THE EFFECTS OF MENTAL TRAINING ON ACUTE PSYCHOPHYSIOLOGICAL STRESS RESPONSES IN ENDURANCE ATHLETES

by

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A thesis

submitted in partial fulfillment

of the requirements for the degree of

Master of Science in Kinesiology

Boise State University

December 2022

BOISE STATE UNIVERSITY GRADUATE COLLEGE

DEFENSE COMMITTEE AND FINAL READING APPROVALS

of the thesis submitted by

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Thesis Title: The Effects of Mental Training on Acute Psychophysiological Stress Responses in Endurance Athletes

Date of Final Oral Examination: 13 October 2022

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DEDICATION

I would like to dedicate my thesis to my wonderful daughters, Jade Kujala Ziker and Scarlett Kujala Ziker, for your patience as I worked through my thesis, and for cheering me on every step of the way. Thank you for your unconditional love and the tremendous joy you bring into my life each day. You are my sunshines and my greatest teachers. I would also like to dedicate my thesis to my husband, John Ziker for your unwavering love and support during both the easy and difficult moments of my thesis and life. Lastly, I would like to dedicate my thesis to my dad, Gerald Kujala, for always believing in me, as well as for teaching me the value of self-belief, education and hard work, and the importance of approaching life with humour, kindness, love, gratitude and curiosity, and to always keep going, even when things are difficult.

ACKNOWLEDGMENTS

I would like to thank my advisor, Dr. Eric Martin for your encouragement, advice and support during the entire thesis process. While COVID caused some delays and required us all to be flexible, I appreciated your support in working around COVID related changes so I could complete my study. I am very grateful for your time, constructive criticism, and for having had the opportunity to work with you. I would like to thank Dr. Katie Demps and Dr. Heather Van Mullem for being on my committee and for providing help and advice whenever I needed it. Thank you to Dr. John Ziker and the Boise State Anthropology department for your support of the saliva testing. Thank you to the Salimetrics lab for completing the saliva testing. Thank you to Gretchen Hurlbutt for your help connecting me with coaches. Lastly, thank you to the participating coaches for championing my study and athletes for participating in my study. You were a pleasure to work with. Thank you for your positive energy and enthusiasm for my study, growth and learning. Thank you all very much.

ABSTRACT

Introduction: In sports, pre-competition stress responses can influence performance. Mental skills training is a strategy used to successfully mitigate stress responses and positively impact performance. Psychological (e.g., anxiety) and physiological (e.g., cortisol) stress responses are not often measured in a single study, providing an incomplete picture of athlete experiences. When researchers have measured these constructs together, studies have excluded endurance athletes and ways to effectively buffer stress responses. **Purpose**: The current study had two aims. 1. How will athlete's perceptions of stress and physiological markers of stress be related to each other? 2. How will athlete's perceptions of stress and physiological markers of stress be impacted by a mental skills training program? **Hypothesis:** H1: It was hypothesized that perceptions of stress will be positively correlated to physiological markers of stress. H2: It was hypothesized that athletes who participate in the three mental training sessions would have lower levels of acute pre-competition psychological (anxiety) and physiological (salivary cortisol levels) stress responses prior to races. **Methods:** Twenty-one endurance athletes were recruited from two local high school cross country running teams. Cortisol and anxiety testing occurred on three occasions (Baseline, Time 1, and Time 2). Participants completed three mental training sessions between Time 1 and Time 2. Mental skills training included relaxation and breathing, imagery, and self-talk. Anxiety was quantified using the Competitive State Anxiety Inventory (CSAI-2R). Salivary cortisol levels were analyzed at the Salimetrics lab. **Statistical Analysis:** A one-way repeated measures ANOVA (Time) assessed anxiety, and cortisol levels. Bivariate correlations were conducted to assess the relationships between the study variables. One-way ANOVAs also assessed the association between reported stress the week prior to testing, school, gender and cortisol, self-confidence, and anxiety **Results:** The ANOVA results showed no statistically significant changes between variables of cortisol, anxiety and self-confidence at different times. Statistically significant positive correlations were found between self-confidence at B, T1 and T2 testing, and significant a negative correlation was found between anxiety and self-confidence at Baseline testing. The relationship between reported high levels of stress the week prior to T2 and high levels of cortisol at T2 testing was statistically significant as was the relationship between cortisol and school at Baseline testing. **Discussion:** A small sample size likely contributed to the low number of statistically significant results. The relationship between stress the week prior to T2 and cortisol points to the importance of focusing on mental skills training through an entire season versus just the few days prior to competition. The significance between cortisol and school at B testing was a result of cold weather during testing conditions and points to the need to consider time of day and other conditions when interpreting cortisol results. Future studies should include more participants in a longer study design.

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LIST OF ABBREVIATIONS

B	Baseline data collection/testing
CSAI-2R	Competitive state anxiety inventory-2R
HR	Heart rate
MT	Mental training
MST	Mental skills training
MTS	Mental training sessions
MTS1	Mental training session 1
MTS2	Mental training session 2
MTS3	Mental training session 3
RPE	Rate of perceived exertion
T1	Time 1 data collection/testing
T2	Time 2 data collection/testing

CHAPTER ONE: INTRODUCTION

Anticipation of sports competitions can bring about stress responses in athletes that impact performance (Williams, 2009). Every athlete experiences some level of pre-competition anxiety (Hogue, 2019). While some athletes are able to manage their stress responses well, and even view the pre-competition anxiety as facilitative to their performance, others are not. Management of stress responses prior to competition is within an athlete's control, and it is important for athletes to understand how they are impacted by impending competition stresses, and how they can control their stress responses to perform at their optimum level (Williams, 2009).

Stress and Stress Responses

We cannot avoid experiencing some stress in life. The two main types of stress we encounter are chronic and acute stress (Dhabhar & McEwen, 1997). Chronic stress occurs less often than acute stress, and occurs with long-term exposure to one or more stressful stimuli (Scott, 2018). Chronic stress can have deleterious effects on individual health and performance. Acute stress, while still having potentially negative effects on performance, occurs most often, and includes exposure to a short-term stressful stimulus, such as anticipation of a race or an alarm clock going off (Scott, 2018). When someone encounters an event that contains a stressor, or stimulus, the brain interprets that stimulus and may activate the body's stress responses if it is seen as a threat (Dhabhar & McEwen, 1997).

How one chooses to manage their responses to the stressors they encounter can prove to be the difference between being successful or not (Wolframm & Micklewright, 2011). If managed appropriately, acute stress before a competition can provide the stimulus an athlete needs to create their best performance. If not managed well, pre-competition stress can cause an athlete to crumble under the pressure they experience. Athletes, especially those competing at high levels, have numerous psychological and physical demands placed on them which can present itself as pre-competition stress and anxiety (Williams, 2009). The pre-competition stresses encountered by an athlete causes both psychological and physiological stress responses. Psychological stress responses, or anxiety prior to competition can come in the form of either cognitive or somatic anxiety. Cognitive anxiety impacts how an athlete thinks or feels about themselves, their situation and their control over their situation. Somatic anxiety includes physiological stress responses such as how an athlete feels physically such as increased sweating, breathing and heart rate and is measured subjectively with athlete self-perceptions. In contrast to these subjective measures, physiological stress responses are more objective and include the release of catecholamines such as epinephrine and norepinephrine, as well as the release of the hormone cortisol into the blood as a natural response when the body interprets a stimulus as a threat (Dhabhar & McEwen, 1997).

Measuring Stress Responses

There are different ways of measuring psychological and physiological stress responses. The psychological stress responses of cognitive and somatic anxiety are measured subjectively in a self-administered questionnaire such as the commonly used Competitive State Anxiety Inventory-2R (CSAI-2R; Cox et al., 2003). Somatic stress responses, because they pertain to physiological changes in the body, can be measured both subjectively through the use of a survey like the CSAI-2R or in an objective manner through measuring physiological stress responses commonly done through analyzing salivary cortisol (Hellhammer et al., 2009; Kirschbaum & Hellhammer, 1994). The collection of saliva is non-invasive, quick and easy for participants and provides accurate objective data on how the body is physically responding to stressors.

