The Effect of a Brief-Mindfulness Intervention on Psychophysiological Exertion and Flow-State Among Sedentary Adults

Abstract

Mindfulness-acceptance commitment interventions in sport and exercise contexts have been helpful in increasing a positive psycho-physiological state among competitive athletes and recreational exercise participants. In the current study, we sought to extend research in this area by identifying the effect of a brief-mindfulness intervention on psychophysiological functioning among sedentary young healthy adults. Our mixed gender sample (n = 48) of inactive individuals performed a brief cycling task without training (control condition) followed by task completion with brief mindfulness training (15-minute audio engagement with mindfulness techniques and specific present moment 'anchors'). We found that participants self-reported more accurate ratings of perceived exertion (i.e., self-ratings better matched actual physiological indices of exertion) suggesting that mindfulness techniques can increase bodily awareness which may be useful in helping sedentary participants appreciate physiological changes associated with exercise. The mindfulness manipulation also increased participants' absorption into the activity, suggesting that participants were more attentive to the exercise task and less distracted by irrelevant external and internal cues. Generally, these findings suggest that mindfulness may be a complementary psychological training tool for inactive, sedentary young adults who are re-engaging with exercise. We provide recommendations for future research.

Key Words: exercise, physical activity, mindfulness, RPE, flow

Introduction

Recent sport and exercise research has included studies of mindfulness-acceptance paradigms as a means of using acceptance and tolerance of positive and negative emotional and cognitive experiences to aid performance (Bernier, Thienot, Codron & Fournier, 2009). For example, prior to an important race or meet, track athletes may have transient negative thoughts about the consequences of losing, and feelings of nervousness and anxiety about the outcome that might be better managed through a mindful approach to mental skills training. Through mindfulness training athletes might be encouraged to learn and focus on present moment and non-judgemental awareness of these thoughts and emotions so as to better tolerate the full range of psychophysiological states that are inevitable in sport and exercise contexts (Gardner & Moore, 2004). The central tenant of the mindfulness approach is that people can benefit from developing greater awareness of their own experiences and can then learn to tolerate various states (perhaps especially distress) as they arise, without attempting to control, modify or respond to a given emotional or cognitive state (Kabat-Zinn, 1994). This may be particularly important for athletes striving for peak performance, as they inevitably experience numerous stressors, demands and challenges. Related to these themes, using mindfulness training to support exercise adherence among typically sedentary individuals has also received recent research attention (Cox, Roberts, Cates & McMahon, 2018; Ivanova, Jensen, Cassoff, Gu & Knauper, 2015). Further research is needed to identify and understand exercise performance and related health benefits that may arise from mindfulness training.

There are multiple conceptual models of mindfulness, but a definition that stems from Buddhist philosophy is "*paying attention in a particular way: on purpose – in the present moment and non-judgementally*." (Kabat-Zinn, 1994, pp.4). The mindfulness approach emphasizes a need to maintain a sense of openness, acceptance and curiosity for one's present cognitive and emotional states. Mindfulness advocates anticipate that through meditative practices there will arise an increased awareness of the transient nature of positive and negative states and that this awareness will limit the recruitment of habitual judgements and secondary appraisals. Shifting attentional resources to sensory cues and experiencing potentially uncomfortable emotions with effortful attention and present moment acceptance allow an individual to perceive new aspects of the situation, disrupting the processing of automatic reactions (Farb, Anderson, Irving & Segal, 2015). Since the emotional response, following a mindful effort, is more tuned to the demands of the immediate situation, emotional responses to mindfulness are expected to be more adaptive than the emotional responses that are habitually based on past experiences. Research has suggested that the two primary mechanisms of change in mindfulness training are enhanced *attention and emotional regulation* (Jha, Krompinger & Baine, 2007; Jha, Stanley, Kiyonaga, Wong & Gelfand, 2010).

