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THE EFFECT OF MINDFULNESS TRAINING ON MUSCULAR ENDURANCE EXERCISE PERFORMANCE, MINDFULNESS, AND MENTAL TOUGHNESS

Donte McGee

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Department of Kinesiology, Recreation, and Sport
Western Kentucky University
Bowling Green, Kentucky

By
Donte McGee Jr.

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The Effect of Mindfulness Training on Muscular Endurance Exercise Performance, Mindfulness, and Mental Toughness

Donte McGee

Date Recommended 4/5/2024

DocuSigned by:
Scott W. Arnett
639109FF6EF544A...
Chair

DocuSigned by:
Danilo V. Tolusso
91D7499DC2C440C...
Committee Member

DocuSigned by:
5301E46EF970431...
Committee Member

Committee Member

DocuSigned by:
Jennifer Hammonds
EBE3858E068F42D...
Interim Director of the Graduate School

ABSTRACT

THE EFFECT OF MINDFULNESS TRAINING ON MUSCULAR ENDURANCE EXERCISE PERFORMANCE, MINDFULNESS, AND MENTAL TOUGHNESS

INTRODUCTION: Mindfulness training is a method of mental training becoming increasingly popular and has been positively associated with mental toughness, which may be valuable in highly fatiguing and stressful activities, like endurance exercise. Mindfulness training has resulted in increased endurance performance, but limited literature exists on a similar modality, muscular endurance exercise. The purpose of this study is to examine the effect of an acute bout of mindfulness meditation on muscular endurance performance, mindfulness, and mental toughness. **METHODS:** Participants (n=24) completed two sessions, a week apart, of three planks until fatigue, with one-minute rest intervals. Immediately following each plank, RPE was assessed. The first session included baseline assessments of state mindfulness (Toronto Mindfulness Scale) (TMS) and mental toughness (Mental Toughness Index) (MTI). Then, the plank protocol was performed. During the second session, the TMS was administered before conditions. Participants were divided into two 6.5-minute conditions: mindfulness meditation vs audiobook, followed by the TMS and MTI. Then, the plank protocol was administered following conditions. Participants' times were hidden until the completion of the study. Data were analyzed as follows: plank performance and RPE - 2x2x3 mixed measures ANOVA, TMS - 2x3 mixed measures ANOVA, and MTI - 2x2 mixed measures ANOVA. **RESULTS:** No statistical differences were found between condition, time, and day for plank performance ($F_{1.1.430,31.467}$=49.751; $p < 0.329$; $\eta 2$=0.047; N-B = 0.197) or RPE ($F_{1.272,27.976}$=7.764; $p = 0.006$; $\eta 2$=0.261; N-B = 0.830). No significant interaction was found between time x condition on state mindfulness ($p = 0.270$); however, time had a main effect ($p < 0.001$). No statistical differences were demonstrated for time x condition ($p = 0.098$) or time ($p = 0.397$) for mental toughness.

DISCUSSION: An acute bout of mindfulness meditation failed to influence plank performance, perception of exercise performance, mental toughness, and state mindfulness. The minimum effective dosage of mindfulness training needs to be established for performance-related benefits. Future studies should evaluate exercise performance following sport-specific mindfulness interventions in novice and experienced meditators.

Key Words: Mindfulness, mental toughness, muscular endurance exercise performance

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CHAPTER I

THESIS INTRODUCTION

Mindfulness training is a method of mental training that is becoming increasingly popular in performance-based populations, like athletes (Buhlmayer et al., 2017). This type of training involves paying attention purposefully to an individual's present experience accompanied by a non-judgmental awareness (Kabat-Zinn, 2003). Individuals who regularly perform mindfulness training report decreased stress, including athlete (Anderson et al., 2021), clinical (Khoury et al., 2013), and student (Worsely et al., 2022) populations. Thus, mindful individuals find a more effective strategy for managing stress: changing their appraisal and perception of stressful events (Kaiseler et al., 2009).

Changing the appraisal and perception of a stressful event gives an individual more exposure to it (Jones et al., 2002), which has been shown to develop mental toughness (Wang et al., 2021). Mental toughness is crucial for athletes to psychologically manage stressors and enhance performance, including aerobic endurance, where negative perceptions can hinder performance outcomes (Jones et al., 2002, McCormick et al., 2015). Mindfulness training has been shown to improve perception of exercise intensity while increasing running performance (Nien et al., 2020, Wang et al., 2021). However, mindfulness training and its impact on muscular endurance training, a modality like aerobic endurance, remains to be fully understood.

Overall Purpose and Study Significance

The current review sought to investigate the current literature regarding mindfulness meditation as a tool to improve sport and exercise performance. Following the review, a study was developed to investigate the efficacy of mindfulness meditation as a performance enhancer

of maximal muscular endurance exercise. A secondary purpose of the study was to analyze whether an acute bout of mindfulness meditation could influence state mindfulness, mental toughness, and perception of exercise intensity. To the authors' knowledge, there is only one study that assessed the influence of an acute bout of mindfulness meditation on muscular endurance exercise in a group of novice meditators (Stocker et al., 2018), and no study assessing the influence of an acute bout of mindfulness meditation on mental toughness and perception of exercise intensity. The current study has the potential to build on the limited literature of mindfulness meditation as a tool, that can be used acutely, for increasing exercise performance. Additionally, the current study investigated the effects of shorter periods of mindfulness meditation, which can build on the existing literature where it was reported that training mindfulness meditation for extended periods can lead to sport improvement (Gardner and Moore, 2004, John et al., 2011, Lutkenhouse, 2007, Schwanhausser, 2009, Thompson et al., 2011).

Potential Limitations

- Mindfulness meditation as an acute tool has no established dosage
- Novices have difficulty performing mindfulness meditation
- Novices benefit differently than expert meditators

CHAPTER II

Review of the Literature

This literature review begins with an overview of mindfulness training including various parameters. The benefits of mindfulness and the different populations that have been investigated are presented next. The relationship between mindfulness training, mental toughness, and athletic performance will also be discussed. Additionally, mindfulness training and its relationship to pain is examined. Lastly, alternative forms of mindfulness training, such as mobile apps, and the limitations that exist within mindfulness training are highlighted.

Mindfulness Training

Mindfulness training is a mode of mental training involving mindfulness practice. Mindfulness is most often described by Kabat-Zinn (2003) as a form of purposefully paying attention to an individual's present experience, with a non-judgmental awareness. In doing so, an individual must consciously be attentive and aware moment-to-moment (Melbourne Academic Mindfulness Interest Group, 2006). So, mindfulness may be characterized by its two key features: first, maintaining present awareness and second, being open, curious, and nonjudgmental to the current stream of consciousness (Bishop et al., 2004, Verplanken & Fisher, 2014). Mindfulness training typically is delivered through a mindfulness-based intervention (Quaglia et al., 2016). This is commonly accomplished with various techniques, which contain a meditative component (Melbourne Academic Mindfulness Interest Group, 2006). Such techniques typically are formal mindfulness meditations performed either sitting or lying, although mindfulness can be cultivated through daily activities like walking and eating (Holzel et al., 2011, Luberto et al., 2020). Thus, mindfulness training enables a mindful mode of

processing, which keeps the mind receptive, in the moment, and able to create flexible and objective psychological and behavioral responses (Brown et al., 2007).

Cultivating a mindful mode of processing involves enhancing the ability to manage attention and awareness of an individual's sensations, thoughts, and emotions (Baer, 2003). This way of processing is a voluntary and fluid regulation of attention and awareness (Brown et al., 2007). So, through this fluid regulation, an individual can learn to shift their focus like a zoom lens, focusing on situational details while simultaneously having a clear awareness of the larger perspective (Brown et al, 2007). Guiding attention and awareness to the present moment can include attending to an individual's body sensations, emotional reactions, mental images, mental talk, and perceptual experiences (Creswell, 2017). Thus, an individual can monitor their internal and external environments while also adopting an openness or acceptance of the current experience that is inviting to all experiences, even if they are deemed difficult or unpleasant (Creswell, 2017, Gavrilova & Zawadzki, 2023, Schuman-Olivier et al., 2020). Specifically, this lens to the experience should be oriented around curiosity, openness, acceptance, nonreactivity, and nonjudgement (Luberto et al., 2020, Schuman-Olivier et al., 2020).

By adopting this lens, practitioners of mindfulness training can learn to cultivate mindful states more often and raise their baseline levels of mindfulness (Zanesco et al., 2018). Mindfulness has been evaluated as both a dispositional trait (stable characteristic), and a state characteristic (momentary condition) (Tomlinson et al., 2018). Dispositional mindfulness is the tendency to be in a mindful state more often over time (Brown et al, 2007). On the other hand, state mindfulness measures momentary mindfulness (Brown et al., 2007). Regular mindfulness training can raise an individual's baseline level of this trait (Quaglia et al., 2016) enabling them to be more mindful more often. Thus, through both formal and informal mindfulness training, an

individual can build their ability to cultivate mindfulness (Luberto et al., 2020) and its associated benefits.

A range of general benefits from mindfulness training has been cited such as improvements in perceived stress (Anderson et al., 2021, Khoury et al., 2013, Greeson et al., 2014, Huberty et al., 2019, Oman et al., 2010), positive affect and well-being with decreases in negative affect (Anderson et al., 2007, Brown & Ryan, 2003, Carmody & Baer, 2008, Davis & Hayes, 2011, Davidson et al., 2003, Loucks et al., 2021, de Vibe et al., 2018), and emotion regulation (Josefsson et al., 2019, Loucks et al., 2021, Teper et al., 2013). Another commonly reported effect is relaxation, although it should be noted that while there are similarities between relaxation therapies and mindfulness training, the practices are separate from one another (Dunford & Thompson, 2010, Luberto et al., 2020, Melbourne Academic Interest Group, 2006,). In clinical populations, benefits include improvements in mood and anxiety disorders (Kabat-Zinn, 1992, Baer, 2003, Worseley et al., 2021), depression (Strohmaier, 2020 & Worseley et al., 2021), and chronic pain (Kabat-Zinn, 1982, Kabat-Zinn et al., 1985, Cherkin et al., 2016). Additionally, mindfulness training has become popular in performance-based populations, like athletes (Buhlmayer et al., 2017). Benefits cited in athletic performance include improved physiological measures of stress, like cortisol (John et al., 2011), mental toughness (Ajilchi et al., 2019 & Wang et al., 2021), running performance (Nien et al., 2020 & Wang et al., 2021), running economy (Hill et al., 2021), shooting performance (John et al., 2011), basketball performance (Gross et al., 2016), and flow (Hamilton & Schutte, 2016, Kaufman et al, 2009). Thus, mindfulness benefits span from treating clinical populations to helping athletes with performance. Major populations that have been investigated include clinical, student, and athlete populations.

Within clinical populations, Mindfulness Based Stress Reduction (MBSR) is the most well-known form of mindfulness training (Baer, 2003, Creswell, 2017). Kabat-Zinn first employed MBSR, formerly known as the Stress Reduction and Relaxation Program, with a group of chronic pain patients (Kabat-Zinn, 1982). This practice consists of weekly group-based classes with a trained teacher (about 2-2.5 hours long), daily audio-guided home practice (about 45 minutes/day), and a day-long mindfulness retreat during week 6 of an 8-week program (Baer, 2003, Creswell, 2017). Additionally, the mindfulness classes use discussions shaped around how mindfulness is used in their everyday lives and how they manage achievements and stressful challenges with their practice (Carmody and Baer, 2008). MBSR was further demonstrated to be effective in improving ratings of pain in chronic pain patients (Kabat-Zinn et al., 1985) and more recently in improving back pain and functional limitations in patients with chronic low back pain (Cherkin et al., 2016). Additionally, anxiety patients showed significant improvements in anxiety and depression post-intervention (Kabat-Zinn, 1992). Because of the intervention's success, Kabat-Zinn's MBSR has since been applied to other clinical populations (Ludwig and Kabat-Zinn, 2008).

Popular mindfulness-based interventions for other clinical populations that stem from MBSR include mindfulness-based cognitive therapy (MBCT) (Teasdale et al., 2000) and mindfulness-based relapse prevention (MBRP) (Bowen et al., 2014). Although similar in basic program structure, the interventions differ in treating specific populations or outcomes (Creswell, 2017). The interventions focus on treating depression and depression relapse (Teasdale et al., 2000) and drug addiction (Bowen et al., 2014). MBSR influences several other popular mindfulness-based interventions, however, they do not exclusively stem from MBSR as other evidence-based mindfulness interventions do exist (Creswell, 2017), such as Acceptance

Commitment Therapy (ACT) (Hayes & Pierson, 2005, Harris, 2006). Another well-studied, high-stress population that has had success with a variety of mindfulness interventions is college students (Dawson et al., 2020, Worseley et al., 2022).