Research Measuring Only Psychological or Physiological Stress Responses

Numerous studies have been conducted to assess psychological or physiological stress responses by measuring perceived cognitive and somatic anxiety or physiological measures, such as cortisol, before competition (Williams, 2009), but rarely are self-perceptions and physiological measures collected concurrently. Although both of these approaches have provided many important insights into the athlete experience, taking only one of these measurements alone fails to paint the entire picture of athlete responses to pre-competition stressors. Because questionnaires are subjective measures that require honesty on the part of the participants, they may not be measuring individual experiences accurately, even if the inaccuracy is done unintentionally. On the other hand, measuring objective measures alone fail to take athlete's psychological state and perceptions of their experiences into account. As both physiological and psychological states impact performance, it is important to utilize both objective and subjective data to have a thorough understanding of the athlete experience. This information can be useful for those working with athletes such as coaches, trainers, parents, and athletes themselves.

Research Measuring Both Psychological and Physiological Stress Responses

As researchers have recognized the need to measure and compare both the objective and subjective stress response data, studies have begun moving in that direction (Fernandez-Fernandez et al., 2015; E. Filaire et al., 2001; Edith Filaire et al., 2009; Lim, 2018; Salvador et al., 2003). Not surprisingly, the results of these studies have shown a connection between both physiological and psychological stress responses prior to competition. They have also shown variation in their results in cognitive and somatic anxiety as well as cortisol related to match winners and losers, competition level and sex of participant.

Certain studies, such as a study done with tennis athletes conducted by Filaire et al., (2009) found match winners had higher cognitive anxiety, and lower somatic anxiety and cortisol levels than match losers. Other studies in this area have found different variations in their results (Fernandez-Fernandez et al., 2015; E. Filaire et al., 2001) and therefore, further investigation is merited. These studies all used athletes in real-world sport settings, and demonstrated how both types of stress responses can vary in relation to competition, sex, sport, and performance. Although the authors of these studies mentioned the need for using coping strategies in competition, they failed to compile any data on how athletes managed their stress responses and how that impacted athletes and competition results.

Mental Skills Training and Managing Stress Responses

Managing stress responses can impact an athlete’s performance, and mental skills training (MST) has been used as an effective means of achieving that management (Williams, 2009; Wolframm & Micklewright, 2011). The methodical practice of psychological skills training has been commonly used to reduce anxiety, improve performance, and heighten levels of sport enjoyment in athletes (Hackfort et al., 2019; Williams, 2009). Multimodal mental skills training programs in particular, or programs teaching more than one mental skill, have been widely used and demonstrated to be effective at reducing sport anxiety (Harwood & Thrower, 2019). This approach provides athletes with a number of skills, and the athlete can then choose which skill to use in different situations, depending upon their needs at the time. Some mental skills that are commonly seen when aiming at reducing pre-competition anxiety, and the three mental skills that will be used in the present study, include relaxation and breathing, imagery, and self-talk (Williams, 2009). Relaxation and breathing help athletes learn techniques to use diaphragmic breathing which improves oxygen flow to systems of the body, as well as increase the ability to focus (Williams, 2009). Imagery is a very powerful tool because it allows one to practice skills mentally by creating or re-creating experiences before actually preforming them (Williams, 2009). Self-talk is an effective means of changing or developing thought patterns as it includes everything athletes say or think to themselves (Williams, 2009). All of these skills taken together provide a powerful collection an athlete can choose from depending upon their situation and help them to better handle stressful situations.

Research Measuring the effects of MST on Both Psychological and Physiological Stress Responses

Only very recently have researchers begun moving towards investigating the effects of MST on both physiological and psychological stress responses (Hogue, 2019; Hogue, 2020; Mehrsafar et al., 2019). This has been an important development, as this area of research has been lacking in the sport psychology literature. Understanding more about how the athlete responds to stress pre-competition and how MST can be used to help manage those responses can prove useful for researchers, athletes, trainers, coaches, and others working with athletes.

The studies in this area have also seen variation in their results (Hogue, 2019; Hogue, 2020; Mehrsafar et al., 2019). Hogue (2019) found that while the MST group had higher cortisol than those in a motivational lecture group, the MST group was better able to view stress as being performance enhancing than either the motivational lecture or control groups. These results differed from the Hogue (2020) and Mehrsafar et al. (2019) studies in which the intervention group had lower cortisol and anxiety after the intervention than the control group. These results show the importance of measuring both psychological and physiological stress responses because if only one had been measured, the results of this study, and potential decisions made upon them could be different depending upon the data presented. While these studies have added to the literature by assessing both types of stress responses, they also had limitations. Mehrsafar et al. (2019) included a small sample size of participants and included only males, the 2019 Hogue study did not include females or athletes, and both Hogue studies (2019 & 2020) included only one mental skill in a single session and did not assess stressors in a competitive sport in a real-world sport competition. Because of these limitations, further research is needed.

Filling the Gaps

Although past studies have investigated different pieces of the athlete pre-competition stress response experience, only recently have researchers started to bring all these pieces together into one study. As no study is without limitations, past studies have also missed important factors. Understanding how MST can impact both psychological and physiological pre-competition stress responses is a practical manner is important to truly understand the effects of MST. It is the interest in filling gaps in current literature that has driven the current study to be designed to investigate the impact a 3 session-multimodal mental skill training intervention on both physiological and psychological stress responses in endurance athletes in real-world racing situations.

Need of the Study

Many studies have recognized that there is an increase in either cortisol (Van Paridon et al., 2017) or anxiety (Woodman & Hardy, 2003) stress responses before competition. It is important, however, to look at measuring both cortisol and anxiety together in the same study to get a holistic picture of the athlete (Kirschbaum and Hellhammer, 1994). Studies measuring both physiological and psychological stress responses have not delved into the topic of how mental training can impact both or either physiological and psychological stress responses. Information on the effects of mental skills training would be useful for coaches to better understand their athletes, and how those athletes are impacted by the unavoidable stresses of performance and provide a basis on which to create training and competition plans and strategies.

Purpose

The current study has two aims. Specifically:

1. How will athlete's perceptions of stress and physiological markers of stress be related to each other?
2. How will athlete's perceptions of stress and physiological markers of stress be impacted by a mental skills training program?

Hypothesis

H1: It was hypothesized that perceptions of stress will be positively correlated to physiological markers of stress.

H2: It was hypothesized that athletes who participate in the three mental training sessions will have lower levels of acute pre-competition psychological (anxiety) and physiological (salivary cortisol levels) stress responses prior to races.

Operational Definitions

Pre-competition psychological anxiety levels, or how the athletes are feeling prior to competitions will be measured by participants completing the Competitive State Anxiety Inventory-2R (CSAI-2R), which is an instrument that is often used to measure pre-competition anxiety in sport psychology studies (Cox, Martens, and Russell, 2003; Lundqvist and Hassén, 2005). Physiological stress responses will be measured through analyzing salivary cortisol.

Significance of the Study

This study is important because it can help build off of previous research that has investigated whether mental training has a positive influence over acute psychophysiological stress responses in athletes. It will also expand this research into the endurance sports arena and investigate how MST relates to endurance performance in a real sport context. As endurance athletes experience acute forms of stress before competitions, mental training may prove to be an important key to maintaining health and improving performance.

CHAPTER TWO: LITERATURE REVIEW

Numerous factors can impact an athlete's competitive performance. Some are outside of an athlete's control, such as weather, playing surface, equipment, competitors, and officials. Other factors within an athlete's control include things like preparation, how they perceive their situation, and how they manage the physical and psychological demands they face. All of these demands can also be called stressors (Williams, 2009). All athletes experience some degree of acute stress before competition (Van Paridon, et al., 2017; Hogue, 2019). In fact, previous studies have shown that excess amounts of anxiety can be detrimental to performance (Wolframm & Micklewright, 2011) and that if either cortisol or cognitive anxiety is not at the optimized level, performance might be negatively impacted (Siart, Nimmerichter, Vidotto, & Wallner, 2017). Pineschi & di Pietro (2013) and Harwood & Thrower (2019) found a number of skills can be taught to athletes to overcome the negative effects of anxiety. Specifically, utilization of a multimodal mental skills training program (MST) could help athletes deal with competition and other athletic stressors (Harwood & Thrower, 2019). If managed well, pre-competition stress can be performance enhancing, but if not, it can be detrimental to performance. Therefore, it is imperative for athletes to utilize coping strategies to manage stress responses in order to perform at their best (Hogue, 2019).

This chapter will outline the use of cortisol and anxiety measurements within recent sport psychology studies, as well as the effectiveness of mental skills training. It will move on to discuss studies in which cortisol and/or anxiety were measured with and without the use of mental training. Finally, the most recent literature investigating the effects of mental training on both cortisol and anxiety will be discussed.