An important systematic review of mindfulness benefits by Rivera, Quintana and Rincon (2011), suggested that athletes are likely to experience '*flow*' when practicing mindfulness. Evidence from several sport studies suggest that mindfulness training can provide an opportunity for athletes to experience the '*flow-state,*' defined as an optimal experience when an individual is completely present and immersed in their current activity, and the awareness of time passage becomes unconscious (Csikszentmihalyi, Abuhamdeh & Nakamura, 2005). There are nine dimensions of the flow experience, and, of these, *challenge-skill balance, action-awareness merging, and clear goals* permit optimal flow conditions to occur (Nakamura & Csikszentmihalyi, 2002). In terms of mindfulness training for novices, these conditions are put into practice by instructing participants to focus on their breath (action-awareness merging) or to perform simple everyday tasks with focused attention (challenge-skill balance). The remaining six dimensions of mindfulness; *unambiguous feedback, concentration on task, sense of control, loss of self-consciousness*, *time transformation* and *autotelic experience* are proposed as experiential aspects of flow. These experiential aspects of flow, with their strong emphasis on concentration and focus, are interrelated and consistent with the aims and practices of mindfulness training (Jackson, 2016). A recent systematic review of the occurrence and experience of flow among elite athletes (Swann Keegan, Piggot & Crust, L 2012) found that the most commonly cited dimensions of flow were concentration on the task at hand and the merging of action and awareness. As mindfulness training emphasises the present moment and a non-judgemental acceptance of internal and external experiences, it seems logical that mindful practice may be helpful in achieving the flow state and leading to an exercise session that is more likely to be repeated, with an ultimate goal of transforming a non-habitual exerciser into a habitual exerciser (Fortier & Kowal, 2007).

Brief-mindfulness interventions can be useful for increasing acceptance and a non-judgemental attitude toward potentially unpleasant cognitive and emotional states, creating the possibility of flow in exercise contexts. There are two attention processes that underlie affective experiences during exercise - a dissociative focus (i.e., allowing exercisers to " tune out" or draw attention away from the body) and an associative focus (i.e., focusing on interoceptive cues such as breathing, heart rate and muscle sensations) - both of which may influence physiological processes during physical exercise. Research suggests that non-exercisers' decreased motivation toward exercise is associated with negative affect and perceptions of effort (Pollock, 2001). Therefore, interventions that help participants simply accept these factors may have a role in increasing exercise satisfaction. Mindfulness interventions can help individuals form neutral associations with these interoceptive cues and focus on novel aspects of the experience during exercise to help improve satisfaction and motivation (Ivanova, Jensen, Cassoff , Gu & Knäuper, 2015). Brief-mindfulness manipulations with untrained participants can demonstrate the '*raw/acute*' effect of brief-mindfulness training on physiological, psychological functioning and performance outcomes. Another important research consideration for exercise practitioners is the optimal length of interventions, since time is often cited by low-motivated, habitual non exercisers, as an excuse for non-adherence to exercise. Cox, Roberts, Cates and McMahon (2018) more recently reported the effects of a brief mindfulness intervention on affective responses and accuracy of perceived exertion ratings (measured by their correlation with actual heart rate) in relatively inactive adults during a moderate intensity (LT <60%) treadmill exercise task. These researchers found that a brief audio mindfulness intervention increased perceived exertion accuracy and positive affect. However, other related research has demonstrated that disassociation from interoceptive cues during intense exercise also has positive emotional outcomes (Hutchinson & Tenebaum, 2007).

Moreover, Jones, Karageorghis and Ekkekakis (2014) examined the effect of two methods of disassociation attentional strategies: video and music (disassociation strategies) on psychological responses at two different intensities (10% below and 5% above Ventilatory Threshold or VT) during an exercise on a stationary cycling ergometer. Participants were a mixed sample (*N*=34; *Mage*=21.1, *SD*=1.9 years), and the study used a repeated-measures design in which participants exercised in three experimental conditions (music-only, video-only, and music-and-video) and a control condition (no music or video). Participants self-reported higher ratings of affective valence and enjoyment when they received music or music/video combined, in comparison to the no music or video control group. This study therefore supported the efficacy of dissociative attentional focus techniques in enhancing positive affect during exercise at intensities both below and above VT. However, other strategies may be needed to directly measure negative affective responses that may occur while attending to interoceptive cues. Since attentional focus becomes more associative as the level of exercise intensity increases, the authors suggested that by focusing on positive interoceptive cues and emotion during exercise, participants may be better able to generate an overall enjoyable experience that supports exercise adherence or performance. Although mindfulness refers to attending to one’s current experience, these latter qualities distinguish it from an associative attentional focus (Mackenzie, et al., 2014). Mindfulness of physical sensations (i.e., mindfulness of the body) is likely to be more noticeable as exercise intensity increases.