Due to college students being faced with increasing stressors (Hurst et al., 2012), there is a call for more accessible, and alternative, interventions for improving mental health and well-being (Worseley et al., 2022). Mindfulness interventions have been shown to impact measures of mental stress significantly (Galante et al., 2018, Galante et al., 2020, Greeson et al., 2014, Huberty et al., 2019, Kang et al., 2009, Oman et al., 2010). Additionally, through developing awareness and insight, mindfulness interventions have successfully targeted well-being in college students (Dvorakova et al., 2017, Galante et al., 2020). Of note, mindfulness-based interventions have varied considerably across these studies.

Many differences exist between the interventions utilized in college students, such as population, length of the intervention, home practice, method of delivery, and class structure. Interventions may be designed for specific populations like first-year college students (Dvorakova et al., 2017), nursing students (Kang et al., 2009), division 1 athletes (Baltzell & Akhtar, 2014), and female students only (Wang et al., 2021). Interventions may require home practice (Baltzell & Akhtar, 2014, Galante et al., 2018, Huberty et al., 2019, Greeson et al., 2014, de Vibe et al., 2018), no home practice (Kang et al., 2009, Wang et al., 2021), or varied amounts of home practice (Dvorakova et al., 2017, Loucks et al., 2021). Many interventions had an expert or coach trained in mindfulness (Baltzell & Akhtar, 2014, Dvorakova et al., 2017, Kang et al., 2009, Galante et al., 2018, Greeson et al., 2014, Loucks et al., 2021, de Vibe et al., 2018, Wang et al., 2021), however, one intervention utilized an app grounded in mindfulness practice, Calm (Huberty et al., 2019). Lastly, most interventions made use of group classes (Galante et al., 2018,

Greeson et al., 2014, Dvorakova et al., 2017, Kang et al., 2009, Oman et al., 2010, de Vibe et al., 2018, Wheatley et al., 2021), but not all included this practice (Huberty et al., 2019). Taken together, it is important to note that although many different interventions were used for college students, many facilitated the improvement of mindfulness when measured (Baltzell & Akhtar, 2014, Greeson et al., 2014, Huberty et al., 2019, Kang et al., 2009, Wang et al., 2021). Another population of interest for mindfulness interventions is athletes.

Mindfulness and Athletic Performance

Mindfulness training has become an approach for populations, like athletes, to aid in performing optimally (Buhlmayer et al., 2017, Carraca et al., 2018), leading to performance-specific interventions being developed. Popular sports performance, mindfulness-based interventions include the Mindfulness Acceptance Commitment Program (MAC) (Gardner & Moore, 2004) and Mindfulness Sport Performance Enhancement (MSPE) (Kaufman et al., 2011). These two mindfulness-based interventions are similar in concept; however, their application is different (Carraca et al., 2018, Kaufman et al., 2009).

MAC is based on both Mindfulness-Based Cognitive Therapy and Acceptance Commitment Therapy, while MSPE is more closely related to Mindfulness Based Stress Reduction (Carraca et al., 2018). MAC focuses on incorporating brief meditations with a focus on holding a nonjudgmental stance to all internal and external stimuli and maintaining a clear view of the goals for athletic performance (Gardner & Moore, 2004). MSPE makes use of developing mindfulness skills through various exercises (e.g., meditation, body scan, yoga, and walking) like MAC, however, MSPE does not specifically focus on values, value-driven behavior, or commitment while MAC does (Kaufman et al., 2009). Although these two interventions are the most cited in the current literature, they do not makeup all the interventions

within mindfulness and performance literature (Buhlmayer et al., 2017, Carraca et al., 2018). Nonetheless, mindfulness training within athletic populations has shown many benefits, including relevant athletic outcome measures (Buhlmayer et al., 2017).

Mindfulness training has seen improvements in measures of mindfulness in various athletic populations (Aherne et al., 2011, Ajilchi et al., 2019, Baltzell & Akhtar, 2014, Bernier et al., 2014, Hamilton & Schute, 2016, Hasker, 2010, John et al., 2011, Joseffson et al., 2019, Nien et al., 2020, Schwanhausser, 2009, Scott-Hamilton et al., 2016), which may lead to several benefits. Cortisol, a measure of physiological stress, decreased in elite shooters following mindfulness training (John et al., 2021). Mental toughness, a trait found to correlate with performing better in stressful, difficult environments (Aryanto & Larasati, 2019), improved following mindfulness training (Ajilchi et al., 2019, Wang et al., 2021). Additionally, flow, which is a state of mind that involves being completely absorbed in the task at hand and demonstrating enhanced skill performance (Aherne et al., 2011), has been positively impacted (Aherne et al., 2011, Kaufman et al., 2009, Scott-Hamilton et al., 2016). Flow was found to be positively correlated with levels of mindfulness (Kee & Wang, 2008) and mindfulness training has resulted in an increased ability to reach a flow state (Aherne et al., 2011, Kaufman et al., 2009, Scott-Hamilton et al., 2016). In addition to secondary performance measures improving, objective measures of performance were impacted like shooting performance (John et al., 2011), diving performance (Schwanhausser, 2009), swimming performance (Gardner & Moore, 2004), weightlifting performance (Gardner & Moore, 2004), lacrosse performance (Lutkenhouse, 2007), and running performance (Nien et al., 2020, Thompson et al., 2011, Wang et al., 2021). However, not all mindfulness interventions targeting running performance have been successful (De

Petrillo et al., 2009). Taken together, mindfulness training and how it is impacting athletes must be further investigated to understand optimizing performance.

Several mindfulness training interventions demonstrating performance improvements are case studies (Gardner & Moore, 2004, Lutkenhouse, 2007, Schwanhausser, 2009) that sought to evaluate the effectiveness of MAC (Gardner & Moore, 2012). However, the athletes attained improvements in personal best performances in weightlifting and swimming (Gardner & Moore, 2004), diving performance (Schwanhausser, 2009), and lacrosse performance (Lutkenhouse, 2007). Improvements in process-related measures of awareness and attention were found in the studies as well (Gardner & Moore, 2012). This was especially beneficial for the 19-year-old female lacrosse player because she had significant interpersonal and emotional regulation difficulty (Lutkenhouse, 2007). The athletes ranged in age from adolescent to adult, suggesting that mindfulness training may be beneficial for different age groups. Although the case studies demonstrated improvements in sport performance through mindfulness training, larger groups of people needed to be evaluated to gain empirical support (Gardner & Moore, 2012).

Gardner and Moore (2012) identified four different studies that utilized an open trial mindfulness intervention (Bernier et al., 2009, De Petrillo et al., 2009, Hasker, 2010, Kaufman et al., 2009, Thompson et al., 2011, Wolanin, 2005). Wolanin (2005) demonstrated that MAC can increase self and coach ratings of athletic performance and self and coach ratings of task focused attention and practice intensity in both NCAA Division 1 female volleyball and field hockey athletes. However, this study still suffered from a relatively small sample size with 11 participants, no randomization, and a no-treatment control. The study conducted by Bernier et al. (2012) had only 7 elite adolescent golfers, and only 4 of the participants received mindfulness training. However, all the participants receiving mindfulness training improved their national

rankings, while the participants in the psychological skills training (PST) group showed improvement in only two participants.

These results are comparable to Hasker's (2010) findings when comparing MAC to PST in 19 Division 2 athletes from various sports. Although there were no observed performance differences between groups, the MAC group did demonstrate a higher ability to be nonreactive to inner experiences and act toward goals (Hasker, 2010). The last of the open trial studies cited by Gardner and Moore (2012) with the largest sample size of 57, consisted of adult archers, golfers, and long-distance runners (Thompson et al., 2011). Mindfulness impacted all participants with improved ability to act with awareness, increase flow, and decrease task-related worries (Thompson et al., 2011). The only subset of participants to improve performance were the runners, who had improvements in best mile times (Thompson et al., 2011). However, it should be noted that this study by Thompson et al. (2011) was a one-year follow-up from previous MSPE interventions conducted by Kaufman et al. (2009) and De Petrillo et al. (2009).

In the one-year follow-up, it was noted that the runners had an improvement in best mile times (Thompson et al., 2011), however, the initial study by De Petrillo et al. (2009) cited no significant differences in running performance. There were many limitations to this study including a lack of randomization due to the open trial nature, injuries in the experimental group, the timing of the intervention being between Thanksgiving and Christmas (a busy Holiday season), a short intervention of only 4 weeks, a small sample size, participants being recreational runners and not elite, the participants reporting running less often, and performance being measured by average mile time across runs of all distances (De Petrillo et al., 2009). It was suggested by 80% of the participants that if the intervention had been longer, then they believed it would have been beneficial. Additionally, 80% of the participants reported being able to apply

skills learned in the workshop for dealing with stress in day-to-day life and reported decreases in sport-related worry (De Petrillo et al., 2009). Thus, despite the limitations, these open trial interventions added to the body of literature suggesting that mindfulness training may be beneficial for sport performance (Gardner & Moore, 2012).

Stronger controlled studies, like randomized controlled trials (RCTs), are needed to better gain empirical evidence of mindfulness-based interventions (Gardner & Moore, 2012). Such interventions have been performed on a variety of D1 university athletes (Aherne et al., 2011, Lutkenhouse et al., 2007), DIII female basketball players (Gross et al., 2016), elite male cyclists (Scott-Hamilton et al., 2016), elite male shooters (John et al., 2011), and beginner dart throwers (Zhang et al., 2016). Skill performance such as shooting and dart throwing performance improved following mindfulness training (John et al., 2011, Zhang et al., 2016). Additionally, free throw percentage was significantly correlated with mindfulness levels and basketball experience (Gooding & Gardner, 2009) while basketball performance, measured by coaches' rating of performance, improved following mindfulness training (Gross et al., 2016). The study conducted by Lutkenhouse et al. (2007) demonstrated that 32% of the athletes in the MAC condition had at least a 20% improvement in their coach's ratings of performance in a variety of sports including men's and women's soccer and rowing, women's field hockey, and men's wrestling. The control group in the study conducted by Lutkenhouse et al. (2007) made use of PST and only 10% demonstrated a 20% or more increase in coach's ratings of performance, thus suggesting that mindfulness training is a better method of training for performance improvements.

Taken together these RCTs and other mindfulness interventions demonstrate that mindfulness may be effective for a wide range of sports, including endurance sports. Endurance

sports can be mentally grueling due to their long-term repetitive behavior that induces many uncomfortable physiological feelings like fatigue and pain (De Petrillo et al., 2009, Wang et al., 2021). Additionally, aerobic endurance performance may be altered by how difficult an individual perceives their performance to be (Pageuax & Lepers, 2016), which could relate to the psychobiological model of endurance performance. This model states that individuals undergoing high stress could perceive themselves to be working harder, thus negatively impacting aerobic endurance performance (McCormick et al., 2015). Moreover, Wang et al. (2021) have demonstrated that through mindfulness training, the perception of aerobic endurance exercise intensity can decrease.

Perception may be important for things such as long-distance running, which requires focus on running and simultaneously regulating fatigue, boredom, pain, performance anxiety, and negative thoughts (De Petrillo, 2009). In the study conducted by Wang et al. (2021), mental toughness improved and the participants receiving mindfulness training reported reduced fatigue feelings in an 800-meter run. This result may be further supported by participants' improved running performance, assessed by time until exhaustion on a Graded Exercise Test, in a five-week mindfulness training program conducted by Nien et al. (2020). Additionally, Scott-Hamilton et al. (2016) found mindfulness training can increase the tendency of an athlete to experience flow in elite cyclists.

Flow is the experience of feeling enhanced physical and psychological function through a sense of freedom and lack of negative thought or self-conscious evaluation (Schuler & Brunner, 2009). Scott-Hamilton et al. (2016) found that higher mindfulness scores correlated with more experiences of flow, which is in line with the previous literature (Aherne et al., 2011, Kaufman et al., 2009). Getting into a state of flow may be beneficial for aerobic endurance athletes because

they may potentially deal with negative thoughts during a bout of performance (De Petrillo et al., 2009). Additionally, mindfulness training can impact and reduce the impact of exercise-related worries and exercise-irrelevant thoughts on performance (Wang et al., 2021), thus potentially getting athletes into a state of optimal performance.

