A conditional process model of the effect of mindfulness on 800m personal best times through pain catastrophizing

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Word Count

5100

Acknowledgement

This work was supported by the British Miler's Club under the Frank Horwill Research Scholarship Scheme

Abstract

The purpose of this study was to examine the relationship between mindfulness and 800m PB times through pain catastrophizing and to see whether the magnitude and direction of the relationship depended on gender. One hundred and nine participants reported their gender, completed measures of mindfulness (MAAS) and pain catastrophizing (PCS) and reported personal best 800m times that were standardized based on current world records. Results revealed moderate sized relationships between the predictor variables and standardized 800m PB. The size of these relationships reduced after we controlled for gender. The follow-up, conditional process analysis, revealed significant direct and indirect effects that confirmed that pain catastrophizing partially mediated the relationship between mindfulness and 800m PB and gender moderated the indirect paths. The indirect path between mindfulness and pain catastrophizing was consistent with existing literature. However, the path between pain catastrophizing and standardized 800m PB was positive for females and negative for males. The different direction of the relationship could suggest that pain catastrophizing could be performance enhancing for females.

Keywords

Mindfulness, Pain Catastrophizing, Middle distance running

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> Every training session was painful . . . 'I'd wake up in the morning and think 'Damn, I have to train today', and you'd start thinking - as we all do - reasons why you could not train. 'I have something more important to do,' 'That twinge in my muscle hurts,' 'It is too hot.' You just have to ignore it and get on
>
> (Herb Elliot in Lane, 2014)

Middle distance running is physically and mentally tough. The high-intensity training needed to compete in this sport can elicit fatigue and pain. Both fatigue and pain may precede negative thoughts and emotions that have the potential to influence running performance (De Petrillo, Kaufman, & Glass, 2009). There is a need for athletes to develop psychological skills that facilitate the management of the burdens of high-intensity training and competition, including pain so that they can thrive in the sport. In the past three decades, researchers have examined a range of cognitive behavioral strategies that athletes could employ to improve performance. In the last ten years, a “third wave” of cognitive behavioral therapies (Hayes, 2004) has increased in popularity with mindfulness and acceptance therapies beginning to enter the realm of athletic training. Kabat-Zinn (1994) defined mindfulness as the nonjudgmental focus of attention on experiences that occur in the present moment. Mindfulness comprises a self-directed, nonreactive awareness of present experience (Schütze, Rees, Preece, Schütze, 2010). Various forms of mindfulness therapies (e.g., Mindfulness-Acceptance-Commitment (MAC): Gardner & Moore, 2006 and Mindful Sport Performance Enhancement (MSPE) Kaufman & Glass, 2006) have been employed in sporting contexts. De Petrillo and colleagues showed that practitioners can use the MSPE intervention with runners (despite no improvements in running performance). Other researchers have taken a different approach to mindfulness by examining whether a trait like measurement of mindfulness correlates with flow states and mental skills adoption (e.g., Kee & Wang, 2008). Other researchers proposed neural correlates of mindfulness and their associations with performance (Marks, 2008). Despite the growing popularity of mindfulness, no researchers have examined mindfulness and performance within the context of high-intensity sport. Nor have researchers considered how a relationship between mindfulness and performance exists (mediators) and when a relationship exists (moderators). It was, therefore, the purpose of this study to extend previous research by examining the relationship between mindfulness and 800m PB times.

How mindfulness affects performance is a difficult question that has stimulated a mercurial debate in the sport and exercise psychology literature and there may be several different answers to this question based on various sports and skill requirements. We propose that in the context of middle distance running mindfulness connects with performance because of the relationship between mindfulness and pain.

The opening quote by Olympic gold medalist Herb Elliot suggests that pain is an unpleasant experience, and it may be best to ignore pain in the context of sport. In sporting contexts, particularly track and field athletics, the pain associated with continued energy expending effort is a potential limiter upon athletic performance (Kress & Statler, 2007). Because of this fact, pain is an integral feature of involvement in sport (Sullivan, Tripp, Rodgers, & Stanish, 2000a). Paradoxically, coaches have likened the importance of athletes' self-inflicting exertion-induced pain during training to investment, where increased deposits help to develop desirable performance outcomes (e.g., speed; Sands, 1995). Subsequently, the desire to experience pain and the ability to manage pain could influence performance (e.g., running speed). Consequently, pain management could be an expedient accompaniment to psychological skills training programs for athletes in high-intensity sports (Birrer & Morgan, 2010). Because of the importance of an athlete's capacity to manage and endure pain, researchers have examined cognitive strategies to control exertion pain symptoms (Masters & Ogles, 1998; Salmon, Hanneman, & Harwood, 2010).

The undesirable judgment of pain can negatively influence emotional reactivity (Salmon, Hanneman, & Harwood, 2010). Baron, Moullan, Deruelle, and Noakes (2011) suggested that less favorable emotional responses can lead to maladaptive behaviors. For example, when in pain people might slow the pace to reduce perceived exertion. Reducing pace would likely be detrimental to performance. Rather than ignoring symptoms, adopting a receptive attention to painful stimuli that is nondiscriminatory or nonjudgmental (i.e., mindful) could ease painful experiences (Kabat-Zinn, 1982). Therefore, mindful attention may influence performances that comprise painful efforts (e.g., middle distance running).