Research evidence supports a potential for mindfulness to enhance affective responses during physical activity. Hayes (2004) sampled inactive adult women and examined the efficacy of cognitive techniques related to Acceptance Commitment Therapy (ACT) that emphasised the need for athletes to approach their cognition and emotion in a non-reactive and accepting manner. Hayes (2004) implemented a 40-minute training session designed to help the women tolerate uncomfortable physical sensations during exercise. ACT strategies were designed to teach participants how to tolerate unpleasant sensations without trying to control, change or suppress them. This intervention resulted in lower ratings of perceived exertion, higher exercise tolerance (longer time frame before pain was reported) and increased positive affect or enjoyment. Also using the ACT framework, Ivanova, Jensen, Cassoff, Gu and Knäuper (2015) employed an acute randomized mindfulness intervention pre- and post- exercise trial using a constant work rate cycle protocol with 39 low-active women. These researchers found that exercise enjoyment was higher and Rate of Perceived Exertion was lower at post intervention in the mindful group compared to the control, although there was no in-task affect improvement. These results suggest that, mindfulness could be a useful tool for coping with interoceptive cues from an associative attentional focus during exercise.

In the current study, we aimed to explore the effect of a brief mindfulness training intervention (to increase associative attention) on perceived exertion level and accuracy (calculated by the correlation between heart rate and perceived exertion; RPE) and flow state (absorption by activity, fluency of performance and perceived importance) during a laboratory based physical exercise task on the cycling ergometer. This was completed with a relatively inactive participant group who exercised at 85% maximal HR (moderate-high intensity). Our hypothesis was that participants in the mindful condition would experience a higher flow state on a flow state measurement tool and lower RPE scores compared to their experience in the control condition.

Method

Participants

We recruited 42 relatively inactive participants without any physical health conditions (PAR-Q & gymnasium health check) via purposive sampling such that they were physically healthy (as indicated by PAR-Q and basic health check assessments conducted at a gymnasium) and they had recently signed up to take part in an 8-week bootcamp challenge at a gymnasium. All participants (18 females Mage = 27.61, SD = 1.72; 24 males; M_{age}= 29.2, SD = 1.23) provided informed consent following an explanation of the study's aims, and all participants self-reported that they had been relatively sedentary and that they had engaged in no gym or regular exercises other than daily life physical activities for the previous six months. No participants had ever practiced or incorporated mindfulness in previous exercise or sport practice.

Measures

Short-form flow state scale (DFS; Jackson, Martin & Eklund, 2008). To measure flow, we used the 13-item short-form flow self-report scale (DFS) with three sub-scales containing, respectively: five items measuring fluency of performance (*I have no difficulty concentrating*), five items measuring absorption by activity (*I did not notice time passing*) and three items measuring perceived importance (*I am worried about failing*). Participants responded to items on a 7-point Likert scale anchored from 1 (*not at all*) to 7 (*very much so*).

This instrument has been found to be a valid and reliable measure of flow-state (Jackson et al, 2008) with Cronbach alpha = 0.77.

Ratings of Perceived Exertion scale (RPE; Borg, 1982). Participants were asked to rate their level of physical exertion on a scale from 1 (*not exerted at all*) to 10 (*fully exerted*). This tool has been used as a valid measure of subjective perceptions of exercise intensity (Borg, 1982).

Engagement with the mindfulness exercise-scale. We developed an exploratory scale to assess participant perceptions of whether the mindfulness manipulation had been effective during the exercise task. Participants were asked to rate their level of engagement from 1 (*no engagement*) to 10 (*complete engagement*).

Cycling task protocol

Participants came in for testing on three separate sessions at least two days apart. Each participant engaged first in a habituation session, followed by a control condition and then the mindfulness experimental condition. Participants were told before the first session not to engage in vigorous exercise on the day of testing and to consume no food two hours prior to testing. During the first baseline testing session, participants completed a questionnaire assessing their demographic characteristics and physical activity levels. Participants were fitted with a heart rate monitor (Model:Tickr X) and then cycled for five minutes prior to baseline testing at a self-chosen cadence with no resistance. We used age-based calculations to calculate their Max HR according to Fox formulae (HRmax = 220- current age), and we calculated target heart rate as a % of the HRmax. Participants then cycled at 100 W for 20 minutes, with expired gas collected for 60 seconds between minutes 4-5, 9-10, 14-15 and 19-20. During expired gas collections, participants wore a heart rate monitor, nose clip and breathed through a mouthpiece attached to a low resistance breathing valve (Cranlea, Birmingham, UK). Expired gases were collected in 150-L Douglas bags via a

1.5-m length of Falconia tubing (3.5 cm internal diameter) (Cranlea). The expired gases were collected from complete respiratory cycles that were timed using a digital stopwatch. We analyzed the gases for mixed expired fractions of O2 (Fe O2) and CO2 (Fe CO2) using a Servomex gas analyzer (Servomex). Participants completed the RPE and DFS questionnaires on completion of the protocol only in sessions two and three. Also, during the third session, participants completed the exploratory mindfulness engagement scale.