Taken together, mindfulness training may be beneficial for a wide range of athletic performances, however, despite a vast amount of literature covering mindfulness and sports, few studies have investigated mindfulness training and exercises like weightlifting. A case study resulted in a 37-year-old elite female weightlifter improving on personal bests (Gardner and Moore, 2004) after being in a training plateau. Additionally, a study by Stocker et al. (2018) investigated the effects of mindfulness training on muscular endurance performance assessed by using maximal performance planks. After cognitively depleting their participants, Stocker et al. (2018) sought to demonstrate that mindfulness training could make up for being depleted.

However, Stocker et al. (2018) did not find that mindfulness training could attenuate the effects of being cognitively depleted. This could have been due to the novice status of the meditators or that it was only an acute bout of mindfulness training (Stocker et al., 2018). However, this study provides a further call for investigating mindfulness training and muscular endurance performance. Muscular endurance is like aerobic endurance in that one must resist discomfort and displeasure (De Petrillo et al., 2009, Thompson et al., 2011, Riberio et al., 2019). Thus, because mindfulness training has been demonstrated to impact factors of aerobic endurance performance (Nien et al., 2020, Scott-Hamilton et al., 2016, Thompson et al., 2011, Wang et al., 2021), and there is a lack of literature regarding other exercise-based modalities, it must be further investigated. Muscular endurance performance, which is fatiguing and produces

feelings of discomfort (Riberio et al., 2019), may especially benefit from mindfulness training the effects of mindfulness training on mental toughness (Ajilchi et al., 2019, Wang et al., 2021).

Mindfulness and Mental Toughness

Mental toughness is the natural or developed psychological edge that allows an individual to cope with the given sport demands and hold more consistency with being determined, focused, confident, and controlled under pressure (Jones et al., 2002). Additionally, it can be thought of as acting toward and maintaining goal-directed pursuits using a psychological resource that is purposeful, flexible, and efficient (Gucciardi, 2017). Gardner & Moore (2004) suggest that mindfulness techniques can improve behavioral flexibility, which may help individuals stay aligned with their goals, further aiding in developing mental toughness. The Mindfulness Acceptance Commitment (MAC) approach aims to improve the in-moment self-regulation required for optimal performance and improve the goal commitment that a performer has using mindfulness techniques (Garnder & Moore, 2004). Additionally, Jones & Parker (2018) found that mindfulness and mental toughness are positively associated. Thus, the link between mindfulness and mental toughness may be due to the ability to maintain goal-directed behavior through aversive events and stimuli.

Mindfulness training significantly impacts skills of emotion regulation (Ajilchi et al., 2019, Davis & Hayes, 2011, Grecucci et al., 2015, Holzel et al., 2011, Teper et al., 2013). Emotion regulation can be thought of as a wide range of strategies an individual can use to alter their emotional responses (Holzel et al., 2011). A strategy that mindfulness training can impact is the ability of an individual to change how they appraise and perceive things such as stressful events (Birrer et al., 2012, Holzel et al., 2011, Kaiseler et al., 2009). By changing the appraisal of a stressful event and being more accepting of the current conditions, an individual can build their

exposure to that event (Birrer et al., 2012, Holzel et al., 2011, Jones et al., 2002, Masicampo & Baumeister, 2007). Positive reappraisal of an event involves reconstructing a stressful event so that it may be beneficial, meaningful, or benign (Garland et al., 2011). By disengaging from the initial negative appraisal of a stressful event, an individual may reduce stress through this reframing or redefining of that event, and even cultivate more positive emotions toward it such as hope or challenge (Garland et al., 2011). Although mindfulness training increases the ability to positively reappraise a stressful event, an individual is nonetheless exposed to external stimuli, body sensations, and emotional experiences (Holzel et al., 2011) that may be otherwise stressful.

Exposure is a mechanism integral to mindfulness practice due to the uncomfortable sensations and emotions that can accompany mindfulness meditation (Baer, 2003). Although pain and even unpleasant emotions may arise during practice, an individual should shift their attention to these uncomfortable feelings rather than away from them (Baer, 2003). However, an individual's attention should still be nonjudgmental towards the sensations and emotions (Baer, 2003, Grecucci et al., 2015). Shapiro et al. (2006) proposed that by adopting an attitude of patience, compassion, and non-striving, an individual can build their capacity to take interest in each experience, and not continually strive for pleasant experiences or push unpleasant experiences away. Similarly, athletes with high mental toughness can better manage stressors such as negative emotions (Aryanto & Larasati, 2019). This may be due to the suggestion that mentally tough individuals can appraise stressful events with a lower level of stress intensity and hold higher perceptions of control (Kaiseler et al., 2009), such as a mindful individual would. Indeed, mental toughness has an influence on coping mechanisms and an individual's ability to thrive in stressful situations (Marshall et al., 2017).

In a study investigating the relationship between mental toughness, appraisal, coping, and coping effectiveness in sport, it was found that higher mental toughness was associated with problem-focused coping (Kaiseler et al., 2009). Problem-focused coping involves the process of minimizing distress through reducing or eliminating the stressor (Kaiseler et al., 2009). A qualitative analysis found that mentally tough athletes are more likely to see a stressor as a challenge and confront it directly (Jones et al., 2007). This is further supported by the idea that mentally tough athletes perform better in difficult and stressful environments (Aryanto & Larasati, 2019). However, individuals who can cope well with stressors tend to have multiple strategies that allow adaptability based on the stressor and circumstances (Gibbons, 2015). Although problem-focused coping is associated with a more positive outcome, another strategy, emotion-focused coping, can be used effectively as well (Gibbons, 2015). Mindfulness falls under the category of emotion-focused coping (Gibbons, 2015).

Mindfulness, although an emotion-focused coping strategy, can still be valuable for sports because it may allow athletes to regain a goal-oriented state of mind (Birrer et al., 2012). Through reappraisal, mindfulness training may be a precursor to building an individual's resilience, further improving the ability to achieve goals (Garland et al., 2011). In a study investigating the effects of mindfulness training on mental toughness and the emotional intelligence of amateur basketball players, mindfulness training significantly increased mental toughness as well as the ability of athletes to handle emotional reactions to stressful situations (Ajilchi et al., 2019). This is in line with previous literature stating that mindfulness training improved mental toughness and perception of pain, and reduced feelings of fatigue in female college students performing endurance exercise (Wang et al., 2021). Thus, through mindfulness training, an individual can improve mental toughness (Ajilchi et al., 2019, Wang et al., 2021). By

being mindful and improving their ability to endure negative states, individuals may even improve their ability to manage pain (Baer, 2003, Birrer et al., 2012, Cherkin et al., 2016, Davis et al., 2015, Ludwig & Kabat-Zinn, 2008, Kabat-Zinn, 1982, Kabat-Zinn, 1985, Morone et al., 2016, Wang et al., 2021, Zeidan et al., 2009, Zeidan et al., 2018), which may further improve performance.

Mindfulness and Pain

Pain was among the first variables investigated for mindfulness training in clinical populations (Creswell, 2017, Kabat-Zinn, 1982, Kabat-Zinn, 1985, Ludwig & Kabat-Zinn, 2008). Kabat-Zinn (1982) believes that prolonged exposure to sensations of pain eventually leads to the ability to experience pain without excessive emotional reactivity. Chronic pain patients significantly reduced their pain symptoms and their dependence on pain-relief medication following Mindfulness Based Stress Reduction (MBSR) (Kabat-Zinn, 1982, Kabat-Zinn et al., 1985). Additionally, follow-up evaluations of the two studies found that many of the positive changes in pain were maintained (Kabat-Zinn, 1987). However, these studies suffered from a lack of an active control condition, so further studies were needed.

Since Kabat-Zinn's initial studies, many studies have been conducted on the effect of mindfulness training on both chronic pain patients and general pain (Creswell, 2017). In a very large RCT with a sample size of 342, Cherkin et al. (2016) found that MBSR reduced functional limitations due to chronic back pain. However, this study compared MBSR to cognitive behavior therapy and a usual care group and found that there was no difference in improvements between MBSR and cognitive behavior therapy (Cherkin et al., 2016). Still, the results are promising given that MBSR significantly improved chronic low back pain (Cherkin et al., 2016) like another mindfulness intervention demonstrating improvements in chronic low back pain

(Morone et al., 2016). Although Cherkin et al. (2016) found no differences between interventions, Davis et al. (2015) found that mindfulness training had the broadest improvements in overall daily pain compared to a cognitive behavioral therapy group and an arthritis education group. Thus, mindfulness training shows similar effectiveness to well-established interventions like cognitive behavior therapy, even when the mindfulness interventions are novel.

Garland et al. (2014) utilized a novel mindfulness intervention, Mindfulness-Oriented Recovery Enhancement (MORE), on a group of chronic pain patients. They concluded that MORE was successful in reducing pain severity up to three months post-treatment and lessened the desire for opioids (Garland et al., 2014). Additionally, the authors believed that MORE positively impacted how chronic pain patients were able to reappraise events (Garland et al., 2014). Taken together, mindfulness training has provided benefits to several samples with chronic pain, but interventions are typically weeks long with multiple sessions per week (Edwards & Loprinzi, 2019). However, Zeidan et al. (2009) demonstrated that even healthy, college-aged individuals may better manage pain following brief mindfulness training.

Pain may be better managed after mindfulness training, or even without extended formal practice. Zeidan et al. (2009) conducted three experiments, two of which investigated the effect of mindfulness meditation on ratings of pain from electrical stimulation. The first of the experiments found that three days of 20 minutes per day of mindfulness meditation significantly decreased the participants' ratings of pain to low and high electrical stimulations (Zeidan et al., 2009). Additionally, the third experiment demonstrated decreased pain sensitivity in a mindfulness mediation group and math distraction group, but the mindfulness meditation group had better overall improvements (Zeidan et al., 2009). Furthermore, higher trait mindfulness in a group of inexperienced meditators correlated with lower pain intensity and pain unpleasantness

ratings (Zeidan et al., 2018). Thus, mindfulness training and having high levels of mindfulness may attenuate the pain an individual feels (McCracken et al., 2007, Zeidan et al., 2009, Zeidan et al., 2018).

For performance, athletes must be willing to remain in contact with unpleasant experiences and often need to extend their threshold of pain (Birrer et al., 2012). Activities producing pain, like endurance performance (De Petrillo et al., 2009, Wang et al., 2021) and muscular endurance performance (Riberio et al., 2019) stand to benefit from improvements in perceptions of pain. Following mindfulness training, Wang et al. (2021) found that undergraduate female college students improved their pain tolerance. Additionally, they were more open and nonjudgmental of the physical experience itself, indicating they were less likely to avoid such a grueling activity (Wang et al., 2021). Thus, through mindfulness training, individuals may better regulate pain, continue the painful activity, and potentially improve performance (Wang et al., 2021). Although mindfulness training is beneficial for many aspects of performance, most interventions utilize extended, in-person training. However, a method that may effectively facilitate mindfulness training in large groups without the need to be in person is using a mobile app (Gal et al., 2021, Gavrilova & Zawadzki, 2023, Mani et al., 2015, O'Daffer et al., 2022, Taylor et al., 2022).

Mindfulness and Apps

Those seeking low-cost and effective treatments for mental health help tend to gravitate toward mental health apps (Mani et al., 2015, O'Daffer et al., 2022). Digital mediums are increasingly popular because they offer wider-reaching, less time-consuming, and more affordable options for improving health (Economides et al., 2018, Gal et al., 2021). Additionally, an RCT conducted by Cavanagh et al. (2013) found that even brief online mindfulness-based

interventions can improve mindfulness and decrease perceived stress, anxiety, and symptoms of depression. A popular mental health app that promotes mindfulness is Headspace® (O'Daffer et al., 2022).

A recent meta-analysis of mindfulness meditation apps showed that they can be valuable tools for managing mental health and well-being (Gal et al., 2021). Headspace® allows users to select a given topic for meditation, such as sleep or stress relief (O'Daffer et al., 2022), offering a wide range of potential uses. However, given the complexity of mindfulness practice and its philosophy, mindfulness apps must explain the concept of mindfulness and its common misconceptions (Mani et al., 2015). Headspace® offers a high efficacy for mindfulness training (Gavrilova & Zawadzki, 2023, Mani et al., 2015). However, in a recent systematic review, it was found that of Headspace® RCTs measuring mindfulness, 4/7 had positive findings while 2/7 had null findings (O'Daffer et al., 2022).