Several studies show a robust relationship between mindfulness and pain. For example, McCracken, Gauntlett-Gilbert, and Vowles (2007) found that clinical pain patients that had high scores on a dispositional measure of mindfulness (with no mindfulness training) reported less pain and less pain-related distress than patients with low mindfulness. Similarly, Schütze et al. (2010) examined mindfulness and pain perceptions in a sample of chronic pain outpatients. These researchers found that a dispositional measure of mindfulness significantly negatively predicted pain catastrophizing, pain-related fear, pain hypervigilance, and functional disability. Moreover, mindfulness uniquely predicted pain catastrophizing when the researchers statistically controlled other variables.

Catastrophizing is an extreme style of unipolar thinking where people believe that the most adverse outcome is likely to occur (Beck, 1976; Ellis, 1962). Beck described catastrophic cognitions as a faulty alarm system where people perceive relatively benign stimuli as noxious, threatening, or dangerous. Sullivan et al. (2001) defined pain catastrophizing as an "exaggerated negative mental set brought to bear during an actual or anticipated pain experience" (p 53). Pain catastrophizing refers to a particular response to pain (Sullivan, Martel, Tripp, Savard, & Crombez, 2006). Individuals who excessively catastrophize focus their attention on pain sensations, exaggerate the threat values of pain, and perceive themselves unable to cope with pain. Pain catastrophizing is a multifaceted construct comprising rumination, magnification, and helplessness (Sullivan, Bishop, & Pivik's, 1995). Rumination is repetitive thinking about the negative sensations associated with noxious stimuli. Magnification is the elevation of the threat value of pain. Helplessness is a belief that nothing can be done to extricate oneself from the pain experience). These components contribute to appraising painful stimuli by myopically focusing on pain. The combination of catastrophizing components also contributes to people displaying a tendency to increase the intensity and threat value of these sensations. They then draw the conclusion that he or she does not have adequate coping resources to deal with pain. It is important to recognize that pain catastrophizing refers to negative emotional and cognitive schema during actual or anticipated painful stimulation. Because of this detail researchers typically measure pain catastrophizing as a trait-like or dispositional variable (Quartana, Campbell, & Edwards, 2009). Moreover, pain catastrophizing is relatively stable over time (Sullivan et al. (1995). Consequently, a moderate proportion of the pain catastrophizing research examines people who are not currently experiencing pain. Researchers adopt this strategy because of the widely held belief that pain catastrophizing (as a trait-like measures) will predict how these people generally respond when in pain regardless of the context of the pain (e.g., training exertion vs. injury).

Researchers have suggested that mindfulness could attenuate catastrophizing cognitions and affect a person's response to pain (e.g., reports of pain intensity: Kingston, Chadwick, Meron, & Skinner, 2007). In addition to the value of mindfulness and acceptance in clinical populations, researchers in sport psychology suggest that mindfulness may indirectly influence sport performance (e.g., Gardner & Moore, 2004; Kee & Wang, 2008). Hence, the ability to accept pain in a nonjudgmental fashion, rather than adding negative judgment to the experience, may be a useful skill for an athlete to acquire.

Pain catastrophizing is evident in athletic populations (Deroche, Woodman, Stephan, Brewer, & Le Scanff, 2011; Sullivan et al., 2000a; Sullivan et al., 2002). The athletes from these studies were not injured, ill, or referred to any chronic pain clinics catastrophize over pain (real or anticipated). Given the relationship between pain catastrophizing and a negative orientation toward pain (i.e., threat) athletes could benefit from developing strategies that help manage catastrophic cognitions. We contend that athletes who do catastrophize could be missing out potentially useful training regimens and may, therefore, be slower. To date, researchers have not shown a relationship between catastrophizing and indicators of performance and it is unclear whether boundary conditions exist (e.g., moderating variables). It is clear that mindfulness and pain are related (in chronic pain populations). However, it is unclear whether the same relationship is evident in athletic populations who are more likely to experience acute rather than chronic pain. Therefore, the examination of pain catastrophizing, mindfulness, and performance in sport is warranted.

To date, few researchers have examined whether gender moderates the relationships between mindfulness and performance (and the indirect paths through pain catastrophizing). Despite preliminary evidence that meaningful relationships exist it is unclear whether the size or direction of the relationship depends on gender. Previous researchers have suggested that there are no meaningful differences in dispositional mindfulness scores between genders (MacKillop & Anderson, 2007). However, in educational contexts Anglin, Pirson, and Langer (2008) reported that mindfulness training did moderate gender differences in academic performance. Furthermore, a review of gender differences in the effectiveness of mindfulness-based treatment for substance abuse showed that females gravitated more towards mindfulness-based treatments and benefited more from mindfulness interventions than males (Katz & Toner, 2013). There is also an emergent body of work that highlights gender as a determinant of pain experiences (Lautenbacher & Rollman, 1993; Unruh, 1996). For example, females typically differ in their behavioral responses to pain. Sullivan, Tripp, and Santor (2000) reported that females engaged in a greater volume of pain behavior when compared with males during a cold-water immersion task (immersing the forearm). Pain behavior included grimacing, rocking and flexing the nonimmersed arm, vocalizations, and shaking or rubbing the immersed limb. Given that gender differences do exist, we contend that it is likely that the magnitude of the relationships between mindfulness and performance, mindfulness and pain, and pain and performance will differ between males and females.