Procedure

Participants first attended the laboratory for a familiarization session to establish a baseline power output for the task and to achieve a sub-maximal heart rate; resting heart rate and maximal heart rate were used to establish 85% of maximal HR. Next, they were instructed, on day two of testing, to complete a 20- minute cycling task progressing up to 85% maximal heart rate, followed by providing a 1-minute post heart rate and then completion of the self-report measures of perceived exertion questionnaire and flow-state. On day three (and the second testing session) participants engaged in a 10-minute brief mindfulness training script, delivered via an audio device, that included a 5-minute body scan exercise. The mindfulness instructions were based on the mindful body scan (Kaufmann, Glass & Pineau, 2018): '*We are about to tour the entire body with our attention. The goal here is not to relieve the tension or to relax the muscles, although this may happen along the way. Our intention is to notice a variety of sensations with our full attention, and then simply to let them go. If a particularly intense sensation calls for your attention at some point on this journey, it is not necessary to resist it. Welcome the sensation into your experience. Acknowledge and appreciate this communication from your body. Once you have heard what your body has to say, gently let go of the intense sensation and bring your attention back to where you are on your tour'*. The aim was to encourage participants to focus their attention on the physical sensations of a specific part of the upper or lower body as present moment anchors. Participants practiced this while at rest, while lying down, initially and after finishing, and they were encouraged to engage in this practice during the cycling task.

Data Analysis

We checked parametric assumptions of a normal data distribution and homogeneity of variance and found them to be acceptable. First, to examine differences between the participants' experiences in the control and mindfulness conditions, we used paired sample *t*-tests to compare flow state subscales, heart rate and perceived exertion. Second, we calculated a Pearson's correlation co-efficient in order to examine the correlation between recorded heart rate during the exercise activity and the participants' ratings of perceived exertion in both the control and experimental conditions. We set the alpha levels for detecting statistical significance on inference testing to $p < .05$.

Results

Mindfulness engagement

Participants provided generally high engagement ratings with the mindfulness exercise, and indicated some heterogeneity in terms of engagement with the mindfulness manipulation during the exercise task (9 for males [n = 24] and 10 for females [n = 18]) .

[Table 1 here]

Pearson's correlation co-efficient revealed that, in the experimental condition, perceived exertion and HR were significantly ($p < 0.01$) positively correlated (moderate strength relationship), $r = 0.56$, $p < 0.01$.

In terms of exertion made to reach the required heart-rate, there was no significant difference in ratings of perceived exertion scores between the experimental ($M = 4.50$, $SD =$

2.00) and control (*M* = 4.21, *SD* = 2.09) conditions, *t* (55) = 1.22, $p > 0.05$. There was a significant difference in absorption of activity between the experimental (*M*= 14.41, *SD* = 4.26) and control (*M*= 15.55, *SD* = 4.40) conditions, *t* (55) = -2.09, $p < 0.05$ on the Short Term Flow State Scale. However, there was no significant difference in fluency of performance between the experimental (*M*= 32.64, *SD* = 7.64) and control (*M*= 34.13, *SD* = 5.71) conditions, *t* (55) = -1.19, $p > 0.05$. Similarly, there were no significant differences in perceived importance of the exercise between the experimental (*M* = 12.21, *SD* = 2.13) and control (*M* = 13.25, *SD* = 2.42) conditions, t (55) = -.102, p >0.05 .