Despite the mixed findings in the RCTs of Headspace® and the effect on mindfulness, the results are still promising (O'Daffer et al., 2022). An app gives individuals the option to have an experienced instructor deliver high-quality guided meditation training with no need for demanding face-to-face training (Cavanagh et al., 2014). The app is low-cost and if it does not provide benefits, then users can discontinue use with a low opportunity cost (Gal et al., 2021, O'Daffer et al., 2022). Additionally, it has been found to work in some samples of people, which if extended to the public, could have further reaching effects (O'Daffer et al., 2022). Headspace® is beneficial to perceived stress ratings for highly stressed populations like healthcare workers (Taylor et al., 2022), medical students (Yang et al., 2018), and college students (Flett et al., 2019).

In an RCT comparing Headspace® to another popular mindfulness-based app and a control app, Headspace® significantly improved measures of depressive symptoms, college adjustment, and mindfulness in college students (Flett et al., 2019). Additionally, this study was broken into a 10-day and 30-day usage period, with benefits being shown after only 10 days of use (Flett et al., 2019), similar to another RCT using Headspace® (Howells et al., 2016). Thus, Headspace® can be effective for various factors of mental health in as little as 10 days and the positive mental health benefits acquired were better maintained in those who continued use of the app (Flett et al., 2019). Other RCTs have also found that more frequent use of Headspace® is associated with greater improvements in psychological outcomes (Bostock et al., 2018, Taylor et al., 2022). It should be noted that usage was much higher in the first 10-day period than in that of the 30-day continued access period (Flett et al., 2019), which supported the researcher's hypothesis that short-term, adherence-requested usage would be higher than during the medium-term, discretionary use period.

Flett et al. (2019) used a medium-term, discretionary use period to measure app usage in a naturalistic way, rather than having the researchers require a certain amount of use. O'Daffer et al. (2022) confirm that app usage may be different in a naturalistic compared to an experimental setting. Additionally, Yang et al. (2018) had 88 medical students enroll in a Headspace® intervention after being invited via email. After being stratified by year in medical school and split into intervention and control groups, the intervention group was asked to download Headspace® and use the app daily, or as much as possible for 30 days (Yang et al., 2018). Although the intervention group was given access to the app, only 27/45 participants downloaded and used the app at least one time (Yang et al., 2018). It should be noted, however, that those who did use the app used it for 11.97 days on average with no reminders or outside

accountability demonstrating that Headspace® can be effective in a relatively short time frame for decreasing perceived stress (Yang et al., 2018). A study conducted on healthcare workers demonstrated that stress could decrease up to 4.5 months from Headspace® usage compared to an active control (Taylor et al., 2022).

Taken together, Headspace® may be an effective means for targeting mental health through mindfulness training in a low-cost, easily accessible manner (Economides, 2018, Gal et al., 2021). Additionally, it can help in a relatively short time frame for symptoms such as mental stress (Yang et al., 2018). Although mindfulness training may be more effective in person, some studies have demonstrated that mindfulness training delivered digitally is comparable to traditional delivery methods (Compen et al., 2018). There is concern with digital interventions, however, as there are typically high attrition rates (Gavrilova & Zawadzki, 2023). Despite high attrition rates, digital interventions typically being low-cost and easily accessible make them valuable for those who decide to use them and continue use. Thus, mindfulness training can be effectively delivered through digital mediums, such as Headspace® (Bostock et al., 2018, Flett et al., 2019, Howells et al., 2016, O'Daffer et al., 2022, Yang et al., 2018), however many limitations exist within all mindfulness training interventions that require further investigation.

Limitations in Mindfulness Interventions

Mindfulness training has been demonstrated to be beneficial for clinical and non-clinical populations for various mental health outcomes, however, limitations do exist within the literature (Strohmaier, 2020). A major limitation is the time investment that interventions typically take (Edwards & Loprinzi, 2019, Mahmood et al., 2016, Strohmaier, 2020). Traditional mindfulness interventions run over eight weeks with one-hour face-to-face sessions (Cavanagh et al., 2013, Mahmood et al., 2016, Morledge et al., 2013, Strohmaier, 2020). Additionally, most

mindfulness interventions, like Mindfulness-Based Stress Reduction (MBSR), require a skilled practitioner, may not be cost-efficient, and are limited to the location of the skilled practitioner (Mahmood et al., 2016, Morledge et al., 2013). In addition to the need for a skilled practitioner, Crane et al. (2010) found that the proficiency of the practitioner is an important factor.

A form of mindfulness intervention that reduces the need for a skilled practitioner is an online intervention (Compen et al., 2018). Specifically, interventions can be delivered through audio guides, online programs, or even smartphone apps (Cavanaugh et al., 2013). Online interventions may be a valuable tool for modern mindfulness-based interventions due to the cost-effectiveness and wide reach that they provide (O'Daffer et al., 2022) and the lower time requirement than traditional mindfulness-based interventions (Strohmaier, 2020). Thus, apps such as Headspace® provide access to mindfulness training that would otherwise require in-person training with a skilled practitioner (Gavrilova & Zawadzki, 2023). Although apps may replace the need for in-person training, there is still confusion about the optimal length of mindfulness-based interventions as the time demands typical of an 8-week MBSR program are a primary reason for declining participation in studies (Carmody & Baer, 2009).

Typical interventions lasting eight weeks are not always feasible or practical (Mahmood et al., 2016, O'Daffer et al., 2022). Thus, interventions investigating the short-term effects of mindfulness training are necessary. In a series of experiments conducted by Mahmood et al. (2016), it was found that as short as five minutes of mindfulness training delivered online can increase state mindfulness. Additionally, this mindfulness training was delivered with no specialist input, thus the participants could carry out the training on their own with no additional help (Mahmood et al., 2016). Being able to autonomously train mindfulness skills and raise state

mindfulness may improve the ability to use mindfulness in day-to-day life (Mahmood et al., 2016).

Being able to transfer skills into daily life is especially important in busy, stressed populations like college students (Hurst et al., 2012). Flett et al. (2019) found that mobile mindfulness training may be a valuable tool to improve adjustment to college life and enhance the ability to cope with stressors. Technology gives the option of potentially effective mental health care while overcoming many barriers typically associated with mental health care interventions (Price et al., 2014). Gaining access to a relatively low-cost, easily accessible form of training such as a mobile app eliminates the need for relying on costly, impractical in-person mindfulness-based interventions (Flett et al., 2019, Gavrilova & Zawadzki, 2023). It should be noted that in-person mindfulness-based interventions may be more effective (Taylor et al., 2022), although Compen et al. (2018) found an online mindfulness-based intervention was similarly effective to a traditional, in-person mindfulness-based intervention. Thus, given the benefits of cost, feasibility, and practicality, online mindfulness-based interventions such as mobile apps provide greater access to mindfulness training that may otherwise not be available (Gavriolva & Zawadzki, 2023). Mindfulness interventions can be effective both online and in person, but the length of interventions is often extremely varied (Strohmaier, 2020).

Despite the variety in length of mindfulness-based interventions, they seem to be effective in both lower and longer-dose interventions (Strohmaier, 2020). Additionally, in the general population, without clinical mental health issues, brief interventions may be the strongest (Strohmaier, 2020). It is noted that the amount of time spent engaging in individual mindfulness practice has a dose-response relationship with improvements in mindfulness (Jha et al., 2017, Strohmaier, 2020). However, in a qualitative study investigating barriers to practicing a self-help

mindfulness intervention in healthcare staff, the large time commitment was seen as a large barrier (Banerjee et al., 2017). Thus, the establishment of brief mindfulness interventions is an important step in providing more accessible mindfulness training, especially to populations that have busy schedules (Banerjee et al., 2017).

The length of mindfulness-based interventions may vary, but the interventions are nonetheless effective (Creswell, 2017). An area that still plagues mindfulness research, however, is the lack of rigorous control or comparison conditions (Baer, 2003, Brown et al., 2007, Davidson & Kaszniak, 2015). Mindfulness intervention RCTs typically use a treatment-as-usual group or a wait-list control group but fail to use an active control group with a similar structure to mindfulness (Creswell, 2017, Davidson & Kaszniak, 2015). However, it is very difficult to blind a participant to the fact that they are receiving mindfulness training, therefore a wait-list control is often needed when trying to attribute changes in outcome due to mindfulness training (Davidson & Kaszniak, 2015). Mindfulness interventions should thus utilize several control or comparison conditions to filter out alternative explanations or mechanisms (Davidson & Kaszniak, 2015). Taken together, mindfulness interventions should make use of several groups to understand the effect of mindfulness, so active control conditions such as relaxation interventions (Creswell et al., 2016) or health education programs (MacCoon et al., 2012, Morone et al., 2016) have emerged to attempt to match mindfulness interventions.

A final limitation is mindfulness training and its effects may be different among novice and experienced meditators (Davidson & Kaszniak, 2015, Jha et al., 2017). Novice meditators often report feeling frustrated when developing the awareness that their mind wanders off task during practice (Jha et al., 2017). Novices also are unable to recognize mind wandering as quickly, resulting in more time spent mind wandering (Malinowski, 2013). Additionally, novices

need more cognitive effort to sustain attention compared to experts (Falcone & Jerram, 2018). Mindfulness is a skill that can be learned (Falcone & Jerram, 2018), and brain imaging has shown that the executive control network (the region of the brain responsible for attention) is more active in expert meditators indicating better attentional control. So, mindfulness training can alter the function of an individual's brain (Falcone & Jerram, 2018) establishing differences between novice and expert meditators.

Taken together, mindfulness interventions have many ways of being conducted and of evaluating the effect of mindfulness training (Davidson & Kaszniak, 2015, Creswell, 2017, Strohmaier, 2020). Additionally, the effect of mindfulness training may be mediated by the amount of experience an individual has with mindfulness training (Falcone & Jerram, 2018). Regardless, mindfulness training is an effective means of providing benefits to mental health (Creswell, 2017, Strohmaier, 2020). Furthermore, mindfulness training is increasingly popular among athletes as it may impact sports performance (Buhlmayer, 2017). Additionally, there is a lack of literature surrounding mindfulness and its impact on exercise performance that is not aerobic endurance, skill, or team-sport related. Thus, the effect of mindfulness training should be investigated on muscular endurance exercise performance, a modality of exercise like that of which mindfulness training has already been investigated.

CHAPTER III

THESIS MANUSCRIPT

Introduction

Mindfulness training can be described as purposefully paying attention to an individual's present experience, with a non-judgmental awareness (Kabat-Zinn, 2003), and has received increased attention due to the wide range of reported psychological benefits (Khoury et al., 2013). Additionally, mindfulness training enhances body awareness and stress management, potentially influencing how individuals approach stressful events (Kaiseler et al., 2009, Treves et al., 2019). It is an effective method for reducing mental stress in athletes (Anderson et al., 2021) and students (Worsely et al., 2022), and reducing physiological measures of stress (John et al., 2011). It may also improve mental toughness (Wang et al., 2021), defined as the ability to cope with stressors (Jones et al., 2002).

The proposed mechanism explaining the beneficial effects of mindfulness training on mental toughness is termed increased exposure, which enables athletes to face rather than avoid negative emotions and states (Birrer et al., 2012). By increasing the ability to endure negative states, mindfulness training may enhance performance (Birrer et al., 2012). This approach can lead to viewing stressful events as challenges, reducing perceived stress intensity and positively impacting performance (Kaiseler et al., 2009, McCormick et al., 2015). Additionally, mindfulness training may improve aerobic endurance by affecting how athletes perceive performance difficulty, a critical aspect that could impair performance (Pageuax and Lepers, 2016, McCormick et al., 2015). Endurance exercise requires sustained focus and management of fatigue, boredom, pain, performance anxiety, and negative thoughts (De Petrillo et al., 2009) and

evidence suggests mindfulness can alleviate exercise-related concerns while enhancing running performance (Nien et al., 2020, Thompson et al., 2011, Wang et al., 2021).