To this end, the purpose of this study was to examine the relationship between mindfulness and 800m PB times through pain catastrophizing and to see whether the magnitude and direction of the relationship depended on gender. We chose 800m PB time as our outcome variable because training for the 800m event is painful. Specifically, when people train and compete at high intensities (e.g., an exercise intensity that approaches or exceeds $\dot{V}O_{2max}$: Wood, 1999). We hypothesized that mindfulness would be negatively related to 800m PB time because people high in mindfulness would be low in pain catastrophizing. Furthermore, people low in pain catastrophizing would attend to athletic pain (e.g., lactate build-up) in such a way that will enable them to run more quickly than their lower mindful counterparts.

Methods

Participants

Following ethical approval from the authors' ethics subcommittee we recruited a sample of competitive athletes. We recruited athletes from online forums and through the British Miler's Club email list (BMC: An elite middle distance running club in the United Kingdom). We asked participants aged 18-40 years, who were not injured and had a PB time for the 800m to consider participation. We chose this age range because we could not gain parental consent for under 18s via the internet and PB times likely changed regularly as under 18s matured physically. We did not recruit over the 40s because we felt it was unlikely that participants over the age of 40 were recording new PBs

Procedure

If the participants met our inclusion criteria and wanted to participate in the study, we invited them to click a link written in the email or on the forum post. The link took them to an online information letter, consent form, and battery of questionnaires. We did not record the location or the context of where the participant was when completing the questionnaires. All we can infer is that the participants completed the questionnaires within the range of an internet connection.

Instruments of Data Collection

Demographic questionnaire. We used a demographic questionnaire to record gender, date of birth, and 800m PB times. Participants reported PB times in minutes and seconds, and we converted these values into a value in seconds. We then standardized 800m PB time by dividing the participants' PB by current world record time (males = 100.91 seconds, females = 113.28 seconds). Standardized scores ranged from 1.06 to 1.67. These scores represent a percentage difference between each participant and the world record. For example, a participant scoring 1.06 reveals that that his or her 800m PB time is 6% slower than the current world record (i.e., approximately 7 seconds for males). Subsequently, higher scores demonstrate slower times.

PCS. We used the pain catastrophizing scale (PCS; Sullivan et al., 1995) to measure catastrophic thinking associated with pain. The PCS instructions asked participants to reflect on painful experiences and to indicate the degree that they experienced thoughts or feelings when experiencing pain. The 13-items were scored on a 5-point scale (0 = *not at all* and 4 =

all the time). The PCS yields a total score and three subscale scores assessing rumination, magnification, and helplessness. For the current study, we chose to use total pain catastrophizing score only because we were interested in the combination of catastrophizing constructs. The PCS has high internal consistency (α = .87; Sullivan et al., 1995).

MAAS. We used the mindful attention awareness scale (MAAS; Brown & Ryan, 2003) to measure individual differences in the frequency of mindful states over time. The MAAS instructions ask participants to rate how frequently they have the experience characterized in each statement. The 15-items were scored on a 6-point scale (1= *almost always* and 6 = *almost never*). The MAAS yields a total score with high scores reflecting high levels of dispositional mindfulness and has high internal consistency (α = .82; Brown & Ryan, 2003).

Data Analysis Plan. We examined the magnitude of the relationships between study variables using zero-order correlations. The purpose of these tests was to examine each relationship separately before considering the model as a whole. Next we conducted first-order partial correlations (controlling for gender) to examine whether the magnitude or direction of the relationship changed. Finally, we used the analytic methods discussed by Hayes (2013) to examine the relationship between mindfulness on 800m PB times through pain catastrophizing. These analytical methods also allowed us to see whether this relationship was moderated by gender (see Figure 1). We avoided multiple testing of the separate paths (and the associated errors) with several separate regressions by replacing multiple testing with one moderated mediation model using PROCESS (Hayes, 2013). We used the Hayes' (2013) PROCESS add-on for SPSS because of the ease by which it allows the researchers to specify a model in the SPSS environment. It is not within the scope of this article to discuss the range of benefits of using PROCESS against older approaches to mediation and moderation (e.g., Baron & Kenny, 1986). We refer the readers who wish to learn more about PROCESS to Hayes (2013).

Results

Data Screening and Preliminary Analyses

In total 163 participants submitted data. We removed 21 participants from further analysis because they were under the age of 18 years, 18 participants because they were over the age of 40 years, and 15 people who were injured. The total sample comprised 109 participants, 73 males (M_{age} = 25.48 years, *SD* = 5.31) and 36 females (M_{age} = 24.53 years, *SD* = 5.46). The calculation of standardized scores for skewness and kurtosis revealed that pain catastrophizing, and mindfulness had a normal distribution; however, standardized 800m PB times were extremely skewed.

Rather than transforming standardized 800m PB, we decided to keep the distribution as nonnormal. We did this because ordinary least squares regression is robust with respect to skewness and nonnormality and is insensitive to violations of the fundamental assumptions of normality (Norman, 2010). We screened for univariate outliers on mindfulness, pain catastrophizing and standardized 800m PB time by creating standardized scores and boxplots for each variable identifying outliers as any participant ± 3.29 z scores from the mean. We also screened for multivariate outliers using a $p \leq .001$ criterion for Mahalanobis D^2. We found three univariate outliers (> 3.29 on the standardized 800m PB time) and no multivariate outliers in the sample. We decided to retain these outliers because even though their 800m PB times were slow compared to the rest of the sample it was likely that they did represent real values. We calculated estimates of internal reliability (Cronbach's α) for mindfulness (α = .865) and pain catastrophizing (α = .914). We then calculated zero order and first order partial correlations (controlling for gender: see Table 1).

