntyre, & Campbell, 2015; Lind et al., 2009; W. Morgan et al., 1983).

Finally, **Study Aim 3** examined the effects of the three strategies on psychosocial predictors of exercise behavior, including Theory of Planned Behavior measures, distress tolerance, and trait mindfulness measures. Contrary to **Hypothesis 5**, we did not observe any condition differences in changes in our psychological measures from baseline to post-intervention, and specifically, we did not find that practicing mindfulness in the context of exercise improved intentions, attitudes, norms, self-efficacy, distress tolerance, or trait mindfulness. In fact, on one of the mindfulness measures, the MAAS, we found significant *decreases* over time in the mindfulness condition relative to the others. It is likely that this effect is conceptually similar to the phenomenon of self-efficacy for exercise *decreasing* over the course of an exercise intervention (e.g., Mailey & McAuley, 2014). Essentially, individuals who lack experience with a behavior overestimate their abilities, and experience a "correction" in their confidence as they gain experience (McAuley et al., 2011). In the case of this study, individuals may have overestimated their capacity for mindfulness and, upon attempting daily mindfulness practice realized they were not as mindful as they believed themselves to be.

In sum, when comparing mindfulness to distraction and self-monitoring as strategies to improve subjective response to exercise, we did not find that mindfulness was the best strategy, as we had predicted. These results suggest that, at least in the context of promoting moderate-to-vigorous intensity exercise in individuals who are currently insufficiently active (and, as far as we know, not experienced mindfulness practitioners), engaging in mindfulness while exercising is not the best recommendation. Research suggests that mindfulness can take substantial practice to have significant effects (Carmody & Baer, 2008; Huppert & Johnson, 2010), and even though the intervention was relatively longer and more intensive than some other mindfulness interventions in the literature, it is possible that learning how to effectively apply mindfulness to improve positive affect in the context of difficult exercise would take much more practice than one laboratory session plus two weeks. It is also possible and even likely that in this context, distraction may simply be a better strategy than mindfulness. Our participants reported that distraction was easier to implement than mindfulness while exercising, and distraction consistently led to better subjective response to exercise. It is increasingly common for exercise machines at gyms to have televisions or other media capabilities, podcasts and audiobooks are easily accessible and portable, and other distractions to use while exercising are likely to gain in popularity as technology improves (e.g., virtual reality, exercise games in mobile applications; Gillman & Bryan, 2015). These facts combined with our results suggest that it may be effective to recommend distraction as a way to manage negative affect during moderate-to-vigorous exercise.

Strengths and Future Directions

This study has several strengths. First, in terms of novelty, this is the first study that we know of that compares multiple strategies, selected for theoretically-driven reasons, to one another directly. We do so in the context of a strong study design, utilizing between-subjects random assignment to condition and comparing our two conditions of interest (mindfulness and distraction) to an active control group (association or self-monitoring). The research assistants who interacted with participants were blind to the study hypotheses, reducing experimenter demand characteristics. We also designed our interventions to be both relevant to the study population and scalable—for example, in the distraction condition, we used podcasts, which are easily accessible and free to anyone with a smartphone or similar portable device. Finally, our population was made up of individuals for whom the research questions are most relevant—since the ultimate goal of this research program is to find strategies to promote greater exercise behavior, testing our hypotheses among individuals who were currently insufficiently active was critical.

In terms of future directions, while we did not observe many significant long-term effects of our intervention in the current study, it would be important to examine whether these strategies work over periods of time longer than two weeks, as long-term exercise behavior maintenance is a crucial issue in health promotion. This is relevant to one of the potential theoretical moderators of the effectiveness of these strategies—exercise experience. That is, it is possible that distraction is a useful strategy to use when initiating an exercise routine, but in terms of longer-term maintenance (>two weeks), mindfulness may help individuals continue exercise over the long term. For example, perhaps the novelty of distraction during exercise might wear off after a few weeks, and strategies such as mindfulness might become more important and effective later in the process of exercise maintenance. Future studies should also examine additional moderators of these effects. For example, at especially high intensities of exercise, research shows that maintaining thoughts unrelated to exercise (e.g., focus on a distraction) might not be possible (Balagué et al., 2015). Perhaps mindfulness would be more effective as a strategy for managing affect associated with exercise only at these high intensities.

Limitations

This study did have some limitations. One major limitation is the demographic makeup of our sample—due to the relative homogeneity of the population of the greater Boulder area, our sample was mostly white, mostly young adult, and mostly female. A more diverse sample over race, age, and economic background would be necessary for improving the generalizability of our results.