Acute and Chronic Stress and Stress Responses

Stress can be defined as one or more events that contain a stimulus (stressor), that after being perceived and evaluated by the brain, activates the body's stress responses and challenges the body's homeostasis (Dhabhar & McEwen, 1997). The two main types of stress are acute and chronic stress. Acute stress is the most common type of stress. Whereas acute stress lasts minutes to hours, chronic stress lasts months to years (Dhabhar & McEwen, 1997). Acute stress can be experienced many times through the day when things occur such as an alarm clock going off, an unexpected loud noise, or feeling anxiety before a competition (Scott, 2018). Acute stress is experienced as an immediate real or imagined perceived threat, whether it be an emotional, psychological or physical threat. The perception of the threat triggers the stress responses (Scott, 2018).

Acute stress becomes chronic when one experiences repeated instances of either the same or different acute stressors. When experiencing chronic stress, the body's stress responses are being constantly triggered (Scott, 2018). While acute levels of stress can be performance enhancing, chronic stress is not (Williams, 2009). Exposure to high levels of cortisol over longer periods of time has maladaptive psychological and physiological effects, such as interfering with learning and memory, lowering immune function and bone density, and increasing weight gain, blood pressure, cholesterol, and heart disease (McEwen & Stellar, 1993). Balsalobre-Fernańdez, Tejero-Gonzaĺez, & Del Campo-Vecino (2014) quantified cortisol levels over a training season in middle and distance runners and found that those with higher cortisol levels over the season also had lower race performances. In addition, athletes with higher life stresses are at a higher risk of becoming injured (Andersen, 1988). Although chronic stress will not be measured in this study, it is worth mentioning briefly because if athletes do not employ strategies to manage competitive stress appropriately, it can have chronic effects (Williams, 2009).

Stress Responses

Competitive stress in sports comes largely from psychological and physical demands encountered by an athlete and manifests through stress responses (Williams, 2009). Psychological or cognitive stress responses, which leads to cognitive anxiety prior to competition, are mental stress responses and include things such as feelings of worry, lack of focus, disordered thinking, and negative self-evaluation. Competitive cognitive anxiety is a negative emotional response to an athlete's view of a specific competitive situation. These are influenced by several factors including event importance, the degree to which an athlete feels in control of the situation, perceptions of levels of certainty of their abilities, and how well they feel able to manage demands and difficulty of the task. If an athlete doesn't know how to manage their anxiety, more anxiety can follow. Feelings of anxiety, and not managing these responses well, can lead to physiological stress responses including things such as cortisol release, which can negatively impact performance (Williams, 2009).

Conversely, physiological or somatic stress responses include effects that are more objective such as increased heart and breathing rates, increased sweating, muscle tensions, dry mouth, butterflies in the stomach, and clammy hands (Williams, 2009). Athletes may have an awareness of many of these physiological stress responses when they occur, and they are partly brought about by the release of the hormone cortisol

(Hellhammer et al., 2009). Cortisol is an important part of the evolved physiological stress response mechanism (Flinn, Nepomnaschy, Muehlenbein, & Ponzi, 2011; McEwen & Stellar, 1993). Cortisol is also involved in controlling the body's daily circadian rhythm and is highest in the morning and lowest before bed; so some daily fluctuation in cortisol within the body is normal (Kalman & Grahn, 2004). Cortisol is released into the blood by the adrenal glands when the hypothalamic-pituitary-adrenal axis is activated by the sympathetic nervous system (Hogue, 2019; McEwen & Stellar, 1993). McEwan and Stellar (1993) note that cortisol levels can be affected by physical stressors including heat, inflammation, and exertion, as well as psychological stressors including anxiety, disappointment and fear. Cortisol is also released as part of the warming process when the body gets cold (Shida et al., 2020), so the weather can influence cortisol levels. Cortisol mobilizes glucose reserves for energy, increases heart rate, blood pressure and breathing rate inhibiting pain and non–vital organ systems, and promoting an adaptive fight-or-flight response, which can all help improve mental focus and performance in short-term acute stress situations ("Chronic stress puts your health at risk," 2019; Pineschi & DiPietro, 2013; Williams, 2009).

Both physiological and psychological stress responses can be influenced and experienced in different ways. Cognitive and somatic anxiety and an athlete's understanding of them encompasses their perceptions of how they are feeling, whereas the release of cortisol during physiological stress responses is a very objective measure, although, athlete perceptions can influence physiological stress. As these are important aspects of the athlete's experience, both are important to assess to fully understand athlete performance. Cognitive and somatic anxiety and cortisol release are both measured in different ways, each bringing its own challenges, which will be the focus of the next section.

Measuring Anxiety

Cognitive and somatic anxiety are measured through the use of a participant self-administered survey. These usually include around 20 questions that rely on honest answers by the participants as well as a high level of self-awareness to get the most accurate measure of anxiety. As this data is very subjective, a researcher must consider whether the participant might have been unintentionally influenced to answer a certain way, which could potentially lead to less than accurate results, misplaced conclusions, or unhelpful interventions.

The Competitive State Anxiety inventory-2R (CSAI-2R), developed by Cox, Martens, and Russell in 2003, is frequently used to measure psychological stress prior to sports competitions. The Revised Competitive State Anxiety Inventory (CSAI-2R) includes 17 questions pertaining to 3 domains of cognitive anxiety, somatic anxiety, and self-confidence (Cox et al., 2003). State anxiety refers to how anxious someone is at a specific moment (Williams, 2009) and this survey measures how an athlete feels at the time they complete the survey. Cognitive state anxiety is related to an athlete having self-doubt and negative self-evaluations about their ability to perform their sport (Martens et al., 1990). Somatic state anxiety refers to more physiological reactions to anxiety such as increased heart rate and muscle tension. Self-confidence is related to positive self-evaluations and positive expectations of the outcome of their performance. Self-confidence is the opposite of cognitive anxiety (Martens et al., 1990). An athlete's level of anxiety demonstrates how they perceive potential threats, their control of their situation and their ability to complete their task successfully (Salvador, Suay, González-Bono, & Serrano, 2003).

Anxiety has been used to examine psychological stress responses in many studies (Williams, 2009), but these studies typically do not include more objective stress response measure such as cortisol levels. Cortisol and anxiety can vary between each other given different situations and either being too high or too low can negatively impact performance (Siart, et al., 2017), hence there is a need to measure both to fully understand if one of the constructs is impacting performance.

Measuring Cortisol

Even though the CSAI-2R includes the measure of self-perceived somatic state anxiety, as it is self-administered it remains a subjective measure. Comparing the subjective questionnaire responses with the unbiased measure of physiological stress responses can provide a more in-depth view into what an athlete is experiencing. Measuring cortisol release is an objective means to gather accurate information of how the body's systems are responding to stress (McEwen & Stellar, 1993). Too much cortisol release can interfere with cognitive processing and lead to poor performance and too little cortisol release can lead to the body lacking the performance enhancing effects of cortisol and athletes may end up being too relaxed (Alix-Sy, Le Scanff, & Filaire, 2008; Taverniers, Van Ruysseveldt, Smeets, & Von Grumbkow, 2010). These differences may look like an athlete who starts a race too fast and does not stick to their race plan or may fail to have the extra vigor they would need to finish the race at the level they desire. Therefore, it is important for an athlete to have a moderate level of cortisol to best impact performance (Alix-Sy et al., 2008; Van Paridon et al., 2017).

While cortisol can be measured through urine, blood plasma, saliva or hair samples, saliva samples have been used in numerous studies as an accurate measure of acute physiological stress responses (Crnković et al., 2018; Dehghan et al., 2019; Gerber et al., 2013; Hellhammer et al., 2009; Hogue, 2020; Van Paridon et al., 2017; Vining et al., 1983).Cortisol is transported into the saliva from the blood and is a good indicator of the cortisol stress response (Crnković, et al., 2018). Measuring cortisol through saliva sampling is a very convenient, quick and non-intrusive means of testing cortisol levels (Hellhammer et al., 2009). Because of the ease of sample collection, cortisol levels are measured through salivary samples in the majority of current sport related studies.

Most studies measuring cortisol, however, fail to also include psychological measures that assess cognitive anxiety or self-perceived somatic anxiety. While cortisol release is one symptom of the somatic stress response and is an objective measure of the body's stress responses, it does not provide a complete picture of an athlete's experiences, which is why it is important to also measure an athlete's perception of their performance state anxiety.