Moderated Mediation Model

We initially tested the conditional process model where gender moderated all direct and indirect paths; however, results showed that gender did not moderate the direct path between mindfulness and standardized 800m PB time. Consequently, we removed the non-significant interactions (Hayes, 2013) and reanalyzed the data using a new model where gender moderated the indirect paths only (See Table 2).

There was a significant direct effect of mindfulness on standardized 800m PB time, $b = -0.003$, 95% BCa CI [−0.005, −0.001]. There was a significant indirect effect of mindfulness on standardized 800m PB through pain catastrophizing in females, $b = 0.003$, 95% BCa CI [0.001, 0.005]. However, the indirect effect of mindfulness on standardized 800m PB through pain catastrophizing in males was not significant, $b = 0.000$, 95% BCa CI [− 0.001, 0.000]. Follow-up probing of the interaction between mindfulness and gender on pain catastrophizing showed a stronger negative relationship between mindfulness and pain catastrophizing in females ($b = -0.577$, $t = -4.190$, $p \leq .001$) compared with males ($b = -0.220$, $t = -2.409$, $p = .018$: see Figure 2).

Probing the interaction between pain catastrophizing and gender on standardized 800m PB time showed that greater pain catastrophizing was associated with quicker times in females ($b = -0.003$, $t = -2.126$, $p = .036$) but slower times in males ($b = 0.001$, $t = 2.004$, $p = .048$ see Figure 3). The multiplication of the two indirect paths and the direct path (i.e., a x b x c) was positive. This result indicated complementary mediation (Zhao, Lynch, & Chen, 2010) otherwise known as partial mediation (Baron & Kenny, 1986).

The index of moderated mediation, which is a test of equality of the conditional indirect effects across gender, was 0.003, 95% CIs [0.001, 0.006]. As this confidence interval does not include zero, we concluded that the indirect effect of mindfulness on 800m PB times through pain catastrophizing is moderated by gender (Hayes, 2014).

Discussion

The purpose of this study was to examine the relationship between mindfulness and 800m PB times through pain catastrophizing and to see whether the magnitude and direction of the relationship depended on gender. We hypothesized that mindfulness would be negatively related to 800m PB time. We hypothesized that people who were high in mindfulness would be low in pain catastrophizing. These individuals who were low in pain catastrophizing would attend to athletic pain (e.g., lactic acid) in such a way that will enable them to run more quickly than their low mindfulness and high catastrophizing counterparts. We also hypothesized that the magnitude of these relationships could be different based on the gender of the participants.

Our results revealed that in the current sample, a significant association does exist between mindfulness and standardized 800m PBs through pain catastrophizing and the relationship is moderated by gender. Results of zero-order and first-order partial correlations revealed moderate to large sized relationships between the mindfulness and 800m PBs; however these relationships reduced in magnitude after controlling for gender. The reduction in magnitude suggested that some of the relationships were moderated by gender. The subsequent conditional process analysis revealed a significant direct path between mindfulness and 800m. Gender did not moderate this direct path but gender did significantly moderate the indirect path. The direction of the relationship between mindfulness and 800 PB was in the predicted direction. Specifically, mindfulness was negatively related to standardized 800m PB times. Specifically, the participants in the current sample with higher mindfulness scores reported PB times that were closer to the world record than participants with lower mindfulness scores. The path between mindfulness and pain catastrophizing was in the predicted direction. However, the path between pain catastrophizing and standardized 800m PB time was not what we expected.

Theoretical Implications

These findings have important theoretical implications for mindfulness and pain catastrophizing in the sports domain. We were able to show a significant correlation between dispositional mindfulness and standardized 800m PB times.This association meant that higher levels of dispositional mindfulness correlated with 800m PB times that are closer to the world record. A significant direct path in the mediation analysis suggesting that dispositional mindfulness is beneficial for middle distance runners. According to Baron and Kenney (1986), full mediation occurs when a significant r_{xy} reduces to a nonsignificant direct effect in a mediation analysis. Current findings revealed a significant r_{xy} and a significant direct path, which may show an omitted mediator. Therefore, future researchers could consider other ways in which mindfulness indirectly influences middle distance performance (e.g., coping, attention, perfectionism).

The path between mindfulness and pain catastrophizing is consistent with the existing literature. For example, Schütze et al. (2010) stated that mindfulness uniquely predicted pain catastrophizing in a sample of chronic pain outpatients. Schütze and colleagues believed that a person’s ability to focus on what is happening in each moment might inoculate against the onset of pain catastrophizing. Eccleston and Crombez (1999) stated that pain could emerge over other demands for attention; however, the interruptive function of pain depends on pain related characteristics (e.g., threat level of pain). Therefore, it may be that a catastrophizer has his or her attention disturbed to a state of cognitive and behavioral disruption whenever a painful stimulus occurs (Leung, 2012). Consequently, there is the possibility that mindfulness corresponds with pain catastrophizing because higher mindfulness prevents or diminishes this disruption. People high in mindfulness can become aware of the pain and accept the experience as it emerges in a nonjudgmental style rather than a catastrophic form.