Although mindfulness training may benefit aerobic endurance performance, there is little research in existence on a similar exercise modality, muscular endurance. Muscular endurance can be defined as the capability to resist muscular fatigue while using submaximal resistances (Schoenfeld et al., 2021). To the authors' knowledge, Stocker et al. (2018), are the only researchers that investigated the effects of mindfulness training on muscular endurance performance. Stocker et al. (2018) investigated whether an acute bout of mindfulness training could improve muscular endurance performance, although no performance benefits were found. However, they found state mindfulness, mindfulness in the present moment, improved after a four-minute meditation (Stocker et al., 2018).

Similarly, mindfulness meditations as short as five minutes have demonstrated increased state mindfulness (Mahmood et al., 2016), so it has become of recent interest whether short dosages of mindfulness training can be effective (Mahmood et al., 2016). Most mindfulness interventions do not observe acute effects (Edwards and Loprinzi, 2019), but rather effects over extended periods. Traditional mindfulness training methods can be time-consuming (Edwards and Loprinzi, 2019) and require a trained instructor (Crane et al., 2010), making them challenging for busy populations like college students (Hurst et al., 2012). Increased benefits of mindfulness training due to a dose-response relationship are cited (Strohmaier, 2020). Still, a time-consuming intervention requiring a trained instructor is often not feasible (Mahmood et al., 2016, O'Daffer et al., 2022). However, apps like Headspace® may be promising for future interventions (O'Daffer et al., 2022) because they are a cost-effective, feasible way to deliver

mindfulness training (O'Daffer et al., 2022). Headspace® is effective through teaching foundational principles and practices of mindfulness (Taylor et al., 2022, Yang et al., 2018).

Accordingly, the primary aim of this study was to bridge the gap that exists between mindfulness training and muscular endurance performance. In addition, the study sought to assess the effect of acute mindfulness training on mental toughness, mindfulness, and perception of exercise intensity. To achieve these aims, plank performance, RPE, mindfulness, and mental toughness were assessed both before and after acute mindfulness training, delivered to college students via an app, Headspace®. We hypothesized that an acute bout of mindfulness meditation would benefit plank performance, perception of exercise intensity, state mindfulness, and mental toughness. Increasing exercise performance acutely, with little time investment, would be a valuable tool for exercise and athletic populations.

Methods

Experimental Approach to the Problem

This study implemented a quasi-experimental design with each participant visiting the lab on two separate occasions. The primary purpose of the study was to assess if any differences in plank performance occurred following an acute bout of mindfulness meditation. The first session included familiarization with a prone forearm plank protocol, completion of baseline questionnaires, anthropometric assessments, and repeated maximal performance tests of the prone forearm plank.

The second session began with the completion of additional questionnaires, followed by random allocation into either a mindfulness or control condition. Questionnaires were then administered following each condition, and then three repeated maximal performance tests of the prone forearm plank were completed. Immediately following each maximal performance test,

RPE was assessed. Each session was a minimum of 72 hours apart and a maximum of one week apart to allow for recovery between sessions. The protocol is expanded on below verbally and visually.

Participants

Recruitment consisted of convenience sampling through an online questionnaire emailed to the student body of Western Kentucky University (WKU) and word of mouth in Bowling Green, Kentucky. An *a priori* power analysis using G*power analysis software (v3.1.9.6) indicated a minimum of 18 participants were needed for detecting differences with a significance of $\alpha = 0.05$, a power of 0.80, and a partial eta squared (η_p^2) of 0.26 (Nien et al., 2020). Participants were divided into equal conditions using a random number generator and were excluded if they: (1) were not within the target age range (18-30 years), (2) had exercised in the last five hours or consumed caffeine within three hours of the lab visit, (3) had any bodily injury that prevented full body stabilization, or (4) presented any of the ACSM Cardiovascular Disease Risk factors (American College of Sports Medicine, 2020, p. 47).

All components of the data acquisition were approved by the WKU Institutional Review Board (IRB #24-147) prior to participant recruitment or data collection. Each session was conducted under the supervision of a Certified Personal Trainer (CPT) through the National Strength and Conditioning Association (NSCA). Twenty-four participants (n=24, 12 men and 12 women) who met the above inclusion criteria volunteered to take part in the study; demographics are presented in Table 1.

Table 1

Descriptive statistics of the study participants

	Control (n = 12)	**Experimental (n = 12)**
Age (years)	**21.36 ± 1.36**	**20.7 ± 1.16**
Height (m)	**1.72 ± 0.10**	**1.72 ± 0.07**
Body Mass (kg)	**72.47 ± 15.34**	**82.00 ± 16.62**
Body Fat (%)	**19.74 ± 3.65**	**21.91 ± 6.86**
Trait Mindfulness	**49.12 ± 5.74**	**47.17 ± 8.11**

Familiarization Session

Participants were explained the purpose of the study and completed informed consent before any additional measurements were taken. Additionally, during the familiarization session, participants completed several baseline assessments including descriptive characteristics (gender, age, muscle-strengthening exercise completed weekly measured by the Muscle-Strengthening Exercise Questionnaire Short Form (MSEQ-SF) (Shakespear-Druery et al., 2022), anthropometrics (e.g., height, weight, body composition), the Toronto Mindfulness Scale (TMS) (Lau et al., 2006), and the Mental Toughness Index (MTI) (Gucciardi et al., 2015), before the repeated maximal performance tests of the prone forearm plank. Next, participants completed a 5-minute walking warm-up on the treadmill at a self-selected speed, which was recorded and used for the next session. After the warmup, participants observed a demonstration of the prone forearm plank protocol and were explained the criteria for test termination, as stated by Strand et al. (2014). Additionally, the participants were read the following prompt:

"During the prone forearm plank, you must maintain a position in which the elbows, forearms, and toes are in contact with the ground. Your arms must be directly underneath your shoulders. Your fists must be closed, and your body must remain rigid. Your body should be parallel with the ground while your head is in line with your spine. A neutral lower back should be maintained as well. After each plank, your RPE will be assessed on a 0-10 scale with 0 being rest, and 10 being maximal performance."

"Your plank will be terminated for any of the listed reasons. (1) if you feel you must stop due to fatigue, (2) if two corrective cues are given and you fail to correct your position with the corrective cues, (3) if you experience symptoms such as headache, dizziness, or pain that does not come from fatigue, or (4) if the experimenter notices any signs indicative of ill effects. Your goal is to perform each plank for as long as you can. If you have any questions after the demonstration, feel free to ask."

After the demonstration and explanation of test termination criteria, participants completed the three repeated prone forearm planks, with the protocol as described by Strand et al. (2014). A rest interval of 1 minute, guided by NSCA's Table 17.12 (Essentials of Strength Training and Conditioning, 2016, pg. 465) was given between each set. Immediately following the termination of each maximal performance test of the prone forearm plank, RPE (CR-10 RPE scale) (Borg, 1982) was assessed. The clock was hidden from the participants during the maximal performance tests.

Experimental Session

Participants returned for the experimental session after a minimum of 72 hours, but no longer than a week, post-familiarization session. Upon arrival at the laboratory, the participants completed the TMS followed by their assigned intervention protocol (mindfulness vs. control).

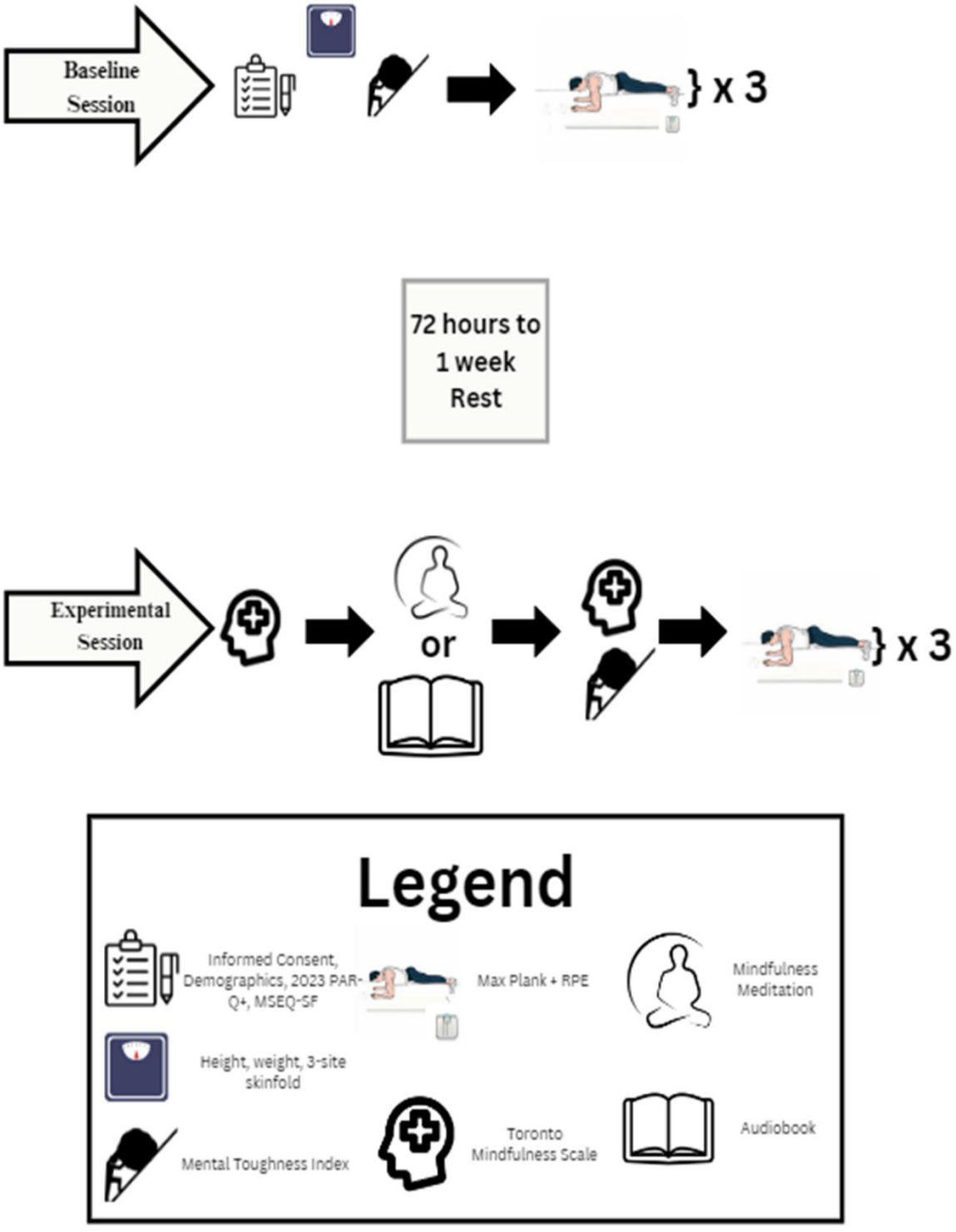
The mindfulness group listened to an audio file consisting of a 6.5-minute mindfulness meditation, selected by the researcher from the Headspace® app. The mindfulness meditation guided participants through a body scan, focusing on sensations from foot to head. This acute mindfulness session was adapted from that of Stocker et al. (2018) and Mahmood et al. (2016). The control group listened to an audiobook discussing the history of travel that was the same duration as the meditation. The audiobook contained no words eliciting strong emotions such as fight, war, or threat. To control for tone and voice, both the audiobook and Mindfulness audio file were delivered by a speaker of the same nationality. This was to standardize the duration of the mindfulness and control groups, and the speaker qualities.

During the 6.5-minute interval, for both groups, participants were asked to sit up on a couch, recline on a couch, or lie down on a yoga mat. Making the participants as comfortable as possible was important for mindfulness and control groups. Participants were asked to fill out the TMS and MTI immediately following their assigned condition.

After completion of the assigned protocol and questionnaires, participants completed the same protocol as they were asked to perform during the familiarization session. The clock was hidden from the participants during the maximal performance tests. If participants wanted to know the time for each maximal performance test, it was shared after they had fully completed the study.

Figure 1.

Graphic of study design and data collection.



Assessment of State Mindfulness

The Toronto Mindfulness Scale (Lau et al., 2006) was presented at baseline, before, and immediately following the mindfulness (vs. control) exercise. The scale is a 13-item measure evaluating state mindfulness. This scale measures an individual's mindfulness at a single point in time. Participants were asked to respond to questions related to their experience on a 4-point Likert scale from 0 (not at all) to 4 (very much). There are two subscales comprising the measure: decentering (awareness of one's experience with distance) and curiosity (awareness of one's experience with genuine interest). Both subscales have a significant positive correlation with absorption and awareness of one's surroundings, reflective self-awareness, and psychological mindedness (Lau et al, 2006). Curiosity positively correlates with awareness of internal states, while decentering correlates with openness to experience (Lau et al, 2006).