Due to lack of funding for the study, we were unable to use a VO_2 max test to estimate VT, and so used the Talk Test procedure instead. While we were able to demonstrate that based on heart rate ranges in our sample, the Talk Test estimated a moderate-to-vigorous intensity of exercise on average, the relative subjectivity of this method to determine exercise intensity meant that the intensities our participants exercised at ranged from the lower end of moderate intensity to the higher end of vigorous intensity, and while we did statistically control for heart rate during exercise in our analyses, more tight control of exercise intensity may have allowed us to better observe the subjective effects of our manipulations.

Another limitation of our study concerns the relatively short maintenance/follow-up period for this study. Due to time restrictions for the research project, a shorter follow-up period was necessary. However, given that our interests lie in understanding longer-term exercise maintenance, understanding the effects of these strategies over months or even years would be an important future step.

The self-report nature of the two-week exercise intervention is another limitation of our study. Again, given funding and time restrictions, obtaining an objective measure (i.e., step count or heart rate monitor data) of exercise behavior during this time was not feasible, but that means that we did have to rely on self-report data, which may be inaccurate or biased. The self-report nature of remembered affect or perceived exertion during exercise is also an issue for a similar reason, as participants may have been reporting how they remembered feeling during exercise several hours after exercising. In future studies it may be useful to use Ecological Momentary Assessment (EMA) in order to get a more accurate measures of actual subjective response during exercise behavior under different conditions. At the same time, remembered affect has been shown to be useful in predicting and understanding exercise behavior engagement (Kwan, Hooper, Magnan, & Bryan, 2011), thus, using retrospective measures of affective response and RPE during exercise are still useful and relevant in this context.

Finally, this dissertation was written with a subset of the full sample of participants to be recruited for this study; thus, our power was lower than desired to test some of the questions we were interested in, particularly those in the follow-up. Recruitment for this study is ongoing and we will eventually have a fully-powered sample to test these effects.

Summary and conclusions

The majority of American adults are insufficiently physically active (Carlson et al., 2010), and variation in affective response to exercise may partially explain levels of inactivity (Kwan & Bryan, 2010a; Rhodes et al., 2009; Williams et al., 2012). Examining ways to improve affective response to physical activity is therefore an important direction for research aiming to promote greater exercise behavior.

Overall, this study has demonstrated that distraction during exercise leads to improved subjective response to exercise behavior, in terms of more positive affect and lower perceived exertion. As more positive affective response to exercise is associated with greater maintenance over the long-term, individuals wishing to increase their cardiovascular exercise behavior would likely do well to find a method of distracting themselves while exercising to make the experience less subjectively intense and more affectively pleasant, and similarly, health providers hoping to motivate insufficiently active individuals to increase their exercise might wish to recommend distraction as a technique to use while exercising. More research is needed in order to confidently recommend mindfulness as a strategy for managing exercise-related affect and improving maintenance of exercise behavior over time.

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Appendix A

Protocol Script: Introduction and Talk Test

Introductions and Welcome (5-10 minutes)

- "Hi, ____Thank you for coming in today! Since this is a standardized research protocol, I am going to be reading from these notes during our session today."
- "The first thing we are going to do is have you sign an informed consent form. This form will explain in more detail what is going to happen in the study, but here is an overview of what to expect today: first, you will fill out an online survey for us. Then we will be doing a short exercise test, which will determine the heart rate range for your exercise session today. After that, we are going to show you a strategy for you to use during your exercise session today and for the next couple of weeks. Once you learn your strategy, you will exercise for 30 minutes while using that strategy as best as you can. After that, we will explain the two-week at home exercise period and then you'll be on your way! Please take your time to read this form thoroughly. [Greg/Arielle/Tim] is here to answer any questions you might have about the form or the study in general."
- *Put participant in the study room. Participant reads and signs Informed Consent form. Greg, Arielle, or Tim will sign the other line on the form ("Person obtaining informed consent").* **Give the participant a copy of the form (unsigned) for their records, and store the other in the locked filing cabinet.**
- "Okay, now, we are going to have you fill out a survey on this computer for us. It should take about 20 minutes. Please let me know if you have any question about the survey."
    - **Log into your email on the lab computer, open the email from Arielle with the participant's link. Open the link and enter their ID number in the first field, then pass it over to them and let them take the survey.**
    - *They take survey.*
- "Thank you for filling out the survey! We will get you ready for the exercise test now."