The path between pain catastrophizing and standardized 800m PB time was not what we expected. Probing of the interaction between pain catastrophizing and 800m PB suggested that higher pain catastrophizing was associated with faster 800 PB times in females. Existing research suggests that adopting a catastrophic cognitive style may increase the aversive nature of subsequent pain experiences (Keefe et al., 2000) rather than improve performance. In the current study, females who reported higher pain catastrophizing also reported quicker 800m PB times. Previous studies have shown males report lower pain catastrophizing than females (Sullivan et al., 2000b), which could mediate subsequent experienced pain intensity. However, gender differences in pain catastrophizing do not explain the observed antagonistic effects. It appears that pain catastrophizing was performance enhancing for females. Even so, it is not clear whether each facet of pain catastrophizing contributed equally to this effect. It is feasible to hypothesize that magnifying or ruminating on pain may improve performance if athletes perceive pain to be a beneficial investment. By magnifying and ruminating on pain athletes may increase efficacy beliefs because more pain may signify they are training harder and are thus more likely to improve performance. As a result, researchers may wish to examine the components of pain catastrophizing to test this hypothesis.

Sullivan, Tripp, and Santor (2000b) reported that females often report higher pain catastrophizing than males. Similarly, Keefe et al. (2000) reported gender differences on pain catastrophizing and pain behavior (i.e., social communication of pain) possibly because of social learning at a young age. Specifically, Keefe and colleagues suggested that females may catastrophize more than males because young women are socialized to express pain and adult caregivers provide more comfort to children showing greater degrees of distress. Unruh (1996) reported the influential role differences in socialization experiences have upon male and female expressions of pain (e.g., pain behavior). For example, social and cultural norms are a prominent factor where males more so than women are encouraged to endure pain and become adept in minimizing its effects. These socialization effects may also provide a potential explanation for the antagonistic effects observed in the current study and, therefore, require further study. Specifically, females may learn to express heightened distress as a form of social communication about pain (Keefe et al., 2000, Sullivan, 2008). This communication could be an attempt to derive empathy-driven responses from the social environment (e.g., from coaches). The result of heightened distress could be more social support, which may indirectly positively influence performance because of the extra coaching provided. Males may receive less support when expressing pain on the other hand. This issue may be particularly true if coaches adopt a no "pain no gain" attitude or athletes are told to "man up." To date, the degree to which males and females differ on pain catastrophizing has been studied in clinical samples; however there are limited investigations of pain catastrophizing in athletes. The results of the current study suggest more research into gender differences in sport is warranted.

Practical Implications

These findings have significant implications for scholars and practitioners who work with middle distance runners or who have an interest in mindfulness and pain. Most notably, our results suggest that males and females are different in terms of mindfulness and pain catastrophizing, and coaches need to recognize that pain catastrophizing could be performance enhancing in female middle distance athletes. Deroche, Woodman, Stephan, Brewer, and Le Scanff (2011) examined pain catastrophizing to predict combat athletes' inclinations to play through pain. Results revealed that pain catastrophizing led athletes to reduce their physical involvement in their sports activity and the more an athlete catastrophized his pain, the less he was inclined to play through the pain. In the context of middle distance running the gender of the athlete could be an important variable. Gender may determine whether athletes reduce involvement or use catastrophizing as a form of communal coping (i.e., express pain to engender support).

It is important that coaches and athletes recognize that pain can be an indication of tissue damage or similar physiological processes. Therefore, coaches should not encourage athletes to accept pain and push through the extreme discomfort if doing so could cause long term damage. Catastrophizing is analogous to a false alarm based on exaggerated perceptions of potentially benign stimuli. It is possible that athletes are not exaggerating, and the pain stimulus is not harmless and coaches must, therefore, allow athletes to behave accordingly. A careful balance, therefore, needs to be struck to maintain a safe training environment and to promote adaptation to training.

Researchers have shown that practitioners can apply mindfulness training in sports domains. However, few people have considered whether dispositional mindfulness is amenable to change. We adopted a relatively stable unidimensional measure of mindfulness; however it is likely that mindfulness is a skill that can be learned and may be domain specific (e.g., mindful training vs. competition). A multidimensional measure of mindfulness may better measure the unique nature of the construct in the context of athletic pain. Researchers may, therefore, consider alternative measurement models in future research (e.g., Five Facet Mindfulness Questionnaire: Baer, Smith, Hopkins, Krietemeyer, & Toney, 2006).

Limitations and Future Research Directions

It is important to note that the cross-sectional nature of the current study renders us unable to infer causality. Therefore, these emergent results warrant replication over time with larger samples, so the accuracy of interval estimates increase. Researchers may also wish to design studies that involved the manipulation of mindfulness attributes and pain catastrophizing to establish whether a causal relationship exists.