Studies Measuring Both Physiological and Psychological Pre-Competition Stress Responses with No Mental Training

There have been several studies measuring both anxiety and cortisol in athletes without the use of mental training. In these studies, different results were found between competition levels and sex of participant. Those results are important because they demonstrate how competition stress manifests itself in various ways within athletes. These studies also illustrate the importance of including both stress responses in order to obtain a more complete picture of the situation the individual is experiencing when facing challenges.

The first study to be discussed examined the potential differences in stress responses and their influences on performance was a study by Filaire et al. (2009), which measured pre-competition physiological salivary cortisol and psychological anxiety levels during a tennis tournament. Filaire et al. (2009) had 16 adolescent female and male athletes complete the Competitive State Anxiety Inventory-2 (CSAI-2) 15 min before competition. Saliva samples were collected 7 times, at baseline (2 weeks pre-competition), 30 minutes after waking at 8am, 1-hour before competition, 10 minutes pre-competition, and 10 minutes post-competition, 1-hour post competition, and in the evening at 8pm. The researchers found that on competition day, cortisol was twice the level of their baseline in both females and males, although females had higher competition day levels than males. In addition, males had higher levels of self-confidence and females had higher levels of somatic anxiety, with no difference in cognitive anxiety. Match winners had significantly higher cognitive anxiety and self-confidence, and lower cortisol and somatic anxiety scores than match losers (Filaire et al., 2009). Overall, this study demonstrated the anticipatory psychological and physiological stress responses differed between females and males and winners and losers. The authors indicated that future studies needed to consider more physiological measures, as well as compare results between simulated and real competitions.

Even though Filaire et al. (2009) measured both cortisol and anxiety, the study did not provide any information on the physical demands of a tennis competition or compare the results of competition with a non-competition day. This information would provide important information to help improve the efficacy of training and be valuable for monitoring the demands of both training and competition. This is especially important given recommendations from the International Olympic Committee for international federations to monitor young athletes and ensure they are not exposed to excessive stresses. Because of these rationales, Fernandez-Fernandez et al. (2015) collected data on heart rate (HR) and rate of perceived exertion (RPE) in addition to measuring salivary cortisol and psychological stress responses on both a training day with a simulated match and on a competition day. Saliva samples were collected 6 times in total. Two reference samples were taken 2 weeks before a tennis tournament, on a rest day after a 24-hour period of no training at 8am (30 minutes after awakening) and at 8pm. These times were chosen because of the influence of circadian rhythm on cortisol. Four more samples were taken on both training and match days to allow comparison between both days. These samples occurred at 8am (30 minutes after awakening), 10 minutes prior to the 3pm match, 10 minutes after the match (5:30pm), and at 8pm in the evening before dinner. The twelve adolescent female participants completed the Competitive State Anxiety Inventory-2R (CSAI-2R) when they collected saliva 10 minutes pre- and post-training and competition. The HR and RPE collection occurred after games 1, 3, and every subsequent odd game of each set. Participants had higher cortisol, cognitive and somatic anxiety and lower self-confidence on competition day compared to the training day. All participants had higher RPE on match days. Match winners had significantly lower cortisol, $\%HR_{max}$, somatic anxiety and cognitive anxiety, and higher self-confidence than match losers on both training and match days. Fernandez-Fernandez et al. (2015) stated that other studies have shown winners with higher cortisol levels than losers and suggested that the difference in cortisol levels between match winners and losers could be related to the particular demands or characteristics of tennis. Since tennis is a very tactical sport, psychological stress could play a large role in the relationship between psychological and physiological stress responses. Also, increases in cortisol were positively correlated with somatic and cognitive anxiety on match day. The researchers suggested these findings indicate real competition elicits higher psychological and physiological stress responses than a simulated match in training. The authors suggested that in order to adequately assess stress responses, a real competitive environment is necessary. Overall, the study found higher stress responses on the competition day than the training day with match losers having a more pronounced stress response than match winners. These results emphasize the importance of utilizing coping strategies to manage anticipatory anxiety prior to competitions.

The results from the Filaire et al. (2009) and Fernandez-Fernandez (2015) studies suggest real competition stress negatively impacted performances of match losers and suggested match losers might have interpreted anticipatory anxiety as being debilitative to their performance rather than facilitative. Filaire et al. (2009) stated the anticipatory rise in cortisol demonstrated that the psychological arousal that occurs pre-competition impacts the hypothalamic-pituitary-adrenocortical axis. However, even though they had this common finding, the two studies differed in results found in terms of anxiety levels, where Filaire et al. (2009) found match winners to have had significantly higher cognitive anxiety and self-confidence, lower cortisol and somatic anxiety scores than match losers while Fernandez-Fernandez et al. (2015) found match winners had significantly lower cortisol, somatic anxiety and cognitive anxiety, and higher self-confidence than match losers. Fernandez-Fernandez et al. (2015) suggested this difference in anxiety could be indicating there are other factors at play with cortisol release. In addition to the discrepancy of the two studies, Filaire et al. (2009) suggested the difference between males and females and match losers and winners was because of how athletes perceived competition. Match losers may have interpreted the stress before their competition as being debilitative, where the winners might have thought it was facilitative to their performance (Fernandez-Fernandez et al., 2015). Filaire et al. (2009) collected data on the day of the first match of a tennis tournament, and stated the anticipation of the competition appears to have produced a higher stress response in females than males. In total, these results indicate the potential variation in stress responses that can exist between athletes and demonstrate the need to measure both psychological and physical stress responses prior to a real competition.

Lim (2018) designed a study to investigate the relationship between competition cognitive anxiety, salivary cortisol, and salivary alpha-amylase in 24 female low and high performing elite archery athletes. Competitive cognitive anxiety was assessed by using a Likert scale and cortisol and alpha-amylase were assessed through saliva samples. All testing was completed both 30- and 3-minutes pre-competition, and 30 minutes post competition. Researchers found that lower performing athletes had higher levels of cognitive anxiety and that their anxiety continued after the competition had ended, which could negatively impact future competitions. Unlike the past studies, however, both groups had similar cortisol levels both 30 and 3 minutes before competition, and it wasn't until 30 minutes after competition that the lower performing group had significantly higher cortisol levels than the higher performing group. Both groups had similar alpha-amylase levels 30 minutes prior to competition, and the lower performing group had significantly higher alpha-amylase levels at both 3 minutes before and 30 minutes after competition. While this study did not measure somatic anxiety or self-confidence, as is done on the CSAI-2R, these findings indicate a potential connection between physiological and psychological competition stress responses and performance in competition. Athletes who had better performances also had lower cognitive anxiety at all testing times, but measuring somatic anxiety and self-confidence along with cognitive anxiety along with cortisol could have shown something different. In addition, including all those measures would have provided more information for researchers to understand how the athletes were responding to the stress of competition, since all of those factors impact performance.

Even though previous studies have found that higher performing athletes have had lower cortisol levels or anxiety than lower performing athletes (Fernandez-Fernandez et al., 2015; Filaire et al., 2009; Lim, 2018), not all studies have found higher performing athletes to have lower levels of stress responses. In a study with 12 male interregional level judo athletes with 10 years of experience, participants completed saliva samples and the CSAI-2 5 minutes before competition (Filaire et al., 2001). Participants in this study competed in both a regional and interregional competition. Similar to past studies, both cortisol and anxiety levels were higher on competition days than baseline. Differing from previous studies, athletes had higher cortisol, cognitive and somatic anxiety, and lower self-confidence levels at the higher level, interregional competition indicating the athletes perceived their interregional competitions as being more stressful than regional ones as they were attempting to qualify for the national team. Filaire et al., (2001) explained the high levels of anxiety surrounding the interregional competition by stating that athletes use high levels of cognitive anxiety to enhance their performance, and attempt to control their physiological arousal that comes with those higher levels. This study compared stress responses at different levels of competition, but did not compare those stress responses with the competition results, which could have provided useful information to coaches and athletes considering there was a rise in both stress responses before the higher-level competition. In addition, although Filaire et al., (2001) and Fernandez-Fernandez et al. (2015) stated that athletes at higher competition levels experienced greater competitive stress and need to manage their anxiety levels, they provided no information about their chosen mental strategies to manage the increased stress.