Talk Test Protocol

- **Heart Rate Monitor Setup and Explanation of Measures:**
    - "Next, we are going to do a short exercise test that is going to determine the heart rate range that we will use for your 30-minute exercise session today. It is called the Talk Test. The reason we call it that is that we are going to gradually increase the intensity during this exercise session, and every couple of minutes we are going to ask you to talk, by having you say the Pledge of Allegiance. Then we are going to ask you how comfortable it was for you to talk at that intensity of exercise. By "comfortable", we mean that you feel almost as if you are carrying on a conversation without exercising. You can answer "yes", "no", or "not sure". This will help us figure out what a moderate-to-vigorous intensity means for you. Do you have any questions?"

- "Do you feel confident that you know the Pledge of Allegiance? If not, you can read it off a cue card."
- "Great. Once you reach the intensity we are looking for, we are going to have you stay at that intensity for 5 minutes. Then we are going to have you rate how you feel with these three questions."
- **Show participant cue cards for Feeling Scale, Felt Arousal Scale, and Rate of Perceived Exertion. Get the set of cue cards for the Talk Test. Read these explanations of the measures below:**

Feeling Scale:

"While participating in exercise, it is common to experience changes in mood. Some individuals find exercise pleasurable, whereas others find it to be unpleasurable. Additionally, feelings may change over time. That is, one might feel good and bad a number of times during the same exercise session.

Please choose the number that best describes how you were feeling on average **IN THE PAST FIVE MINUTES**:"

-5	-4	-3	-2	-1	0	+1	+2	+3	+4	+5
Very Bad		Bad		Fairly Bad	Neutral	Fairly Good		Good		Very Good

Felt Arousal Scale:

"It is also common to experience changes in arousal while exercising. By "arousal" here we mean how "worked-up" you feel. You might experience high arousal in one of a variety of ways, for example as excitement or anxiety or anger. Low arousal might also be experienced by you in one of a number of different ways, for example as relaxation or boredom or calmness.

Please indicate how aroused you felt on average **IN THE PAST FIVE MINUTES:**"

1	**2**	**3**	**4**	**5**	**6**
Low Arousal					**High Arousal**

RPE:

"Last, you will rate the intensity of the past five minutes running on a 6-20 scale. 6 would indicate that you feel no exertion at all, and is what you would rate if you were sitting down not moving. 20 would represent as hard as you could possibly be exercising."

- "Do you have any questions about these measures or the talk test in general?"
- "Okay great! Let's get started. First, we need to put this heart rate monitor on."

  - **Show participant how to put on heart rate monitor, and let them do it. Make sure watch is registering HR correctly.**
- **Begin Talk Test Protocol (Have timer ready):**
  - "Let's have you get on the treadmill."
  - "I am going to start you out walking and then slowly increase the speed." **0% incline: Let participant walk for about 30 seconds, check heart rate monitor to see if it's responding.**
  - "Okay, now we are going to move a little faster." **Speed participant to a fast walk or slow jog; this should be an easy pace!**
  - "Does this feel like an easy pace to you? Right now, you should feel like you could sustain the current pace for a long time."
  - "Okay, great, we are going to start the Talk Test now. First, we will just keep you at this intensity for a few minutes. Since we're following the research protocol, I'm going to request that you talk to me only when I ask you a question, or if it's something important, like a safety concern." **Start timing 4 minutes.**
  - **At 3:30,** "Please say the Pledge of Allegiance now." **When they finish:**
  - "Were you able to speak comfortably?"
  - (If yes): "Alright, we are going to raise the incline of the treadmill up." **Record Heart Rate, Increase 2%, Time 2 minutes**
  - **At 1:30,** "Please say the Pledge again." **When they finish:**
  - "Were you able to speak comfortably?"
  - (If yes): "Okay, thank you." **Record Heart Rate, Increase 2%., Time 2 minutes**
  - **At 1:30,** "Please say the Pledge again." **When they finish:**
  - "Were you able to speak comfortably?"
  - **Continue until the participant gives an equivocal response (yes, but/ not sure, etc.) If no, then slow them down to the previous stage and go again. Record heart rate at equivocal response. Keep them stable at this point.**
  - "Great! You are at the intensity level we'd like you to maintain. We are going to have you exercise here for five minutes so you can get a feel for it. After five minutes, we will have you answer the questions we just talked about."
  - **Time 5 minutes (ensure participant is staying in their heart rate range)**
  - **At 5 minutes, show participants cue cards for FS, FAS, and RPE and record them on your sheet.**
  - "Okay, we're done!"
  - **Slow down treadmill gradually. Offer participant water.**

While participant is getting water, look at random numbers sheet in the filing cabinet and look up what condition they were assigned to. Mark it on your sheet. Then get the corresponding script for that condition and take participants back to the private room for their strategy training.