Limitations of the study included the distinctiveness of the sample and the nature of online data collection. We chose to recruit a sample of competitive middle distance runners because of the likelihood they experienced regular, painful high-intensity interval training. It soon became apparent that individuals who did not compete or train frequented the online forums that we used for data collection. Consequently, we could not include many potential participants because they were not from our population of interest. The participant deletions considerably reduced our sample size and negatively influenced the precision of the interval estimates. A larger sample could have increased the accuracy of the parameter estimates compared with a smaller sample. Hence, the range of values falling between upper and lower confidence limits could have been reduced (as accuracy is increased the intervals get smaller). Some participants may have falsified personal best times. We did not collect data that we could use to identify participating athletes and could not check personal best times, so the veracity of our outcome variable remains undetermined due to issues of anonymity. Because of the model of online data collection, it is also unclear whether participants completed the measures alone or with the help and observation of others (e.g., coaches and peers). Researchers should include measures of social desirability responding, given the demand characteristics of this research. Finally, given the distinctiveness of the sample we cannot draw inferences about relationships between mindfulness and pain catastrophizing in other running disciplines or sports that integrate painful training sessions (e.g., cycling).

The MAAS and PCS demonstrated good internal reliability; however, it is important to note that neither measure was perfect; therefore, the relationships that we reported were limited by measurement error. Researchers may wish to try to reduce error or investigate relationships using statistical methods that account for measure error at the item and subscale level. Pain is multifaceted, and participants may have been thinking about experiences related to different types of pain (e.g., injury) when completing the battery of questionnaires. Consequently researchers should consider the context of pain, and level of meaning attached to pain, as we assumed that pain was a negative experience. It is possible, however, that pain athlete's perceived pain positively (i.e., training harder).

Researchers may wish to design experiments and conduct prospective longitudinal studies to see whether mindfulness and pain catastrophizing translate into behavior over time, specifically, faster times. The utilization of experimental designs that allow for the manipulation of mindfulness skills between groups of athletes across an athletic season is a viable way forward. Researchers may also wish to use prospective research designs where they measure mindfulness, pain catastrophizing, and running times at different times in the season to see whether temporality can be established.

Conclusion

The purpose of this study was to examine the relationship between mindfulness and 800m PB times through pain catastrophizing and to see whether the magnitude and direction of the relationship depended on gender. Our study offers several significant contributions to the study of mindfulness and pain catastrophizing. We were able to show a statistically significant association between dispositional mindfulness and performance (standardized 800m PB). Our findings also show that mindfulness contributes to pain catastrophizing, which in turn is related to 800m PB times in females. The finding that higher pain catastrophizing contributes to quicker 800m PB times in females was not consistent with our original hypothesis or the existing literature and thus warrants further research. We hope that these findings stimulate researchers to replicate the current study and extend research in mindfulness and pain catastrophizing in high-intensity sports such as middle distance running.

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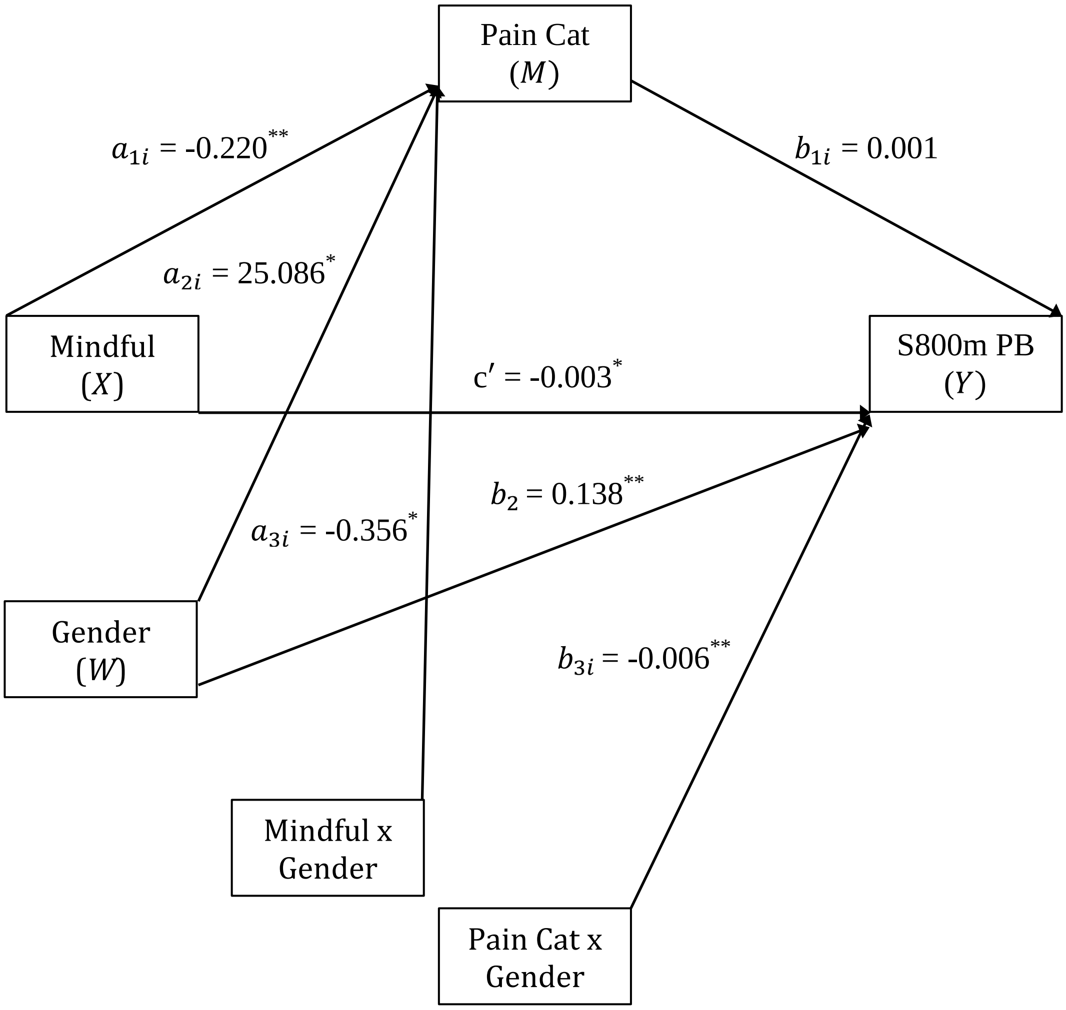
Figure 1. Statistical Diagram of Mindfulness (*X*) on standardized 800m PB (*Y*) through Pain Catastrophizing (*M*) moderated by gender (*W*)