Similar to the previously discussed studies, Salvador et al. (2003) compared the psychological and physiological anticipatory competition stress responses. Unlike the previously mentioned studies, Salvador et al. (2003) did not compare competition results. This study included 17 male judo players. The study measured anxiety and mood states with a Spanish version of the STAI-S (state anxiety inventory) and the POMS (profile of mood states), and participants also answered two questions on their possibility and interest of winning on a Likert scale of 1-4. Cortisol and testosterone were both taken from saliva samples. Participants were tested on eight resting days throughout the season, and prior to warm up on 2 competition days. Data on the resting days in this study showed consistent results for both physiological and psychological measures. Both psychological anxiety and physiological cortisol levels were higher on competition days than rest days. Salvador et al. (2003) suggested this response before competition was facilitating to the athletes' performance by increasing available energy, self-confidence, motivation to win, effort and competitiveness.

A common aspect across all of these studies, across different sports, is that each reported level of anxiety and cortisol rose as competition neared. Filaire et al. (2009) found higher cognitive anxiety and self-confidence scores and lower cortisol and somatic anxiety scores were associated with better performances in tennis and found that males experienced higher levels of self-confidence and had lower cortisol and somatic anxiety levels when compared to females. In contrast, Fernandez-Fernandez et al. (2015), found higher performing tennis athletes experienced less increases in cortisol, somatic anxiety and cognitive anxiety, and higher self-confidence than match losers. When Lim (2018) investigated archery competitors, cortisol was the same across all competitors, but cognitive anxiety was higher in lower performing athletes. Additionally, Filaire et al. (2001) and Salvador et al. (2003) found that higher anxiety and cortisol levels were associated with higher performing athletes in judo. The variation in results between male and female and level of competition indicates that there can be variation in both types of stress responses prior to competition. While these studies all noted the importance of incorporating strategies to cope with competition stresses, none of these studies collected data on coping strategies used by athletes or the influence of coping on anxiety or performance.

Interventions for Sport Anxiety

If an athlete understands the psychophysiological stress responses they typically experience before competitions, they can learn to control their individual stress responses through the use of mental skills training and perform at a level that is at or nearer to their optimum performance than if they had not utilized mental skills. This section will overview what mental skills training is, its purpose, and its influence over stress responses and performance.

Mental Skills Training

Mental skills training (MST) is defined as the consistent or systematic practice of mental or psychological skills (Hackfort, Schinke, & Strauss, 2019). The purpose of mental skills training in sports is to enhance performance, increase enjoyment, reduce anxiety, and achieve more satisfaction in relation to sports or physical activities (Hackfort et al., 2019; Williams, 2009). Several key factors related to performance in sports include regulation of arousal, concentration, and self-confidence (Coelho et al., 2012). MST aims to achieve all of these aspects by teaching athletes how to recognize their own stress responses and utilize skills to mitigate those responses so they do not impede performance.

While there are a good number of types of mental skills, several, including arousal regulation, imagery, goal setting, and self-talk have been shown to help reduce competition anxiety (Williams, 2009). Mental training interventions typically either focus on single skills or are multimodal in nature. Studies have shown that a multimodal mental skills training program approach is effective when facing competition or other athletic stressors (Harwood & Thrower, 2019; Williams, 2009). Multimodal mental skills training occurs when two or more mental skills are taught and utilized by the athlete within one intervention (Harwood & Thrower, 2019). As multimodal interventions can be designed to manage both somatic and cognitive anxiety, they can be particularly important when uncertain of whether anxiety is either more somatic or cognitive in nature, or when working with a group of athletes who will all be experiencing unique individual state anxiety experiences (Maynard et al., 1998). When used together, these skills can provide a toolbox for an athlete to use during times of competitive stress, as athletes can choose what works best for them in a given situation with the aim of reaching their own optimum level of both physical and psychological activation (Harwood & Thrower, 2019; Williams, 2009).

Mental skills training is something that has been shown to help athletes cope with their competition stress and perform at the top of their abilities (Williams, 2009). A review completed by Harwood and Thrower (2019) found the multimodal approach to be commonly used and effective at improving performance and lessening psychological stress response in athletes. There are, however, few studies investigating the effects of mental skills training on the physiological stress response of cortisol release, and even fewer investigating the effects of mental skills training on both the psychological and physiological stress responses (Hogue, 2019, 2020; Mehrsafar et al., 2019).

Mental Skills Training Effects on Psychological Pre-Competition Stress Responses

While there have been few studies looking into the effects of mental skills training on both physiological and psychological stress responses, Harwood and Thrower (2019) found the multimodal approach is often used, and is effective at improving performance and lessening psychological stress responses. The positive effects of multimodal mental skills training on competition anxiety and performance have been well established in the literature, and several of these will be discussed in this section (Harwood & Thrower, 2019).

The first multimodal intervention study that will be discussed was completed by Coelho et al. (2012). This study included 46 elite adolescent tennis players in their study investigating the effects of a multimodal imagery intervention on precompetitive anxiety and stress. Participants completed 25-minute sessions for 9 weeks between tournaments and completed the CSAI to measure anxiety and confidence and the Perceived Stress Scale to measure stress. The training sessions included relaxation, using imagery to promote self-confidence, strategies to self-regulate anxiety and stress, as well as viewing videos of professional players. Results indicated the intervention group had lower levels of perceived stress and cognitive anxiety following intervention. Athletes perceived their situation as threatening with the pressure of competition, but multimodal imagery in this study helped serve as a coping mechanism to alleviate those feelings. Athletes in the intervention group maintained better focus and concentration and experienced lower cognitive anxiety and negative thoughts resulting in higher feelings of self-confidence. Unexpectedly, the intervention group had higher somatic anxiety than the control group. It would have been valuable to also measure cortisol in this study to be able to compare the perceived somatic anxiety with the objective cortisol physical stress responses. While this study focused mainly on the use of relaxation and imagery, other studies utilizing the multimodal approach have used other mental skills for competitive anxiety (Coelho et al., 2012).

The positive effects of a multimodal mental skills training program were also demonstrated in a study by Mamassis and Doganis (2004). The impact of goal setting, imagery, positive thinking, self-talk, concentration, and arousal regulation techniques in a 25-week, season-long mental skills training program for 6 junior tennis players was investigated. Athletes completed the CSAI-2 to measure somatic and cognitive anxiety, and self-confidence and this study also compared performance around 2 tournaments, one before the intervention and one following the mental skills training sessions. They found that athletes in the intervention group had improved somatic and cognitive anxiety as well as self-confidence and performance after the mental training intervention. The control group did not demonstrate these same improvements. In fact, the control group did not experience improvements in performance over the course of the intervention time frame. This finding demonstrates the effectiveness of the multimodal mental skills program. Through participation in the mental skills training program, the participants in the intervention group had better awareness of their stress responses, as well as viewed their stress as performance enhancing, which the control group did not. The authors stated that a possible reason for the decrease in performance in the control group was that the second tournament was of higher importance and included incentives, and participants hadn't learned the coping skills of the mental skills training group. The authors stated that the participants may have been influenced to provide answers on the first questionnaire that were not completely honest as they thought a more positive self-evaluation would lead to their coach perceiving them as having a higher level of performance efficacy. Because the participants did not answer completely honestly the first time they took the questionnaire, it was difficult to gauge how much of an improvement was made over the course of the study (Mamassis & Doganis, 2004). The results still showed improvements in anxiety in the intervention group, but the results clearly demonstrate how answers on self-administered subjective questionnaires can be influenced. Therefore, future studies should integrate objective measures of anxiety in addition to self-administered questionnaires.

In another similar study, Grobbelaar, Duthie and Fanton, (2018) included five 60-minute group mental training sessions over five weeks focused on breathing control, relaxation, imagery, self-talk and thought stoppage to investigate the impacts of their multimodal intervention program on anxiety and self-confidence with 17 amateur golfers prior to competition. In the study, participants completed the CSAI-2 to measure cognitive and somatic anxiety and self-confidence 10 minutes before a competitive golf round both pre- and post-intervention. Participants in the intervention group perceived both their somatic and cognitive anxiety as being more facilitative to their performance and had increases in self-confidence. This was not the case with the control group. This change in the intervention group demonstrated the effectiveness of the intervention program at helping athletes cope with their arousal and anxiety and view their anxiety as being facilitative to their performance. Limitations of the study included a small sample size, not comparing performances between the control and intervention groups, athletes having previous experience with sports psychology interventions, and the high level of participants who possibly did not view their anxiety as debilitative to performance before the study began because of their high competition level. These things could all impact the study results (Grobbelaar et al., 2018) and larger scale studies that make sure to compare performances and include athletes without previous mental skills training experience should be investigated.