Appendix B

<u>Mindfulness</u> Protocol Script

<u>Explain Condition Assignment</u>

- As you know, you are participating in a research study, and there are multiple conditions in this study. Just now, I randomly assigned you to a study condition.
- You have been assigned to the Mindfulness Condition. Mindfulness is an approach for improving our emotional response to everyday life experiences. We are examining mindfulness as a strategy to enhance the experience of exercise.
- When we exercise at a moderate-to-vigorous intensity, sometimes our internal experience feels unpleasant. Our breathing gets hard, sometimes our legs feel tired, and our mind sometimes starts to tell us to stop. Can you relate to that?
- We are going to have you use mindfulness as a strategy to address that feeling.
- When practicing mindfulness, bring your attention to your present-moment experience while exercising. This includes noticing how your body feels, focusing on your breathing, or being aware of the thoughts that arise while exercising. Please do your best to experience these sensations and feelings without judging them.
- A mindful approach to exercise behavior emphasizes a willingness to do two things. First, notice and acknowledge – that is, be mindfully aware of your internal experiences. Second, tolerate your thoughts, feelings, sensations, etc. without trying to change them.
- Do you know what I mean when I say, "be mindfully aware"? What does mindfulness mean to you? [*listen for misconceptions*]
    - One common misconception about mindfulness is that it is about relaxing – it's not. Mindfulness is about cultivating presence and awareness without judgment.
    - Keep this concept in mind, we'll return to it in a little bit.
- We are going to give you some more information about mindfulness and do a short demonstration so that you know what I mean here, and then you will practice mindfulness while exercising both today and for the next two weeks.

<u>Mindfulness Skills (15 minutes):</u>

- Okay –let's talk about how you can respond to your internal experience when you exercise.
- For example, let's say that you are exercising and you notice that it's getting harder to breathe, your legs are burning, and you notice a strong desire to stop.
- A mindful approach to exercise teaches you to look *at* your thoughts rather than distracting away *from* them – to be an objective *observer* of your thoughts

- When we are "fused" with our internal experiences, those experiences often end up guiding our behavior – so we want to be able to step back from those thoughts, feelings, and sensations – and see ourselves as separate from them.
- We call this process "defusion" – defusion is a made up word that describes the process of distancing yourself from your internal experiences
  - One way to help yourself defuse from your internal experiences as you notice them is to label them for what they are – just thoughts, just feelings, and just sensations – they don't require you to do anything, they just are what they are
    - To do this, state what it is that you are experiencing:
      - "Part of me is having the thought that …" (describe thought)
      - "Part of me is having the feeling of…." (describe feeling)
      - "Part of me is feeling the sensation of …" (described sensation)
      - "Part of me is noticing the urge to …"(describe behavioral urge)
    - *For example:* When you are in the middle of an exercise session and fatigue starts to set in, you can say to yourself:
      - "Part of me is having the thought that I want to stop."
      - "Part of me is having the feeling of tiredness"
      - "Part of me is feeling the sensation of burning in my legs"
      - "Part of me is noticing the urge to slow down"
- When you label your experience like this, just notice that you're having a thought or sensation, but that does not mean you have to stop exercising. It's perfectly normal to have such thoughts or sensations arise while exercising. The idea is to notice thoughts and sensations for what they are – simply thoughts and sensations – and keep going!
- Another important part of this is that we want you to cultivate compassion towards yourself. It's totally normal to have negative feelings when you exercise—it's part of the experience, especially in the first few months. So try to cultivate a sense of compassion and understanding toward yourself when these feelings come up.
- Okay, now I'd like to do a quick mental exercise with you that I think will help demonstrate these points. Are you willing to do that with me now?
- Okay great!
  - Sit up straight in your chair and put your legs out straight in front of you so that your knees are locked. Hold your legs there until I tell you to stop.
  - While you are holding out your legs, I want you to practice observing your internal experiences.
  - Okay, why don't you try holding out your legs now. While you do so, I will ask you to think about some things. No need to respond to my questions out loud, just think about them. (Slowly give the following cues about every 10 seconds:)

- What thoughts are going through your mind?
- What sensations do you feel in your body?
- What urges to act are you experiencing?
- No need to analyze or hold onto these experiences, just acknowledge that they are present and watch as they come and go, like cars passing by on a busy road or leaves floating by on a stream.
- You might notice that some thoughts, sensations or urges want to stick around for a while. That's okay too. Just label them for what they are - "there's physical discomfort" or "there's a thought about planning"….