Note. * significant at $p \leq .05$ level (1-tailed), ** significant at the $p \leq .01$ level (1-tailed). Conditional indirect effect of *X* on *Y* through $M_i = (a_{1i} + a_{3i}W)(b_{1i} + b_{3i}W)$. Direct effect of *X* on *Y* = c′

Figure 2. Visual Representation of the Moderation Effect of Mindfulness (*X*) on Pain Catastrophizing (*Y*) by Gender (*W*)

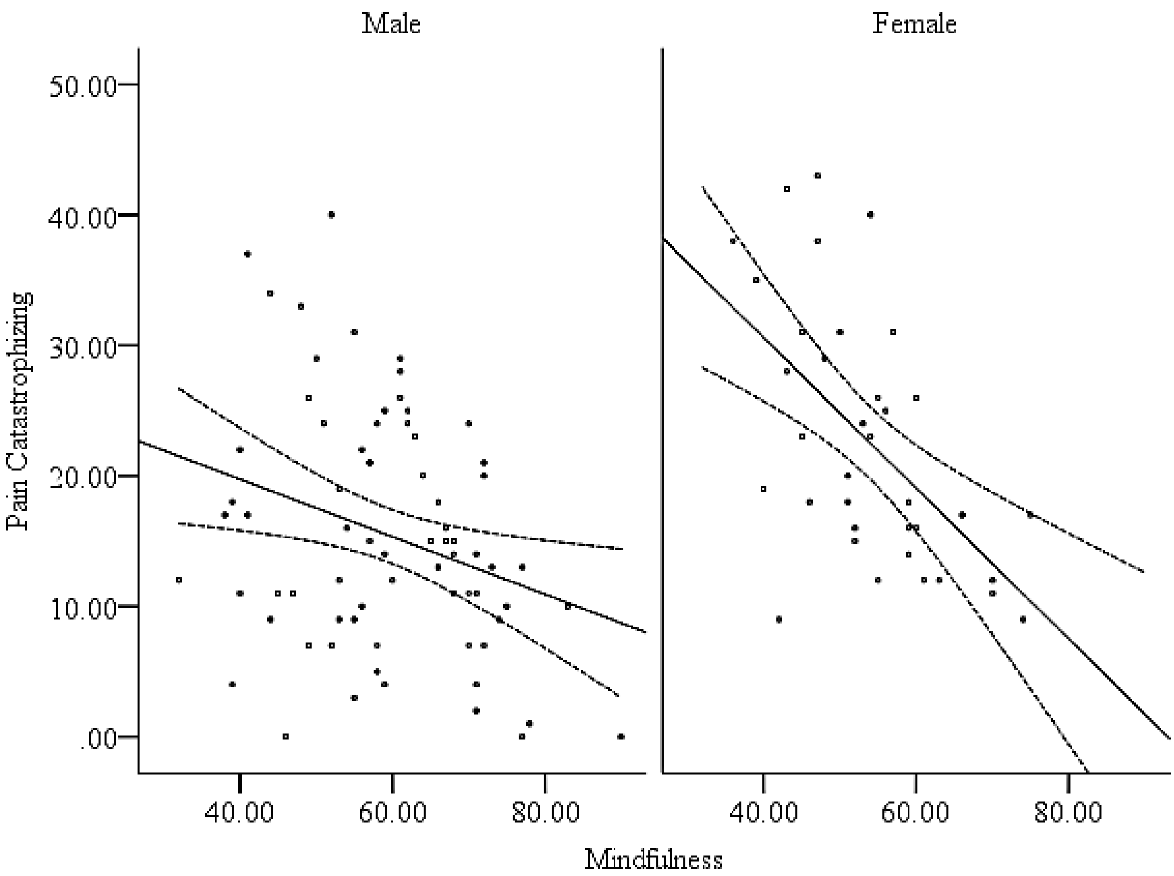


Figure 3. Visual Representation of the Moderation Effect of Pain Catastrophizing (*M*) on Standardized 800m PB times (*Y*) by Gender (*W*)