Assessment of Mental Toughness

The Mental Toughness Index (Gucciardi et al., 2015) was presented at baseline and immediately following the mindfulness (vs. control) exercise. The scale is an 8-item measure evaluating mental toughness. Participants were asked to respond to questions related to their self-evaluation of overall mental toughness on a 7-point Likert scale ranging from 1 (false 100% of the time) to 7 (true 100% of the time). The MTI has demonstrated good psychometric properties across a range of independent samples (Gucciardi et al., 2015) including athletes, students, and employees.

Assessment of Rating of Perceived Exertion

The Borg CR-10 Rating of Perceived Exertion scale (Borg, 1982) was presented immediately following the termination of each maximal performance plank test. The scale is a

10-item measure evaluating RPE. Participants were asked to rate the perception of their exertion from 0 (Nothing at all) to 10 (Maximal). The CR-10 RPE scale has been validated against objective markers of intensity (Eston, 2012) and is used as a standard method for evaluating perceived exertion in both exercise testing and training.

Additional Assessments

Several additional surveys and measures were implemented to assess baseline anthropometrics and demographics. These included a pre-exercise health screen of risk factors (2023 PAR-Q+) in addition to ACSM's Cardiovascular Disease Risk Factors, age, sex, and race. Stature (m), body mass (kg), and body fat (%) were assessed using a manual stadiometer (SECA 213; Seca Ltd., Hamburg, Germany), digital scale (Detecto DR 400, Webb City, MO), and three-site skin folds measured by Lange Skinfold Calipers (Cambridge, MA), respectively. Additionally, self-reported muscle-strengthening exercise frequency was determined using the Muscle-Strengthening Exercise Questionnaire Short Form (Shakespear-Druery et al., 2022).

Statistical Analysis

To detect the effects of mindfulness meditation on plank performance and RPE a 2 (day) x 2 (condition) x 3 (time) mixed factorial analysis of variance (ANOVA) was performed. Additionally, a 2 (time) x 2 (condition) mixed measures ANOVA was performed to assess the effect of mindfulness meditation on mental toughness between time points. To identify the influence that mindfulness meditation has on state mindfulness between time points a 2 (condition) x 3 (time) mixed measures ANOVA was performed. When appropriate, post hoc measures were made with the Bonferroni correction factor applied to the alpha level. Cohen's D effect size used to assess the magnitude of differences.

Assumption of normality of residuals was confirmed via visual inspection of histograms and QQ plots. To address any deviations from the sphericity assumptions, a Greenhouse-Geisser (G-G) correction was applied to the degrees of freedom of the error and model terms when G-G correction factor was <0.75, and a Huynh-Feldt correction was applied when G-G was (>0.75) using Mauchly's test. Homogeneity of variance was assessed using Levene's test. Effect sizes are presented and calculated as partial eta squared (η_p^2). Statistical significance was set at $\alpha < 0.05$ for all analyses. All data were analyzed using SPSS (v29.0, IBM Corp., Armonk, NY, USA). Data is presented using means ± standard deviation (SD) unless otherwise stated.

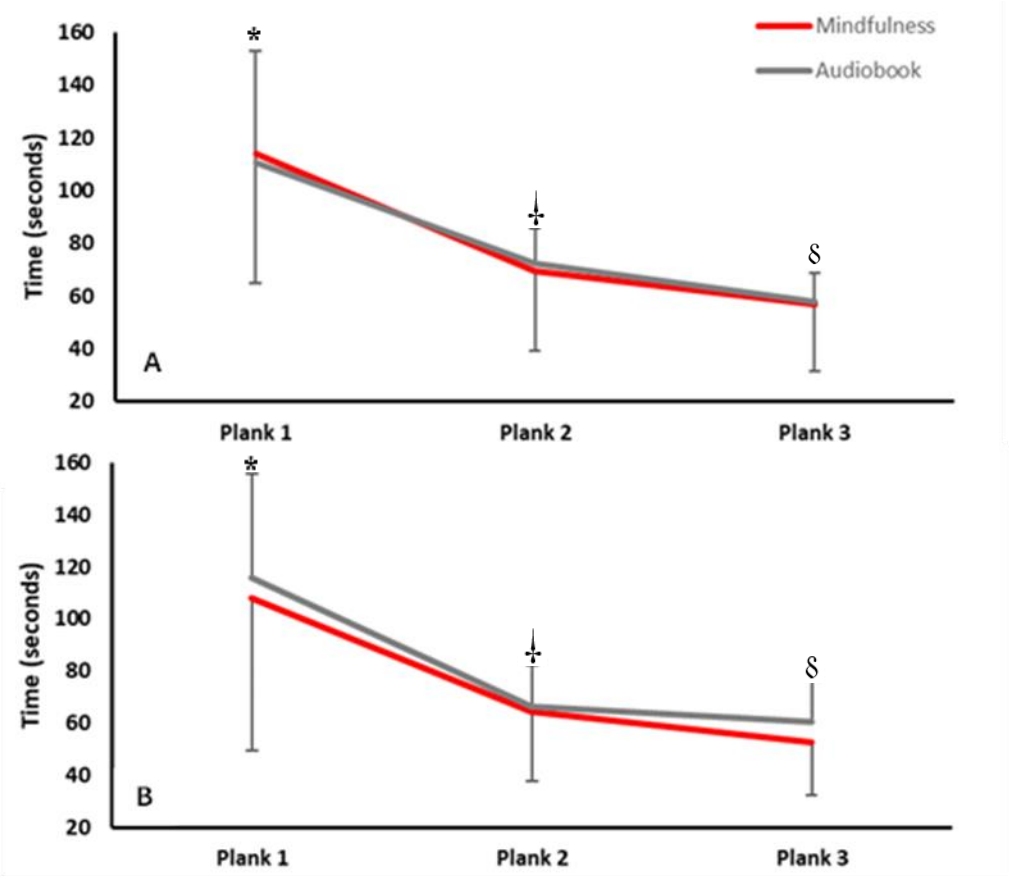
Results

Plank Performance

A significant main effect for time on plank times was demonstrated ($F_{1.193,26.249} = 49.751$; $p < 0.001$; $\eta_p^2 = 0.693$; N-B = 1.000). Pairwise comparisons revealed a significant difference between planks one to two ($p = 0.049$), planks two to three ($p < 0.001$), and planks one to three ($p < 0.001$). There were no statistically significant differences between days ($p = 0.252$, $\eta_p^2 = .059$) or conditions ($p = 0.903$, $\eta_p^2 = .001$). Also, there were no statistically significant interactions for plank times (Figure 2); Day x Condition ($p = 0.308$, $\eta_p^2 = .047$), Time x Condition ($p = 0.916$, $\eta_p^2 = .001$), Day x Time ($p = 0.413$, $\eta_p^2 = .037$), or Day x Time x Condition ($p = 0.334$, $\eta_p^2 = .047$).

Figure 2.

Maximal repeated plank performance averages across days between conditions.



Note: (A) indicates baseline testing and (B) indicates conditional testing.
Note. * Denotes significant difference ($p = 0.049$) from plank one to plank two; ǂ Denotes significant difference ($p < 0.001$) from plank two to plank three; § Denotes significant difference ($p < 0.001$) from plank one to three.

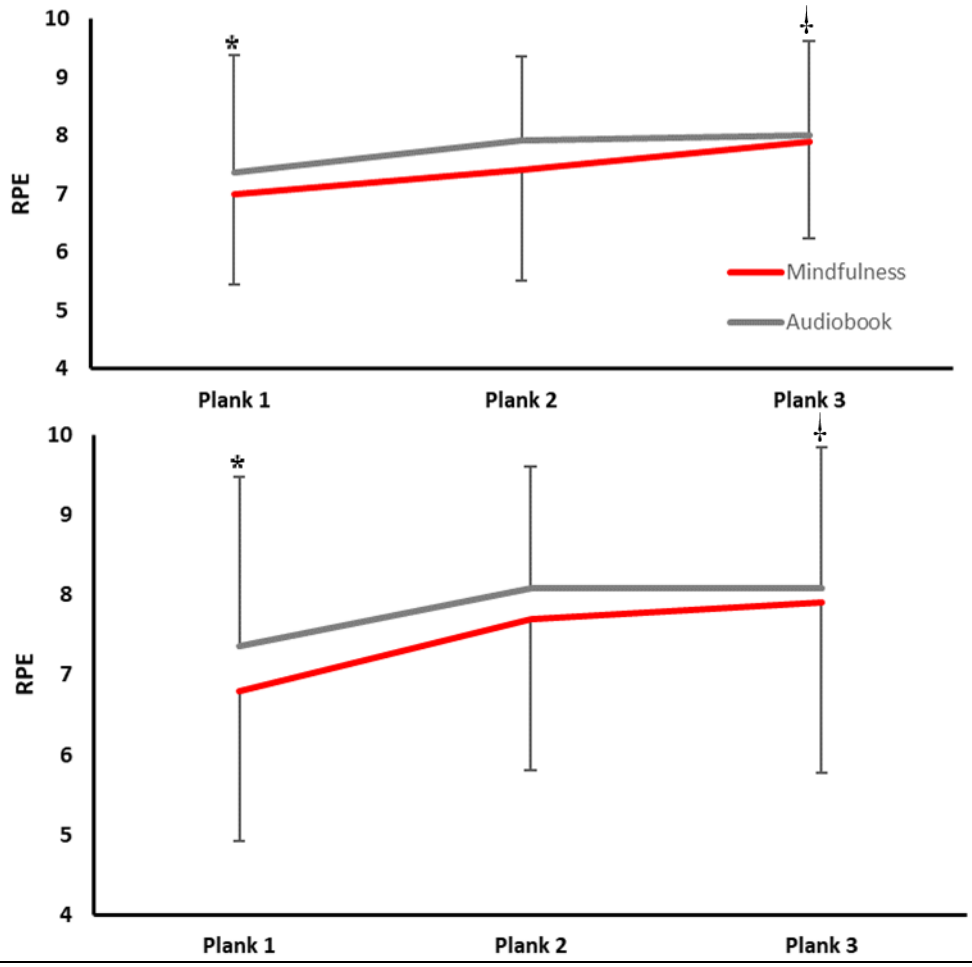
RPE

In this study, a significant main effect for time on RPE existed ($F_{1.272,27.976} = 7.764$; $p = 0.006$; $\eta_p^2 = 0.261$; N-B = 0.830). Pairwise comparisons revealed a significant difference between RPE taken after planks one to two ($p = 0.016$) and planks one to three ($p = 0.025$), but not planks two to three ($p = 0.455$). However, there were no statistical differences between days

(p = 1.000, η_p^2 = 0.000) or conditions (p = 0.967, η_p^2 = 0.000) for RPE. Additionally, there were no statistically significant interactions for RPE (Figure 3); Day x Condition (p = 1.000, η_p^2 = 0.000), Time x Condition (p = 0.936, η_p^2 = 0.001), Day x Time (p = 0.771, η_p^2 = 0.012), or Day x Time x Condition (p = 0.771, η_p^2 = 0.012).

Figure 3.

RPE averages across days between conditions.



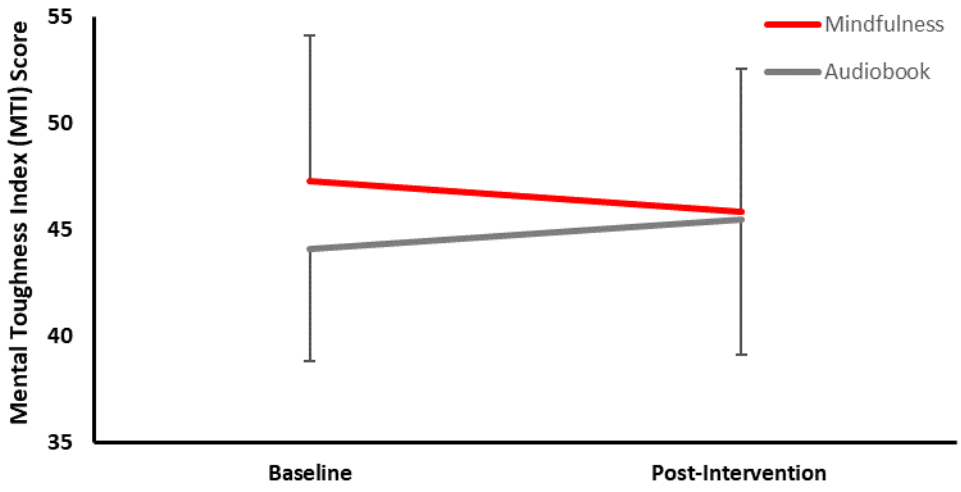
Note: (A) indicates baseline testing and (B) indicates conditional testing.
Note. * Denotes significant difference of RPE (p = 0.016) from plank one to plank two; ǂ Denotes significant difference of RPE (p = 0.025) from plank one to plank three.