Discussion

This study utilized a repeated measures experimental design to isolate the unique effects of brief-mindfulness training on self-reported ratings of perceived exertion (RPE), the accuracy of RPE (as indicated by the degree of their correlations with actual exertion as identified by heart-rate recovery rate) and self-reported flow-state. Our key findings were that exercise participants self-reported a significant increase in the flow-state subscale *absorption by activity* after the brief-mindfulness training manipulation, compared to the control exercise condition that received no mindfulness training. This self-reported increase in absorption by activity indicated that participants experienced a greater degree of immersion in the task and present-moment focus; and they reported attending to associative interoceptive bodily cues during the cycling task, following the mindfulness exercise. This would suggest that mindfulness training improved these exercise participants' self-awareness of their physiological state and their immersion in the activity (increasing associative attention during exercise). This finding appears to support previous research that suggested that associative interoceptive attention is likely to be helpful with lower intensity physical activity and with enhancing skill acquisition (Ivanova, Jensen, Cassoff , Gu, & Knäuper, 2015). Jones et. al., (2014) demonstrated that disassociative strategies may benefit more advanced athletes when reaching ventilatory threshold. Absorption by activity, as action-awareness merging, is one of the pre-conditions of flow-state, and it is defined as complete involvement in the task at hand for the sake of absorbing experience itself. This meta-cognitive awareness of one's current emotional and physiological state could be particularly beneficial for sedentary individuals, since it may limit the alternative recruitment of habitual responses and, instead, increase attention towards novel aspects of the experience. It would be useful to understand if these attention changes translate to greater motivation to exercise and a greater awareness of physiological development through physical training over time (Pollock, 2001). Our findings could be replicated in different participant samples, including older populations and sedentary individuals. It is clear that different attentional strategies used during exercise may serve different functions for various athletic and physical activity populations. It is important for research to develop a more nuanced approach to understand the benefits of different strategies for various populations.

The participants' self-reported scores on the flow-state subscales of *perceived importance* and *fluency of performance* did not significantly change post-mindfulness training. This would suggest that the mindfulness training did not bring about a sense of increased fluidity of motion and performance during exercise or perceptions of importance of the task. This finding does appear to be consistent with theoretical models of the flow experience; specifically, the experimental exercise task did not present a maximal or high-level of physical (below maximal threshold intensity) or psychological challenge (there was no competition or consequence for performing well), meaning that the task may not have presented sufficient challenge to bring about these aspects of flow. This finding appears to be consistent with theoretical models of flow that suggest a high level of challenge can increase engagement in order to bring about flow states (Stavrou, Psychountaki, Geordiadis, Karteroliotis & Zervas, 2015). Future researchers may wish to explore the effect of mindfulness on different facets of flow and consider the moderating influence of the exercise task '*difficulty*'. Future researchers may also explore whether mindfulness training can significantly improve fluency of performance during a task perceived to be challenging.

Limitations

By way of study limitations, as this was a very brief intervention and testing of mindfulness effects, many variables and considerations were not adequately addressed. For example, we did not measure intervention engagement though such a measure would have helped establish whether our finding of self-reported increased *absorption by activity* was likely due to engagement with the mindfulness training technique. We did not compare participants who were engaging in another means of psychological support between the two testing sessions, limiting our understanding of the relative value of mindfulness training compared to other interventions. Accordingly, future researchers should utilize a cross-group design in which participants experiencing mindfulness training are compared with both a control group and one or more groups who experience other psychological preparations and/or exercise motivation/adherence interventions. Future researchers might also employ mixed-method designs to identify both quantitative changes in psychological state and qualitatively experienced alterations in bodily sensations, exercise engagement, enjoyment or motivation and the perceived effect of mindfulness-based psychological training exercises. Certainly, longer and more effortful mindfulness training should be tested against other longer interventions, ideally with a more prolonged series of exercise sessions and follow-up assessments in order to evaluate whether our effects were simply short term or temporary increases in focused awareness and discomfort acceptance.

Conclusions

While our findings are generally consistent with those of Cox et al. (2018) who found no significant reduction in perceived exertion when relatively inactive adults underwent brief-mindfulness training, we did show a mindfulness training effect on increased awareness of pacing or exertion that could be useful for beginners' running training at a time when they are first developing a connection between exercise and physiological health. We found that our participants' RPE accuracy was significantly improved following mindfulness training. We also found a significant correlation between heart-rate post-exercise and perceived exertion during the exercise task for participants in the mindfulness training condition but not for those in the control condition. Thus, the associative nature of the physical sensation present-moment '*anchors*' in mindfulness training facilitated a meta-awareness of exertion during the exercise task. In order to draw conclusive and substantive recommendations for exercise participants from these findings, it will be necessary for future researchers to expand on this study in ways detailed in the Limitations section of this paper. Including progressive and varied physical tasks ranging from low to moderate and high intensity exercise would help determine if the physical exertion awareness we observed is intrinsically linked to physical demands of the task, if participants can discern different exercise intensities more accurately after mindfulness practice, and if mindfulness training enhances exercise performance. This study sets the stage for more sport-specific research of this kind.

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