  - Okay, you can put your legs down now.
    - What did you notice during this exercise?
    - What thoughts, feelings, sensations, and/or urges to act did you experience?

- Another strategy to help you defuse from your internal experiences is to use imagery/visualization techniques. There are a lot of different ways you could to this, so here are just a few suggestions:
    - Raindrops – picture your thoughts as raindrops falling into a big lake
    - Park bench perspective – imagine you are sitting on a park bench and your thoughts are the people in the park, from your vantage point on the park bench, simply watch as other people come and go – there is no need to get up and talk to them or ask them to sit down with you
    - Leaves on a stream – picture your thoughts as leaves floating down a stream
    - Clouds – picture your thoughts as clouds moving across the sky

Exercise Session

- Now I am going to have you use what you just learned about mindfulness while exercising for 30 minutes. Are you ready to start your exercise session?
- Okay Great! Let's go back to the treadmill.
- We are going to have you warm up until you get to the same heart rate as you were during your Talk Test, and then you will exercise for 30 minutes. Every 10 minutes, we are going to have you answer the same questions about exercise as you did during the talk test before—about how good or bad you feel, about your arousal levels, and about the exercise intensity. Remember to apply what you just learned about mindfulness to your experience during exercise. Please repeat to me what you're going to try out in terms of mindfulness while you exercise.
- **Slowly (over a few minutes) ramp up the treadmill to the same speed/incline as they were for the talk test. Monitor heart rate and stabilize them in the same range as**

during the Talk test. When they get there, start the clock for 30-minutes, and take the first measures and write them down under the 'Minute 0' column (FS, FAS, RPE).

- **At minute 5:** "Remember to observe your thoughts and experience with openness and compassion."
- **At minute 10:** FAS, FS, RPE again
- **At minute 15:** "Try and acknowledge whatever is happening in the present moment, gently label it as a thought, feeling, or sensation, and accept it for what it is. It's completely natural to feel a whole range of experiences while exercising."
- **At minute 20:** FAS, FS, RPE
- **At minute 25:** "Remember to stay present as best as possible, and gently allow your thoughts and sensations about exercise to arise and notice them for what they are – simply thoughts and sensations – and then keep going."
- **At minute 30:** FAS, RS, RPE
- Awesome job, you're done! **Slow down the treadmill.** You can cool down for a few minutes at a slow walking pace—let me know when you're ready to stop.
- We'd like you to respond to a few questions regarding how it felt using your strategy and what your experience was like.
- **Give participants the questionnaire on the back of your data collection sheet.**
- Thank you!

Mindfulness Assignment (5 minutes):

- Ok, last but definitely not least – I want to explain your assignment for the next two weeks!
- For the next 2 weeks, try to exercise at least 150 minutes per week, although you can exercise more than that if you'd like. We have chosen 150 minutes as your goal because these are nationally recommended guidelines for the minimum amount of cardiovascular exercise people should engage in for good health. We would like you to run, jog, hike, or walk briskly as your form of exercise to keep it consistent with what you did today.
- Try and exercise at the same intensity that you did during your sessions here with us. You can think about the Talk Test that you did with us—when you exercise, you should still be able to speak, but not quite as easily as in normal conversation. Please try to use the technique you learned here today, *mindfulness*, in all of your exercise sessions over the next two weeks, as best as you can. Please avoid using any distractions like listening to music, listening to podcasts or audiobooks, or watching something on TV when you exercise.
- We will send you reminders about doing exercise and your strategy every morning for the next 2 weeks, along with a very short survey that we would like you to fill out about your exercise and a few other details about your day. You can fill out the survey anytime after you exercise, and if you haven't filled out the survey by the evening we will send you a reminder email.

- Please fill out the surveys even if you didn't exercise that day—we don't expect that you will exercise every single day, since you can spread the 150 minutes over as many days as you choose, but we would still like you to respond to the survey every day. These surveys should take less than five minutes to complete.
- The last survey we send you at the end of the two weeks will ask you a little bit more about your future plans to exercise and your thoughts about the study. After that, your participation in our study is done. If you complete all of these follow-up measures, you will receive $19—one dollar per day for the short daily surveys, and $5 more for the follow-up survey."
- Do you have any questions about this?
- Great! It was so good to meet you, __________, and please be in touch with us if you have any questions.