Mental Toughness (Mental Toughness Index)

For mental toughness, there was no main effect of time ($p = 0.397$, $\eta_p^2 = 0.033$) or condition ($p = 0.416$, $\eta_p^2 = 0.030$), nor a significant interaction for Time x Condition ($p = 0.098$, $\eta_p^2 = 0.119$) (Figure 4).

Figure 4.

Mental toughness averages across days between conditions.



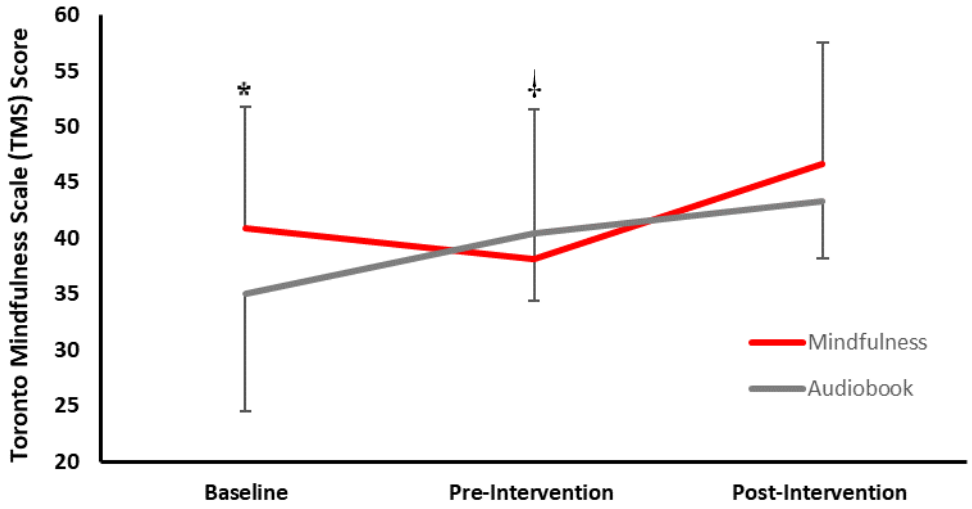
State Mindfulness (TMS)

A main effect of time ($F_{1.932,42.495} = 9.754$; $p < 0.001$; $\eta_p^2 = 0.307$; N-B = 0.972) was exhibited for state mindfulness. Pairwise comparisons indicated that there were significant differences from baseline to post-intervention ($p = 0.001$) and from pre-intervention to post-intervention ($p = 0.004$), but no significant differences from baseline to pre-intervention ($p = 0.614$). There was no interaction effect of Time x Condition ($p = 0.270$, $\eta_p^2 = 0.058$) on state

mindfulness (Figure 5). Additionally, Levene's test for equality of variance was found to be violated at both pre-intervention and post-intervention.

Figure 5.

State mindfulness averages across time between conditions.



Note. * Denotes significant difference ($p = 0.001$) from baseline to post intervention; ǂ Denotes significant difference ($p = 0.004$) from pre-intervention to post-intervention.

Discussion

The current investigation sought to determine whether differences existed in muscular endurance exercise performance due to an acute bout of mindfulness meditation. The mindfulness meditation was delivered to a group of novice meditators through the app, Headspace®. The results did not align with our hypotheses, indicating that an acute bout of mindfulness meditation did not improve muscular endurance exercise performance. Additionally, mental toughness and state mindfulness were investigated as secondary measures. Our secondary aims of improving state mindfulness and mental toughness also did not meet statistical

significance. It should be noted that the effect of mindfulness interventions can vary based on the amount of experience a meditator has (Davidson & Kasznkiak, 2015, Falcone & Jerram, 2018, Jha et al., 2017) and the amount of time engaged in mindfulness practice (Jha et al., 2017).

The participants in the current study were mindfulness novices, which may have impacted their ability to effectively use the skills taught (Stocker et al., 2018). Our results reflected that of Stocker et al. (2018) where they reported no statistical differences between mindfulness and control conditions on plank performance. However, in the current study, participants were kept in a neutral state of mind, rather than a state of ego depletion as Stocker et al. (2018) utilized in their study. Ego depletion involves a writing transcription task in which participants must purposefully omit certain letters resulting in cognitive fatigue, which has previously negatively impacted performance (Stocker et al., 2018). Additionally, in contrast to Stocker et al. (2018), participants' RPE was assessed immediately following each maximal performance plank. However, statistical significance was not met, indicating no difference in RPE following mindfulness meditation. Nonetheless, a strength of the current study is that the participants were not statistically different in trait mindfulness, which can influence the benefits of mindfulness meditation (Kee et al., 2012). Thus, future studies should investigate whether mindfulness meditation can improve muscular endurance performance in experienced meditators vs novices.

In addition to the performance outcomes, an acute bout of mindfulness meditation did not lead to improvements in state mindfulness. However, the results indicated that scores for both conditions changed over time, which could be due to a learning effect. Participants were given the state mindfulness questionnaire once during the familiarization session and twice during their experimental session, so they may have become familiar with the state mindfulness questionnaire

as the questions were not randomized across time points. Although no statistically significant differences were found, the mindfulness meditation group did have higher averages of state mindfulness post-intervention. Additionally, acute bouts of mindfulness delivered through digital mediums have previously improved state mindfulness (Mahmood et al., 2016). So, because mindfulness apps are low cost and they eliminate the need for an instructor (Cavanaugh et al., 2014, Gal et al., 2021), this tool has merit in targeting mindfulness over time.

While apps for promoting mindfulness, like Headspace®, are growing in popularity (Economides et al., 2018, Gal et al., 2021) there are still mixed results in their ability to improve mindfulness (O'Daffer et al., 2022). The size of the sample used in this study might have influenced finding an effect of a bout of mindfulness meditation. In addition to the sample size, Levene's test for homogeneity of variance was violated for the pre- and post-intervention measures of state mindfulness. A violation of this test indicates that the conditions may have had unequal variance in their state mindfulness measures during the experimental session. Thus, the interpretation of the state mindfulness results should be interpreted with caution as the statistical analyses assumed that variances were equal between conditions.

Due to the limitations noted above and the lack of influence of an acute bout of mindfulness meditation on state mindfulness, it is difficult to interpret whether participants were able to apply the skills learned and improve exercise performance. Furthermore, participants were guided to a quiet, private room where they completed their condition, so the researcher could not be present to ensure they were following the assigned condition. However, a strength of the current study is that all possible distractions were removed from the room such as smartwatches, phones, or any other technology. Thus, participants had no distractions in the room and could privately meditate without fear, or worry, of a researcher observing them.

Continuing in line with the other findings of this study, mental toughness scores did not change following a bout of mindfulness meditation. This may reflect that the acute mindfulness session failed to reliably influence levels of state mindfulness. Although levels of trait mindfulness have been shown to correlate with levels of mental toughness (Jones and Parker, 2018) and mindfulness training has improved mental toughness (Ajilchi et al., 2019, Wang et al., 2021), the current study failed to raise state mindfulness. No mindfulness interventions have attempted to raise mental toughness through an acute mindfulness session, but rather over six (Ajilchi et al, 2019) and eight weeks (Wang et al., 2021). Taken together, this adds to the literature by suggesting that it may take an extended period of mindfulness training to gain benefits towards effectively enduring negative states of mind, like mindful and mentally tough individuals. Nonetheless, future studies should look at targeting improvements in mental toughness in a shorter time, such as a week, to establish a minimum effective dose of mindfulness training for developing mental toughness.

Furthermore, the mindfulness meditation used in the current study may not be suitable for improvements in exercise performance. Perhaps an intervention utilizing a mindfulness session from the Mindfulness Acceptance Commitment (MAC) (Gardner & Moore, 2004) protocol would be more conducive to acutely improving exercise performance. MAC was developed to integrate skills of mindfulness into sport and everyday life, incorporating clear goals of athletic performance into the mindfulness practice. (Gardner & Moore, 2004). The mindfulness meditation used in this study was not sport or exercise-specific. However, it was suitable for beginners as it was chosen from the “Basics 1” package from Headspace®, which was developed to teach beginners a mindfulness practice. Nonetheless, the current meditation could be regarded as a limitation due to the mindfulness meditation being a general, beginning meditation, not

targeting sport performance. So, future studies should assess the effectiveness of Headspace® compared to having an instructor present for performance variables.

The current study did experience major limitations. One limitation is the small sample size (n=24), which impacted the power of the statistical analyses. The statistical analysis used for plank performance and RPE was different from the anticipated analysis. This limitation could explain why the bout of mindfulness meditation did not lead to an improvement in performance variables. Additionally, the small sample size likely influenced any differences in mental toughness and state mindfulness from being statistically significant. Nonetheless, this study did make use of an acute mindfulness meditation from an app that has previously shown improvements in levels of trait mindfulness of college students (Flett et al., 2019).

Another limitation is the time of recruitment and the sample of participants. Many participants were recruited at the end of the fall semester, and stress during exam periods tends to be higher (Hurst et al., 2012). Thus, the stress experienced by the participants may have been an influencing factor in the findings of this study. Also, the participants were all students from a single university, limiting the generalizability of the results. Lastly, exercise frequency was not controlled for, which might have influenced the results of the intervention. The participants were, however, matched evenly by gender within conditions to eliminate any potential gender differences. Despite the lack of significant findings, many participants voiced the helpfulness of mindfulness meditation in calming and relaxing them from the stress of the school semester.

Taken together, future studies are needed with larger sample sizes and samples consisting of those with, and without, mindfulness experience. Additionally, future studies should investigate multiple intervention lengths to establish a minimum effective dose of and dose-response relationship between mindfulness training and state and trait mindfulness as well as

mental toughness. The current study does add to the literature revealing an acute mindfulness meditation may not impact the perception of muscular endurance performance, or measured muscular endurance performance, as reflected by Stocker et al. (2018).

Conclusions

The experience a meditator has can influence the benefits of mindfulness meditation. In novice meditators, an acute bout of mindfulness meditation failed to positively influence muscular endurance performance. Despite mindfulness training previously increasing measures of mental toughness and decreasing perception of exercise intensity, the current study did not find similar effects after an acute bout of mindfulness meditation. Existing literature has indicated the beneficial effect of mindfulness training on mental toughness (Ajilchi et al., 2019), perception of exercise intensity (Wang et al., 2021), and performances in skill sport (John et al., 2011) and aerobic exercise (Nien et al., 2020, Thompson et al., 2011, Wang et al., 2021) after numerous weeks of training. However, no current literature has observed extended bouts of mindfulness training and its influence on muscular endurance exercise performance.

Collectively, mindfulness meditation has been investigated in few performance domains and should therefore be further investigated across a multitude of performance domains and among populations with varied mindfulness experiences. An effective minimum dose of mindfulness training needs to be established for the benefits of state mindfulness, trait mindfulness, and mental toughness. The sample in the current study was small and the mindfulness meditation was not sport-specific, so the results should be interpreted with caution. In conclusion, no current recommendation can be made for, or against, mindfulness meditation as a tool for improving exercise performance.

CHAPTER IV

THESIS CONCLUSIONS

The current study builds upon the existing literature regarding an acute bout of mindfulness meditation and exercise performance in mindfulness novices. A previous study investigated the effects of an acute bout of mindfulness meditation in novices following ego depletion on muscular endurance performance (Stocker et al., 2018), however, the current study kept participants in a neutral state. Additionally, RPE was assessed in the current study, adding a measure that mindfulness meditation has previously positively influenced following endurance exercise (Wang et al., 2021). To the authors' knowledge, this is the first study investigating the effects of acute mindfulness meditation on muscular endurance exercise performance, RPE, mental toughness, and state mindfulness within the same study. The current study did not reveal any statistically significant differences in muscular endurance exercise performance, RPE of the exercise performance, mental toughness, or state mindfulness following an acute bout of mindfulness meditation.