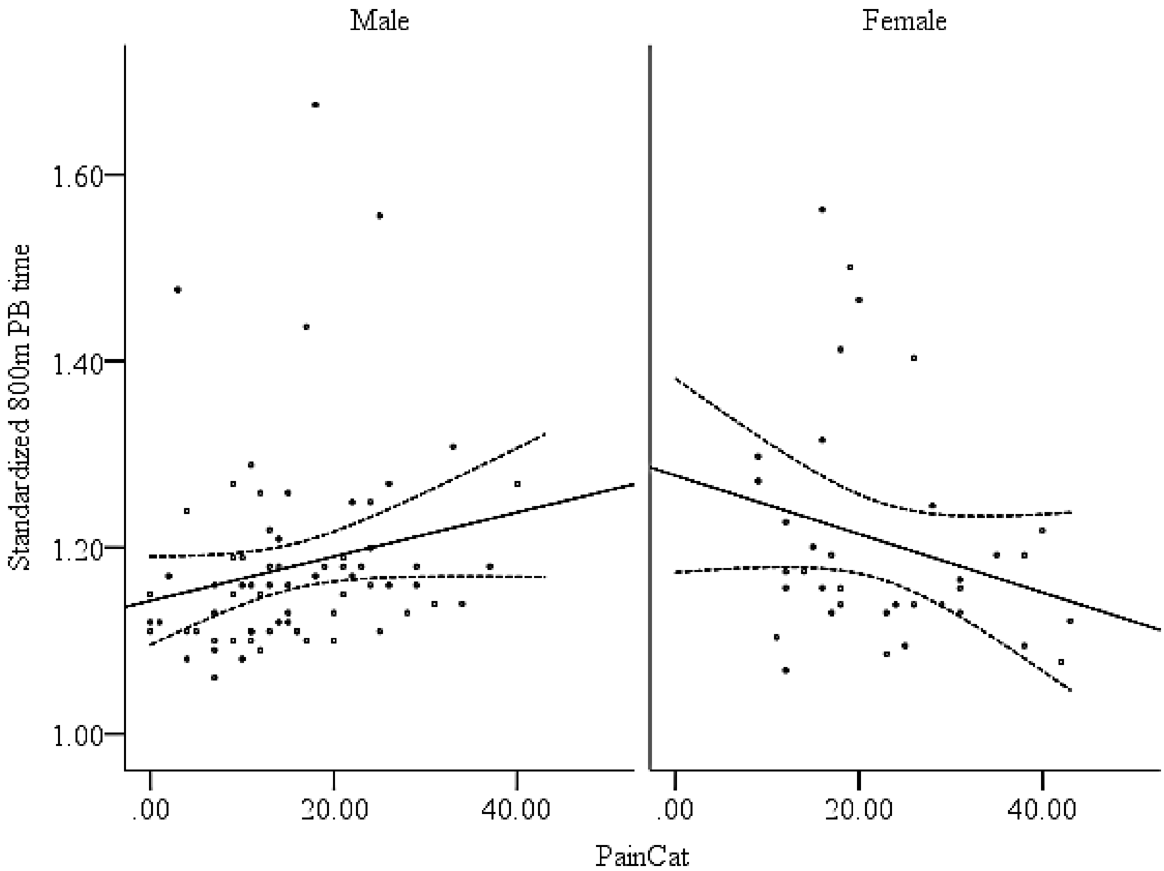


Table 1

Internal Reliability Estimates, Zero-Order Pearson's r, and First-Order Partial Pearson's r between Pain Catastrophizing and Mindfulness, and standardized 800m PB Times

	Zero-order correlations		
Measure	1	2	3
1. 800m PB time			
2. Mindfulness	−.254 [−.403, −.084]***	(α = .865)	
3. Pain Cat	.069 [−.089, .229]	−.415 [−.563, −.249]***	(α = .914)
	First-order partial correlations (controlling for gender)		
Measure	1	2	3
1. 800m PB time			
2. Mindfulness	−.236 [−.402, −.054]**		
3. Pain Cat	.033 [−.139, .206]	−.369 [−.527, −.193]***	

Note. Internal reliability estimates are shown on the diagonals. BCa bootstrap results are based on 10,000 bootstrap samples. BCa 95% CIs [LLCI, ULCI] for Pearson's *r* (1-tailed) are shown in brackets. * Correlation is significant at the $p \leq .05$ level (1-tailed), ** Correlation is significant at the $p \leq .01$ level (1-tailed), *** Correlation is significant at the $p \leq .001$ level (1-tailed).

Table 2

Model coefficients for the Moderated Mediation Analysis

	Consequent							
	M (Pain Catastrophizing)				*Y* (standardized 800m PB time)			
Antecedent	Path	Coeff. [LLCI, ULCI]	*SE*	*p*	Path	Coeff. [LLCI, ULCI]	*SE*	*p*
Constant	i_1	28.557 [16.861, 40.253]	5.899	≤ .001	i_2	1.322 [1.157, 1.487]	0.083	≤ .001
X (Mindfulness)	a_{1i}	-0.220 [-0.402, -0.039]	0.091	.018	c'	-0.003 [-0.005, -0.001]	0.001	.017
M (Pain Catastrophizing)		-	-	-	b_{1i}	0.001 [-0.001, 0.004]	0.001	.311
W (Gender)	a_{2i}	25.086 [5.010, 45.162]	10.125	.015	b_2	0.138 [0.040, 0.237]	0.050	.006
Mindfulness x Gender	a_{3i}	-0.356 [-0.684, -0.029]	0.165	.033		-	-	-
Pain Catastrophizing x Gender		-	-	-	b_{3i}	-0.006 [-0.010, -0.002]	0.002	.002
	R^2 = .265, F(3,105) = 11.276, $p \leq .001$				R^2 = .130, F(4,104) = 3.830, p = .006			

Note. BCa bootstrap results are based on 10,000 bootstrap samples. BCa 95% CIs [LLCI, ULCI].