When participant leaves, open the REDCap "session measure" sheet and enter their condition assignment and measures from the talk test, exercise session, and manipulation check.

Appendix C

Distraction Protocol Script

Explain Condition Assignment

- As you know, you are participating in a research study, and there are multiple conditions in this study. Just now, I randomly assigned you to a study condition.
- You have been assigned to the Distraction Condition. Distraction is a technique for improving our emotional response to everyday life experiences that we are examining as a strategy to enhance the experience of exercise.
- When we exercise at a moderate-to-vigorous intensity, sometimes our internal experience feels unpleasant. Our breathing gets hard, sometimes our legs feel tired, and our mind sometimes starts to tell us to stop. Can you relate to that?
- We are going to have you use Distraction as a strategy to address that feeling.
- When you use distraction, bring your attention away from your experience while exercising. We are going to have you do this by listening to podcasts while you exercise. Podcasts are great because you can bring them with you wherever you exercise, whether it is outside or inside, and there are podcasts about all sorts of topics that can be really interesting and distracting. We want you to use podcasts to take your focus away from negative feelings associated with exercise as much as possible.
- Again, the distraction approach to exercise behavior emphasizes focusing your attention on something besides your exercise experience as much as possible while you are exercising.
- We are going to give you some more information about distraction and do a short demonstration so that you know what I mean here, and then you will practice distraction while exercising both today and for the next two weeks.

Distraction Skills (15 minutes):

- Okay –let's talk about how you can respond to your internal experience when you exercise.
- For example, let's say that you are exercising and you notice that it's getting harder to breathe, your legs are burning, and you notice a strong desire to stop.
- A distraction approach to exercise teaches you to distract your attention *away* from these thoughts rather than tuning into them.
- Our internal experiences often end up guiding our behavior – so we want to really ignore them as much as possible.
- One way to help yourself distract away from your internal experiences as you notice them is to remind yourself to tune your attention to something else

- *For example:* When you are in the middle of an exercise session and fatigue starts to set in, you can say to yourself:
  - "Focus on the distraction instead."

- Now I'd like to do a quick exercise with you that I think will help demonstrate these points. Are you willing to do that with me now?
- Okay great!
  - Sit up straight in your chair and put your legs out straight in front of you so that your knees are locked. Hold your legs there until I tell you to stop.
  - While you are holding out your legs, I want you to focus your attention away from your experience. I am going to play a song on my phone, and I want you to pay attention to that instead.
    - Really immerse yourself in the song, moreso than you might if you were just passively listening to it.
  - [*Start the song*]
  - Ready, go. [*Wait approx. 60 seconds, do not tell participants how long the task will last.]*
    - What was that like for you?
    - What thoughts, feelings, sensations, and/or urges to act to did you experience?
    - Were you able to remind yourself to focus on the song instead?
      - IF NO: That's understandable, this might be a new strategy for you. When you exercise, and find it difficult, try to practice focusing on the distraction instead.

<u>Exercise Session</u>

- Now I am going to have you use what you just learned about distraction while exercising for 30 minutes. Are you ready to start your exercise session?
- We have 3 podcasts for you to choose from to listen to while you exercise. Pick the one that seems most interesting to you! **Show them podcast list (back of script) and let them pick one.**
- Okay Great! Let's go back to the treadmill.
- We are going to have you warm up until you get to the same heart rate as you were during your Talk Test, and then you will exercise for 30 minutes. Every 10 minutes, we are going to have you answer the same questions about exercise as you did during the talk test before—about how good or bad you feel, about your arousal levels, and about the exercise intensity. Remember to apply what you just learned about distraction to your experience during exercise.
- Since you'll be using headphones while you exercise, just be aware that I'll be interrupting you a few times over the course of the exercise session, so you aren't surprised.

- Ok, let's have you start listening to the podcast, and we'll start the exercise session.
- **Slowly (over a few minutes) ramp up the treadmill to the same speed/incline as they were for the talk test. Monitor heart rate and stabilize them in the same range as during the Talk test. When they get there, start the clock for 30-minutes, and take the first measures and write them down under the 'Minute 0' column (FS, FAS, RPE).**
- **At minute 5:** "Remember to really immerse yourself in the podcast."
- **At minute 10:** FAS, FS, RPE again
- **At minute 15:** "Don't think about how you feel; focus on the podcast instead."
- **At minute 20:** FAS, FS, RPE
- **At minute 25:** "Remember to really pay attention to the podcast right now."
- **At minute 30:** FAS, RS, RPE
- Awesome job, you're done! **Slow down the treadmill.** You can cool down for a few minutes at a slow walking pace—let me know when you're ready to stop.
- We'd like you to respond to a few questions regarding how it felt using your strategy and what your experience was like.
- **Give participants the manipulation check measure on the back of your sheet.**

- Thank you!