To continue to investigate the efficacy of mental skills training on performance, Wolframm and Mickelwright (2011) examined the effects of a multimodal mental skills training program on performance and pre-competition anxiety in 10 nonelite dressage riders. In this study, participants served as their own controls. The intervention consisted of relaxation techniques, goal-setting, self-talk, imagery, and concentration techniques and included meeting for 2 hours/week for 6 weeks. Participants completed the first competition 6-8 weeks before the intervention, the second competition 1-2 weeks prior to the intervention and the third competition 1-2 weeks post intervention. Somatic and cognitive anxiety and self-confidence was assessed using the CSAI-2R questionnaire. Performance did not change between the first two testing periods, but performance did increase after the intervention. These results indicated that the intervention was the reason for change and not just additional practice times. Contrary to the hypothesis of this study, cognitive and somatic anxiety as well as self-confidence did not change from prior to after the intervention. Wolframm and Mickelwright (2011) suggested the results could have occurred because a 6-week intervention period did not allow participants enough time to alter their perceptions of their stress responses and how they could cope with competitive stressors. They suggested that the change in performance was due to other influences such as perceptions of control or coping mechanisms. As dressage includes the rider working closely with their horse where the horse responds to stimuli and the rider, the more a rider can improve their emotional composure, the more it can positively affect the horse and, ultimately, performance. Including an objective measure such a cortisol in this study could have provided more information on how the intervention was influencing the riders to have an improved performance.

Previous studies have indicated that MST can have a positive influence on performance and a decrease in cognitive and somatic anxiety. However, there was variation in results between studies including Coelho et al. (2012) and Mamassis and Doganis (2003) found a decrease in cognitive anxiety, and an increase in somatic anxiety and self-confidence in the intervention group. In comparison, the study by Wolfram and Mickelwright (2011) found improvements in performance, but no changes in either somatic or cognitive anxiety or self-confidence after a multimodal mental skills intervention. This discrepancy in results leaves no doubt for the need to measure effects of mental training on both physiological and psychological stress responses with both subjective and objective measures. Measuring self-perceived anxiety alone fails to provide a complete picture of mental training effectiveness, as both physiological and psychological stress responses can impact the athlete.

Mental Training Effects on Physiological Pre-Competition Stress Responses

Although multiple studies have measured the impact of mental skills training on psychological stress responses, only a few studies to date were found to have investigated the effects of mental training on cortisol levels (Bara Filho et al., 2002; Coelho et al., 2014; John et al., 2011). The focus on cortisol is important because it provides a more objective picture of the athlete experience and can also show results that a self-administered questionnaire might miss.

Coelho et al. (2014) investigated the effects of mental imagery training on salivary cortisol with 52 elite adolescent male and female volleyball athletes. Mental training occurred 3 days/week for five weeks and included 5 minutes of videos showing the body language, decision making, attitudes and strategies of winners, then had athletes engage in 5 minutes of relaxation and 5 minutes of imagery where the athlete was asked to reverse stressful or unfavorable competitive situations to positive ones. Saliva collection occurred on a baseline training day and 5 minutes pre-competition before two games five weeks apart (pre-intervention and post-intervention). Male cortisol decreased between pre and post-test, whereas there was a slight increase in females, but not as much as the control group indicating the positive effect of mental training on cortisol levels. Although the study demonstrated the effectiveness of the intervention, Coelho et al. (2014) suggested future studies need to include different sports, levels of competitors, and competition-level performances.

In breaking with using traditional mental skills, John et al. (2011) investigated the effects of a 20-minute mindfulness meditation training, 6 days/week for four weeks on salivary cortisol levels with 96 male elite rifle shooters. For both an intervention and control group, cortisol was measured one day before the first week of the intervention, immediately following the intervention, and then a week following the intervention and prior to a competition. Researchers found there was a decrease in cortisol and improvement in performance in the mental training group, whereas the control group experienced a cortisol increase and no improvement in their performance. This study again demonstrated the effectiveness of decreasing cortisol and improving performance through mental skills training, but failed to show how perceptions of anxiety may have changed as a result of the intervention.

To further investigate the influence of an MST program on performance, Bara Filho et al. (2002) investigated the impact of a progressive relaxation program that included sessions 2 times/week for seven weeks on cortisol stress responses in 23 swimmers. Saliva collection occurred before the intervention, mid intervention and post intervention. Cortisol levels were lower at mid- and post-intervention times for the intervention group but not for the control group indicating the effectiveness of the intervention at reducing physiological stress responses. These results also showed there was a connection between the psychological and physiological body processes, but, again, did not measure the psychological stress responses, so only provided part of the stress response information (Bara Filho et al., 2002).

These findings are important as they have shown the connection between mental training and its beneficial effect on both cortisol levels and performance. The studies also identify that there might be differences in physiological stress responses between males and females. While these studies used mental skills training in their methodology, they did not measure psychological stress responses and could not fully evaluate the effects of mental skills training on both aspects. As we know, measuring both aspects of stress is the only way to gain a complete picture of the impact of mental skills training on athlete stress responses.

Mental Training Effects on Both Physiological and Psychological Pre-Competition Stress Responses

Until very recently, there has been a gap in the literature measuring the effectiveness of mental training on both psychological and physiological stress responses and how these stress responses relate to sports performance (Hogue, 2019; Hogue, 2020; Mehrsafar et al., 2019). This is important because up until now, the literature has failed to gain a full understanding of an athlete’s competitive stress responses and ways in which mental skills could contribute to the alleviation of those responses and add to an improved competitive performance. Specifically, to date, there have only been three studies investigating this topic, all published very recently (Hogue, 2019, 2020;

Mehrsafar et al., 2019). Each of these studies will be overviewed in this section.

The first study found in this area was conducted by Mehrsafer (2019) who measured the effects of mindfulness on pre-competition anxiety and cortisol levels in 26 Wushu (a martial arts sport that originated in China and is now practiced worldwide; Wikipedia contributors, n.d.) male athletes. Mindfulness training included 8-weeks of one-hour/week mindfulness, home meditation practice, and weekly group-based mindful-Wushu sessions. Saliva samples and the CSAI-2R occurred 15 minutes pre-competition on three testing days, each 8 weeks apart (baseline, post-intervention and follow-up). As was expected, cortisol and cognitive and somatic anxiety levels dropped in the intervention group after mental training but remained stable in the control group. The intervention group also scored higher on scores of mindfulness and self-confidence after the intervention and on the follow-up assessment where the control group saw no change in their scores. The results suggest that the mindfulness group was better able to face the stress of competition than the control group because the intervention taught them self-regulation of psychological stress responses and reappraisal of competitive challenges during competition. Performance data was not included, but should be in future studies. As noted by Mehrsafer, the small sample size of 26 participants increased the risk of type II error and limited statistical power in this study. Future research can build onto these findings by including performance, larger samples, other sports, and including both female and male athletes.

Even though the mindfulness intervention implemented by Mehrsafer showed training can influence both objective and subjective evaluations of anxiety, mental skills training was not evaluated in a similar manner until recently. The study by Hogue (2019) measured the effects of a motivational lecture and cognitive restructuring-based mental training intervention on both psychological and physiological performance stress responses in 59 male participants. Participants were split into three groups: mental training, achievement goal perspective theory motivational lecture, and a control group. Following the manipulation, participants completed a 30-minute, intentionally stressful, ego-involving climate learn-to-juggle session. The mental training group content focused on implementing a stress-is-enhancing view of performance. The motivational lecture content focused on learning about a task-involving, cooperative climate, where participants learn from mistakes. The control group was presented with a brief history of sport psychology. Psychological stress evaluations occurred 30 minutes pre- and post-juggling using three questionnaires: The Perceived Motivational Climate in Sport Questionnaire, the Stress Mindset Measure, and a threat and challenge measure. Saliva was collected at baseline (30 minutes pre- intervention), immediately pre-juggling, 45-minutes, and 60-minutes post-juggling. Cortisol was highest in the control group. Contrary to the hypothesis, the mental training group had higher cortisol levels than the participants in the motivational lecture. However, the mental training group had higher stress-is-enhancing mindset, which led to lower perceived anxiety levels in these participants. This study demonstrated how stress responses may not be equally impacted by mental training. Cortisol and anxiety levels were not equally impacted by the mental training and the motivational lecture. This variation in results suggest why there is a need to measure both cortisol and anxiety to understand the depth of influence of mental training on both types of stress responses. If only psychological or physiological stress responses would have been measured, we would see only half of the results, which would change the interpretation of the study. This study did not include females or athletes, and was not conducted in a real-world sport competition setting. Also, this study only included one mental training session that focused solely on one skill. Although the mental skill of implementing a stress-is-enhancing view of performance was effective at creating a positive change, it is not a type of mental skill found in most studies and limits the generalizability of MST training that typically includes a number of mental skills in an intervention. In addition, Hogue (2019) stated that only an ego-involving climate was investigated, but future studies should also include exploring mental training and achievement goal perspective theory in a caring, task involving climate.