Extended mindfulness interventions can positively influence measures of mental toughness (Ajilchi et al., 2019), skill sport performance (John et al., 2011, Zhang et al., 2016), and endurance exercise performance (Nien et al., 2020, Thompson et al., 2011, Wang et al., 2021), but a lack of significant findings have come from acute bouts of mindfulness meditation on muscular endurance exercise performance (Stocker et al., 2018). However, the studies investigating the effects of mindfulness meditation on exercise performance have failed to use sport-specific meditations like those from the Gardner & Moore (2004) Mindfulness Acceptance Commitment program. Mindfulness meditation should continue to be investigated in a wide range of performance domains, in participants both with and without meditation experience, and

under varying intervention lengths. Thus, future studies should focus on establishing the minimum effective dose and dose-response relationship of mindfulness meditation on performance. Determining the minimal time needed to benefit from mindfulness training could be a valuable tool for athletes seeking to improve performance-based metrics as well as understand if there is a point of diminishing returns regarding mindfulness training.

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APPENDIX A

Rating of Perceived Exertion (RPE) Scale.

Rating	Descriptor
0	Rest
1	Very, very easy
2	Easy
3	Moderate
4	Somewhat hard
5	Hard
6	
7	Very hard
8	
9	
10	Maximal

The modified Borg Category Ratio-10 Rating of Perceived Exertion Scale.

APPENDIX B

State Mindfulness (Toronto Mindfulness Scale) Scale.

Toronto Mindfulness Scale

Instructions: We are interested in what you just experienced. Below is a list of things that people sometimes experience. Please read each statement. Next to each statement are five choices: "not at all," "a little," "moderately," "quite a bit," and "very much." Please indicate the extent to which you agree with each statement. In other words, how well does the statement describe what you just experienced, just now?

	Not at all	A little	Moderately	Quite a bit	Very much
1. I experienced myself as separate from my changing thoughts and feelings.	☐	☐	☐	☐	☐
2. I was more concerned with being open to my experiences than controlling or changing them.	☐	☐	☐	☐	☐
3. I was curious about what I might learn about myself by taking notice of how I react to certain thoughts, feelings or sensations.	☐	☐	☐	☐	☐
4. I experienced my thoughts more as events in my mind than as a necessarily accurate reflection of the way things 'really' are.	☐	☐	☐	☐	☐
5. I was curious to see what my mind was up to from moment to moment.	☐	☐	☐	☐	☐
6. I was curious about each of the thoughts and feelings that I was having.	☐	☐	☐	☐	☐
7. I was receptive to observing unpleasant thoughts and feelings without interfering with them.	☐	☐	☐	☐	☐
8. I was more invested in just watching my experiences as they arose, than in figuring out what they could mean.	☐	☐	☐	☐	☐
9. I approached each experience by trying to accept it, no matter whether it was pleasant or unpleasant.	☐	☐	☐	☐	☐
10. I remained curious about the nature of each experience as it arose.	☐	☐	☐	☐	☐
11. I was aware of my thoughts and feelings without overidentifying with them.	☐	☐	☐	☐	☐
12. I was curious about my reactions to things.	☐	☐	☐	☐	☐
13. I was curious about what I might learn about myself by just taking notice of what my attention gets drawn to.	☐	☐	☐	☐	☐

APPENDIX C

Mental Toughness (Mental Toughness Index) Scale.

INSTRUCTIONS: Using the scale below, please indicate how true each of the following statements is an indication of how you typically think, feel, and behave as an athlete – *remember there are no right or wrong answers so be as honest as possible*.

1 *False, 100% of the time*	2	3	4	5	6	7 *True, 100% of the time*

1	I believe in my ability to achieve my goals	1	2	3	4	5	6	7
2	I am able to regulate my focus when performing tasks	1	2	3	4	5	6	7
3	I am able to use my emotions to perform the way I want to	1	2	3	4	5	6	7
4	I strive for continued success	1	2	3	4	5	6	7
5	I execute my knowledge of what is required to achieve my goals	1	2	3	4	5	6	7
6	I consistently overcome adversity	1	2	3	4	5	6	7
7	I am able execute appropriate skills or knowledge when challenged	1	2	3	4	5	6	7
8	I can find a positive in most situations	1	2	3	4	5	6	7

APPENDIX D

Trait Mindfulness (Five Facet Mindfulness Questionnaire-15) Scale.

FFMQ-15: 15-item Five-Facet Mindfulness Questionnaire

Instructions

Please use the 1 (never or very rarely true) to 5 (very often or always true) scale provided to indicate how true the below statements are of you. Circle the number in the box to the right of each statement which represents your own opinion of what is generally true for you. For example, if you think that a statement is often true of you, circle '4' and if you think a statement is sometimes true of you, circle '3'.

	Never or very rarely true	Rarely true	Some-times true	Often true	Very often or always true
1. When I take a shower or a bath, I stay alert to the sensations of water on my body.	1	2	3	4	5
2. I'm good at finding words to describe my feelings.	1	2	3	4	5
3. I don't pay attention to what I'm doing because I'm daydreaming, worrying, or otherwise distracted.	1	2	3	4	5
4. I believe some of my thoughts are abnormal or bad and I shouldn't think that way.	1	2	3	4	5
5. When I have distressing thoughts or images, I "step back" and am aware of the thought or image without getting taken over by it.	1	2	3	4	5
6. I notice how foods and drinks affect my thoughts, bodily sensations, and emotions.	1	2	3	4	5
7. I have trouble thinking of the right words to express how I feel about things.	1	2	3	4	5
8. I do jobs or tasks automatically without being aware of what I'm doing.	1	2	3	4	5
9. I think some of my emotions are bad or inappropriate and I shouldn't feel them.	1	2	3	4	5
10. When I have distressing thoughts or images I am able just to notice them without reacting.	1	2	3	4	5
11. I pay attention to sensations, such as the wind in my hair or sun on my face.	1	2	3	4	5
12. Even when I'm feeling terribly upset I can find a way to put it into words.	1	2	3	4	5
13. I find myself doing things without paying attention.	1	2	3	4	5
14. I tell myself I shouldn't be feeling the way I'm feeling.	1	2	3	4	5
15. When I have distressing thoughts or images I just notice them and let them go.	1	2	3	4	5

APPENDIX E

Exercise Frequency (Muscle-strengthening Exercise Questionnaire Short Form) Scale

Muscle-strengthening Exercise Questionnaire Short Form (MSEQ-Short)

Your participation in muscle-strengthening exercise

The next set of questions are about your participation in **muscle-strengthening exercise**, sometimes called weight or resistance training.

When thinking about muscle-strengthening exercise, we are only interested in exercises that you do during your leisure or free time, and NOT done as part of your work/job, or as a part of household activities (chores).

The types of muscle-strengthening exercise we are interested in include:

- **Using weight machines** - typically in a gym or fitness centre
- **Bodyweight exercises** - including push-ups or sit-ups
- **Resistance exercises** – using free weights like dumbbells or using resistance bands
- **Holistic exercises** - including Yoga, Tai-Chi or Pilates

1. Do you **do muscle-strengthening exercise** in a **usual week?**

   ☐ **Yes**

   ☐ **No** ⟶ **Skip to next module**

2. How **many days**, in a **usual week**, do you do muscle-strengthening exercise?

   _____ **days per week**

3. **On the day(s)** that you **do muscle-strengthening exercise**, please indicate **how long** you spend doing this activity?

   _____ **minutes per day**

4. On a scale from 0 to 10, how **hard do you feel** you are **working when doing muscle-strengthening exercise** with '0' being 'extremely easy' and '10' being 'extremely hard'

   _____ **intensity of session**

5. What **types of muscle-strengthening exercise do you usually do**?

Weight machines (Lat pulldown, bench press, leg press)	Yes or No _____
Resistance exercises (resistance bands/dumbbells)	Yes or No _____
Bodyweight exercises (push-ups, sit-ups)	Yes or No _____
Holistic exercises (Yoga, Tai-Chi and Pilates)	Yes or No_____

6. When you do muscle-strengthening exercise, **do you usually do exercise that target or use the** following **muscle groups or parts of your body?**

Legs (e.g. squats, lunge, leg press)	Yes or No _____
Hips (e.g. bridges, lateral banded walk)	Yes or No _____
Back (e.g. lat pulldown, dumbbell row)	Yes or No _____
Abdomen (e.g. sit-ups, planking)	Yes or No _____
Chest (e.g. bench press, push-ups)	Yes or No _____
Shoulders (e.g. shoulder/overhead press)	Yes or No _____
Arms (e.g. bicep curl, tricep dips)	Yes or No _____

This is the end of the survey, thank you for participating.

APPENDIX F

Health Questionnaire (2023 PAR-Q+)

2023 PAR-Q+

The Physical Activity Readiness Questionnaire for Everyone

The health benefits of regular physical activity are clear, more people should engage in physical activity every day of the week. Participating in physical activity is very safe for MOST people. This questionnaire will tell you whether it is necessary for you to seek further advice from your doctor OR a qualified exercise professional before becoming more physically active.

GENERAL HEALTH QUESTIONS

Please read the 7 questions below carefully and answer each one honestly: check YES or NO.	YES	NO
1) Has your doctor ever said that you have a heart condition ☐ **OR** high blood pressure ☐?	☐	☐
2) Do you feel pain in your chest at rest, during your daily activities of living, **OR** when you do physical activity?	☐	☐
3) Do you lose balance because of dizziness **OR** have you lost consciousness in the last 12 months? Please answer **NO** if your dizziness was associated with over-breathing (including during vigorous exercise).	☐	☐
4) Have you ever been diagnosed with another chronic medical condition (other than heart disease or high blood pressure)? **PLEASE LIST CONDITION(S) HERE:** _____	☐	☐
5) Are you currently taking prescribed medications for a chronic medical condition? **PLEASE LIST CONDITION(S) AND MEDICATIONS HERE:** _____	☐	☐
6) Do you currently have (or have had within the past 12 months) a bone, joint, or soft tissue (muscle, ligament, or tendon) problem that could be made worse by becoming more physically active? Please answer **NO** if you had a problem in the past, but it **does not limit your current ability** to be physically active. **PLEASE LIST CONDITION(S) HERE:** _____	☐	☐
7) Has your doctor ever said that you should only do medically supervised physical activity?	☐	☐

If you answered NO to all of the questions above, you are cleared for physical activity.
Please sign the PARTICIPANT DECLARATION. You do not need to complete Pages 2 and 3.

- Start becoming much more physically active – start slowly and build up gradually.
- Follow Global Physical Activity Guidelines for your age (https://www.who.int/publications/i/item/9789240015128).
- You may take part in a health and fitness appraisal.
- If you are over the age of 45 yr and NOT accustomed to regular vigorous to maximal effort exercise, consult a qualified exercise professional before engaging in this intensity of exercise.
- If you have any further questions, contact a qualified exercise professional.

PARTICIPANT DECLARATION

If you are less than the legal age required for consent or require the assent of a care provider, your parent, guardian or care provider must also sign this form.

I, the undersigned, have read, understood to my full satisfaction and completed this questionnaire. I acknowledge that this physical activity clearance is valid for a maximum of 12 months from the date it is completed and becomes invalid if my condition changes. I also acknowledge that the community/fitness center may retain a copy of this form for its records. In these instances, it will maintain the confidentiality of the same, complying with applicable law.

NAME _____ DATE _____

SIGNATURE _____ WITNESS _____

SIGNATURE OF PARENT/GUARDIAN/CARE PROVIDER _____

If you answered YES to one or more of the questions above, COMPLETE PAGES 2 AND 3.

Delay becoming more active if:

- You have a temporary illness such as a cold or fever; it is best to wait until you feel better.
- You are pregnant - talk to your health care practitioner, your physician, a qualified exercise professional, and/or complete the ePARmed-X+ at www.eparmedx.com before becoming more physically active.
- Your health changes - answer the questions on Pages 2 and 3 of this document and/or talk to your doctor or a qualified exercise professional before continuing with any physical activity program.

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Name: McGee, Donte Elsworth

Email (to receive future readership statistics): donte.mcgee436@topper.wku.edu

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