<u>Distraction Assignment (5 minutes):</u>

- Ok, last but definitely not least – I want to explain your assignment for the next two weeks!
- For the next 2 weeks, try to exercise at least 150 minutes per week, although you can exercise more than that if you'd like. We have chosen 150 minutes as your goal because these are nationally recommended guidelines for the minimum amount of cardiovascular exercise people should engage in for good health. We would like you to run, jog, hike, or walk briskly as your form of exercise to keep it consistent with what you did today.
- Try and exercise at the same intensity that you did during your sessions here with us. You can think about the Talk Test that you did with us—when you exercise, you should still be able to speak, but not quite as easily as in normal conversation. Please try to use the technique you learned here today, *distraction,* in all of your exercise sessions over the next two weeks, as best as you can. To make this easier for you, every morning we will send you a list of a few podcast suggestions you can listen to while you work out. Make sure you always bring along your phone with a podcast downloaded to listen to while you exercise.
- We will send you reminders about doing exercise and your strategy every morning for the next 2 weeks, along with a very short survey that we would like you to fill out about your exercise and a few other details about your day. You can fill out the survey anytime after you exercise, and if you haven't filled out the survey by the evening we will send you a reminder email.
- Please fill out the surveys even if you didn't exercise that day—we don't expect that you will exercise every single day, since you can spread the 150 minutes over as many days

as you choose, but we would still like you to respond to the survey every day. These surveys should take less than five minutes to complete.

- The last survey we send you at the end of the two weeks will ask you a little bit more about your future plans to exercise and your thoughts about the study. After that, your participation in our study is done. If you complete all of these follow-up measures, you will receive $19—one dollar per day for the short daily surveys, and $5 more for the follow-up survey."
- Do you have any questions about this?
- Great! It was so good to meet you, __________, and please be in touch with us if you have any questions.

When participant leaves, open the REDCap "session measure" sheet and enter their condition assignment and measures from the talk test, exercise session, and manipulation check.

Appendix D

Self-Monitoring Protocol Script

Explain Condition Assignment

- As you know, you are participating in a research study, and there are multiple conditions in this study. Just now, I randomly assigned you to a study condition.
- You have been assigned to the Self-Monitoring Condition. Self-Monitoring is a technique for improving our emotional response to everyday life experiences that we are examining as a strategy to enhance the experience of exercise.
- When we exercise at a moderate-to-vigorous intensity, sometimes our internal experience feels unpleasant. Our breathing gets hard, sometimes our legs feel tired, and our mind sometimes starts to tell us to stop. Can you relate to that?
- We are going to have you use Self-Monitoring as a strategy to address that feeling.
- When you self-monitor, bring your attention to your experience while exercising. This includes noticing how your body feels as much as possible, even if these sensations are negative.
- Again, the self-monitoring approach to exercise behavior emphasizes paying attention to your experience, rather than any distractions, while you are exercising.
- We are going to give you some more information about self-monitoring and do a short demonstration so that you know what I mean here, and then you will practice self-monitoring while exercising both today and for the next two weeks.

Self-monitoring Skills (15 minutes):

- Okay –let’s talk about how you can respond to your internal experience when you exercise.
- For example, let’s say that you are exercising and you notice that it’s getting harder to breathe, your legs are burning, and you notice a strong desire to stop.
- A self-monitoring approach to exercise teaches you to tune into these thoughts rather than distracting away *from* them.
- Our internal experiences often end up guiding our behavior – so we want to really pay attention to those thoughts, feelings, and sensations.
- One way to help yourself monitor your internal experiences as they happen is to turn up your internal monologue of your sensations and desires.
    - *For example:* When you are in the middle of an exercise session and fatigue starts to set in, you can say to yourself:
        - “I want to stop”
        - “I’m tired”

- "My legs are burning"
- "I want to walk"

Really allow your mind to run with those thoughts – to turn them around in your mind over and over again.