As Hogue (2019) identified the need to measure female and male athletes and test the effect of mental skills training on stress responses in a caring task-oriented climate, she completed a follow up study in 2020. Specifically, Hogue (2020) investigated Achievement Goal Theory Based psychological skills training's impact on performance stress responses in high school athletes. Achievement Goal Theory concentrates on creating either an ego or mastery state, where ego is focused on outperforming and beating others and social comparison, whereas mastery is focused on task mastery, skill development and seeing one's own improvement (Williams, 2009). There were 72 female and male athlete participants in this study who learned juggling in an ego-involving climate. The 20-minute psychological skills session was focused on teaching participants how to create a caring, task-oriented environment, and athletes were encouraged to view their performance stress as performance enhancing and something that would help them grow. The control group listened to a 15-20-minute lecture explaining the history of sport psychology. Participants provided 5 saliva samples: 50

minutes prior to juggling, immediately before juggling, then 30, 45 and 60 minutes after the juggling session. In addition, participants completed the CSAI-2, the Perceived Motivational Climate in Sport questionnaire, the Caring Climate Scale, the threat and challenge measure, the Positive and Negative Affect Schedule, three individual questions related to shame and humiliation, and the State Self-Esteem Scale before and after the intervention. Results indicated that while both groups had similar cortisol levels immediately prior to the stressor, the control group had higher cortisol levels than the intervention group at all testing points after that. The psychological skills group did not change from their cortisol baseline measures. In addition, the control group reported higher levels of cognitive and somatic anxiety, psychological stressors, feelings of shame, humiliation, being negatively evaluated by instructors, and not having control over their own success when compared to the intervention group. In the control group, females reported greater cognitive and somatic anxiety, shame and humiliation than males, but like cortisol levels, there was no gender difference in the intervention group on those measures. Additionally, females in both groups indicated a threat appraisal of their juggling session, while males did not. These results indicate the intervention was effective at helping reduce anxiety, feelings of self-doubt, shame, humiliation, psychological arousal and worry during performance in the intervention group, but showed differences in potential coping skills of females and males, which could be related to past experiences playing at competitive levels in sports. The lack of change in cortisol and the lower levels of cognitive and somatic anxiety with stressors in the manipulation group is a positive outcome because it indicates participants in the intervention group were able to maintain their level of arousal during the stress of performance, which is part of the goal of mental skills training. The Hogue (2020) results suggest that the psychological skills training was effective at impacting both stress responses in participants. However, this study did not investigate athletes in a real-world competitive setting, compare effects on performance measures, and only included one session and one skill in their mental skills training (Hogue, 2020).

The studies in this section have all added to the sports psychology literature by investigating the impacts of mental skills training on both psychological and physiological stress responses to performance stress. All three of these studies utilized the CSAI-2 or CSAI-2R, and all measured cortisol through saliva. Although the Mehrsafer (2019) study had fewer participants, and only included males, they included a multiple-session intervention that ran over 8 weeks, which would have provided opportunities for participants to learn and practice the mental skills over time. In the Hogue (2019, 2020) studies, large sample sizes were included and she utilized multiple evaluations were utilized to measure psychological stress responses. The Hogue (2019) study did not include athletes, or female participants. In addition, these studies were not conducted in real-world sports competition settings, and only included one brief mental skills training session (Hogue, 2019, 2020). Future studies should investigate these aspects to improve our understanding of how athletes experience stress and how they cope with stressful situations.

Conclusion

The aforementioned studies have demonstrated a consistent relationship between mental training, psychological and physiological stress responses and performance. Mental skills training was found to help lower anxiety and improve performance in the studies by Coelho et al. (2012), Mamassis & Doganis (2010), Grobbelaar, Duthie & Fanton, (2018), and Wolframm & Mickelwright (2011). The relationship of mental skills training to cortisol is more varied (Fernandez-Fernandez et al., 2015; E. Filaire et al., 2001; Filaire et al., 2009; Hogue, 2019). While the importance of mental strategies to cope with pre-competition stress is deemed important, it is not included in all sports studies measuring stress responses. Similarly, the effects of mental training on both physiological and psychological stress responses is lacking. Commonalities in research designs include splitting participants into two groups (intervention and control), measuring stress responses at baseline and after intervention, and including more than one mental training session. Future research needs to include these common study designs while quantifying the impacts of mental training on both physiological and psychological stress responses in endurance athletes' real-world performances.

Therefore, to address these gaps, the current study was designed to investigate the effects of a multimodal mental skills intervention on both physiological and psychological stress responses in both female and male endurance athletes in real-world racing situations. The study had two primary purposes: 1) investigate how an athlete's perceptions of pre-competition stress and physiological markers of stress were related, and 2) investigate how an athlete's perceptions of pre-competition stress and physiological markers of stress were potentially impacted by a mental skills training program. According to previous studies results, I hypothesized that athletes who participated in the three mental training sessions would have lower levels of acute pre-competition psychological and physiological stress responses prior to their second races.

CHAPTER THREE: METHODS

Participants

My study included 21 participants (females =10, males =11, M_{age}=15.67, *SD* =1.20) who were recruited from two local high school cross country running teams (School A n= 12, School B n= 9). The ages and academic grades of the participants are shown in Table 1 & Table 2, respectively. In addition, the number of years participants had competed in competitive running is shown in Table 3. In sum, the highest frequency of runner age was 16, juniors were the most frequently reported year in school, and running experience varied between 0 and 8 years of running experience.

Table 1. Ages of participants

Age	Number
14	5
15	3
16	8
17	4
18	1

Table 2. Participant's academic grade

	n	%
Freshman	5	23.8
Sophomore	4	19
Junior	7	33.3
Senior	5	23.8

Table 3. Number of years of competitive running

Years	n	%
0	2	9.5
1	1	4.8
2	2	9.5
3	3	14.3
4	2	9.5
5	3	14.3
6	2	9.5
7	4	19
8	2	9.5

When asked how familiar they were with sports psychology prior to the study, 33% of participants answered “Not at All”, 52% answered “Somewhat”, and 14% answered “Moderately so”, and no one answered “very much so” (see Table 4).

Table 4. Participant’s familiarity with sport psychology

How familiar are you with sport psychology?	n	%
Not at all	7	33.3
Somewhat	11	52.4
Moderately So	3	14.3

Of the 21 participants in the study, 9 participants completed all 6 activities (3 mental training sessions, and 3 testing days). Additionally, there were 8 participants who completed all but one activity (the missing activity was a mix between mental training sessions and testing days) and 4 participants missed more than one activity. Of the 9 participants who completed the 3 testing days and the 3 MTS, 7 participants were from school A, and 2 were from school B. In this group, there were 2 freshmen, 4 junior, and 3 seniors and seven participants stated they were somewhat familiar with sport psychology, and 2 indicated they were not at all familiar with sport psychology. In the group of 9 athletes that completed all aspects of the program, two participants did not supply enough saliva during Time 1 testing for cortisol testing and are omitted from that analysis. Details for each participant can be found in Table 5.

Table 5. Completed activities by each participant

Participant	Number of Activities Completed	Number of MTS Completed	Number of test days Completed	School
1	6	3	3	A
2	5	3	2	A
3	6	3	3	A
4	6	3	3	A
5	6	3	3	A
6	3	0	3	A
7	6	3	3	A
8	6	3	3	A
9	5	2	3	A
10	4	1	3	A
11	6	3	3	A
12	5	2	3	A
13	4	2	2	B
14	5	2	3	B
15	5	2	3	B
16	5	2	3	B
17	6	3	3	B
18	4	2	2	B
19	6	3	3	B
20	5	2	3	B
21	5	2	3	B

Self-assessed Stress Levels

Participants began each survey with a question that asked about their stress level for that week (Table 6 below). Table 6 shows that the while some of the participants reported feeling more or less stress the week before the testing day, the majority of the participants reported that their stress levels were the same as usual at each testing day (B=11, T1=12, T2=13).