- Now I'd like to do a quick exercise with you that I think will help demonstrate these points. Are you willing to do that with me now?
- Okay great!
  - Sit up straight in your chair and put your legs out straight in front of you so that your knees are locked. Hold your legs there until I tell you to stop.
  - While you are holding out your legs, I want you to notice your internal experience.
    - What thoughts are going through your mind?
    - What sensations do you feel in your body?
    - What urges to act are you experiencing?
    - Really try and turn up the volume – and amplify - your emotional experience. Allow those thoughts, sensations, and urges to turn around in your mind, again and again. Really focus all of your attention on them, on how intense they are. Let your mind continue to expand on what concerns you, thinking about all of the possible things that could happen as a result of whatever it is you're concerned about with exercising.
    - When your mind wanders, please bring it back to thinking about the thoughts and sensations you're having as you exercise and turning up the volume on them…thinking about all the possible things that could happen as a result of whatever it is you're concerned about while exercising….focusing fully on that…
  - Ready, go. [*Wait approx. 60 seconds, do not tell participants how long the task will last.]*
    - What was that like for you?
    - What thoughts, feelings, sensations, and/or urges to act to did you experience? How did you turn up the volume or amplify them?
    - Great. We really want you to practice that when you exercise.

Exercise Session

- Now I am going to have you use what you just learned about self-monitoring while exercising for 30 minutes. Are you ready to start your exercise session?
- Okay Great! Let's go back to the treadmill.
- We are going to have you warm up until you get to the same heart rate as you were during your Talk Test, and then you will exercise for 30 minutes. Every 10 minutes, we are going to have you answer the same questions about exercise as you did during the talk

test before—about how good or bad you feel, about your arousal levels, and about the exercise intensity. Remember to apply what you just learned about self-monitoring to your experience during exercise.

    - **Slowly (over a few minutes) ramp up the treadmill to the same speed/incline as they were for the talk test. Monitor heart rate and stabilize them in the same range as during the Talk test. When they get there, start the clock for 30-minutes, and take the first measures and write them down under the 'Minute 0' column (FS, FAS, RPE).**
    - **At minute 5:** "Remember to really tune into your internal experience."
    - **At minute 10:** FAS, FS, RPE again
    - **At minute 15:** "Try and avoid distracting yourself; instead, think about how you feel right now."
    - **At minute 20:** FAS, FS, RPE
    - **At minute 25:** "Remember to monitor your experience right now."
    - **At minute 30:** FAS, RS, RPE
    - Awesome job, you're done! **Slow down the treadmill.** You can cool down for a few minutes at a slow walking pace—let me know when you're ready to stop.
    - We'd like you to respond to a few questions regarding how it felt using your strategy and what your experience was like.
    - **Give participants the manipulation check measure on the back of your data collection sheet.**
- Thank you!

<u>Self-Monitoring Assignment (5 minutes):</u>

- Ok, last but definitely not least – I want to explain your assignment for the next two weeks!
- For the next 2 weeks, try to exercise at least 150 minutes per week, although you can exercise more than that if you'd like. We have chosen 150 minutes as your goal because these are nationally recommended guidelines for the minimum amount of cardiovascular exercise people should engage in for good health. We would like you to run, jog, hike, or walk briskly as your form of exercise to keep it consistent with what you did today.
- Try and exercise at the same intensity that you did during your sessions here with us. You can think about the Talk Test that you did with us—when you exercise, you should still be able to speak, but not quite as easily as in normal conversation. Please try to use the technique you learned here today, *self-monitoring*, in all of your exercise sessions over the next two weeks, as best as you can. Please avoid using any distractions like listening to music, listening to podcasts or audiobooks, or watching something on TV when you exercise.
- We will send you reminders about doing exercise and your strategy every morning for the next 2 weeks, along with a very short survey that we would like you to fill out about your exercise and a few other details about your day. You can fill out the survey anytime after you exercise, and if you haven't filled out the survey by the evening we will send you a reminder email.

- Please fill out the surveys even if you didn’t exercise that day—we don’t expect that you will exercise every single day, since you can spread the 150 minutes over as many days as you choose, but we would still like you to respond to the survey every day. These surveys should take less than five minutes to complete.
- The last survey we send you at the end of the two weeks will ask you a little bit more about your future plans to exercise and your thoughts about the study. After that, your participation in our study is done. If you complete all of these follow-up measures, you will receive $19—one dollar per day for the short daily surveys, and $5 more for the follow-up survey.”
- Do you have any questions about this?
- Great! It was so good to meet you, __________, and please be in touch with us if you have any questions.

When participant leaves, open the REDCap “session measure” sheet and enter their condition assignment and measures from the talk test, exercise session, and manipulation check.