Table 6. Overall stress experienced in the last week for all participants

	Baseline		T1		T2	
	n	%	n	%	n	%
Less than usual	1	4.8	2	9.5	0	0
The same as usual	11	52.4	12	57.1	13	61.9
More than usual	9	42.9	5	23.8	7	33.3
Missing	0		2	9.5	1	4.8

In addition to asking participants about their overall stress levels, participants were asked to answer an open-ended question to indicate what their stress was related to if it was higher than usual. The responses included school (tests and scholarship applications), recovery from injury, depression, planning a birthday party, attending a family wedding, family, and feeling stress and anxiety about the race (the T2 data collection took place at the last race before their Regional races).

Training Load

The questionnaire also asked how many miles the participants ran the week prior to testing. For the participants who completed all activities, a majority of the participants ran between 21-40 miles the week prior to each testing period (see full details in Table 7).

Table 7. Miles ran in the last week for 9 participants who completed all activities

Miles	Approximately how many miles did you run in the past week? Baseline	Approximately how many miles did you run in the past week? T1	Approximately how many miles did you run in the past week? T2
0-20	0	0	2
21-30	6	7	4
31-40	1	0	3
41-50	0	2	0
51-60	2	0	0

Instruments

The Revised Competitive State Anxiety Inventory-2R (CSAI-2R)

The Competitive State Anxiety inventory-2R (CSAI-2R), developed by Cox, Martens, and Russell in 2003, is frequently used to measure psychological stress prior to sports competitions. The current study used the CSAI-2R in order to provide measures of this key dependent variable. The Revised Competitive State Anxiety Inventory (CSAI-2R) includes 17 questions pertaining cognitive anxiety, somatic anxiety, and self-confidence (Cox et al., 2003). Cognitive state anxiety is related to an athlete having self-doubt and negative self-evaluations about their ability to perform their sport (Martens et al., 1990). Somatic state anxiety refers to more physiological reactions to anxiety such as increased heart rate and muscle tension. State anxiety refers to how anxious someone is at a specific moment (Williams, 2009). Self-confidence is related to positive self-evaluations and positive expectations of the outcome of their performance (Martens et al., 1990). Self-confidence is the opposite of cognitive anxiety.

The response format for these questions used a Likert scale ranging from 1-4, where 1 was equal to “not at all”, 2 was equal to “somewhat”, 3 was equal to “moderately so”, and 4 was equal to “very much so” (Cox et al., 2003; Martens et al., 1990).

Cognitive anxiety questions included things such as, “I am concerned about losing”, “I am concerned about choking under pressure”, and “I am concerned about performing poorly” (Cox et al., 2003). Somatic anxiety questions included things such as, “I feel jittery”, My body feels tense”, and “My heart is racing”. Self-confidence related questions included things such as, “I feel self-confident”, “I am confident I can meet the challenge”, and “I am confident about performing well”.

The CSAI-2R provides scores in three categories including cognitive state anxiety, somatic state anxiety and self-confidence (Cox et al., 2003). The questions on the CSAI-2R are related to one of the three categories. The participant’s indicated responses on a 4-point Likert scale are totaled for each category, divided by the number of questions in that category and then multiplied by 10. Totals range from 10-40 for each category. A low score of 10 indicates low anxiety/confidence, and a high score of 40 indicates high anxiety/confidence (Cox et al., 2003). The CSAI-2R takes approximately 8 minutes to complete.

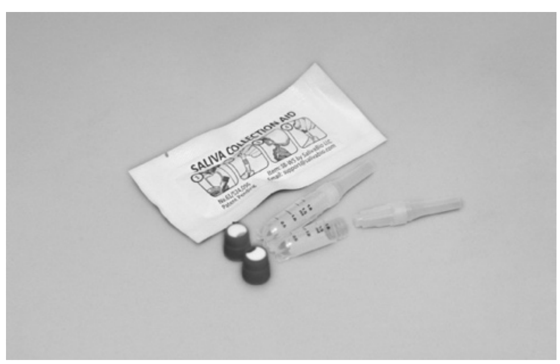
Cox et al. (2003) discussed the data they gathered when they tested the validity and reliability of the CSAI-2R. Cox et al. (2003) used a Confirmatory Factor Analysis (CFA) to test the CSAI-2R with a validation sample of 331 athletes and the results indicated a good fit to the data with a comparative fit index [CFI] = 0.95, non-normed fit index [NNFI] = 0.94 and root mean square error of approximation [RMSEA] =0.054**.** The CSAI-2R survey was developed using intramural athletes and validated using college and high school athletes. The authors note that the factor structure strength across two different populations indicates the CSAI-2R is generalizable to different populations (Cox et al., 2003).

The study by Cox et al. (2003) found Cronbach alpha coefficients for internal reliability for their intramural test at 0.83 for cognitive anxiety, 0.88 for somatic anxiety and 0.91 for self-confidence. The validation test resulted in Cronbach alpha coefficients of 0.81 for cognitive anxiety, 0.81 for somatic anxiety and 0.86 for self-confidence. A Cronbach alpha result between 0.70 and 0.95 is acceptable (Tavakol & Dennick, 2011). Validity and reliability studies conducted in other countries have supported their results including Switzerland (Lundqvist & Hassén, 2005), France (Martinent, et al., 2010), and Brazil (Fernandes, etal., 2013). In the current study, Cronbach alpha coefficient results for Cognitive Anxiety were .61 (B), .77 (T1), .56 (T2) and somatic anxiety results were .76 (B), .78 (T1), -.12 (T2). Alpha results for self-confidence were .91 (B), .95 (T1), and .81 (T2). The reliability results for cognitive anxiety at baseline and T2 just missed the .70 criteria set by Tavokol & Dennick (2011) and the somatic anxiety result at T2 was much below the ideal reliability estimate.

Saliva Collection

Physiological stress, the second key dependent variable of this study, was measured through salivary cortisol levels. Cortisol levels measured from saliva samples are commonly used and are highly correlated to serum cortisol levels (Salimetrics, 2019). Participants were asked to provide a saliva sample via the passive drool method, which allows participants to produce a large amount of saliva (1-5 mL) within 3-5 minutes (Granger et al., 2007). It also decreases probability of contamination by any devices used for collection of samples and ensures samples can be frozen for future testing (Granger et al., 2007). The saliva samples were stored immediately after collection in a cooler with ice until frozen at -20°C, which occurred within 4 hours after collection as suggested (Salimetrics, 2019).

Saliva collection must be done more than 60 minutes after eating a large meal and 12 hours after consuming alcohol (Salimetrics, 2019). High sugar or acidic foods can affect the results because they lower the PH of the sample and can influence bacteria growth. Because of this, participants were asked to rinse their mouth with water 10 minutes before their sample was collected and did not eat or drink anything within 10 minutes prior to collection. Saliva samples were checked for visible signs of blood in the sample; none was visible. Had blood been visible, new samples would have been recollected. To collect the saliva via the passive drool method, the participants passed it through a SalivaBio Collection Aid and into a polypropylene cryovial (see images 1 and 2 below). Date of collection as well as participant identification number were recorded. The saliva samples were sent to the Salimetrics Saliva Lab for cortisol analysis. As the cortisol was tested by the Salimetrics lab in duplicate offsite, reliability was not calculated.



Picture 1. SalivaBio Collection Aid and 2mL cryovial. From https://salimetrics.com/product/passive-drool-method-50pk

Picture 2. Passive Drool Method. From https://salimetrics.com/product/passive-drool-method-50pk

Procedure

Participants were recruited by initially emailing coaches of nine local high school cross country running teams, explaining the study, significance, and potential benefits, then asking to be invited to explain the study and its purpose. Two local high schools chose to participate. The first school chose to have a zoom meeting with parents and athletes to explain the study and answer questions. The second school chose to have an informational meeting with their athletes and have consent forms sent home with parents with the option for parents to contact the researchers with questions about the study. At these meetings, the study was fully explained to the participants and their parents if they were present, and they had the chance to ask any questions before parents signed their informed consent forms. Each participant was identified by a number to keep their identity confidential. Approval by the Institutional Review Board was obtained in April 21, 2021 (186-SB21-062). Approval by the Institutional Biosafety Committee was obtained on September 9, 2021 (IBC21-018).

Data was collected on three different occasions (baseline, Time 1 and Time 2), and an effort was made to be consistent with collection times to control for daily hormone fluctuations (Fernandez-Fernandez et al., 2015).

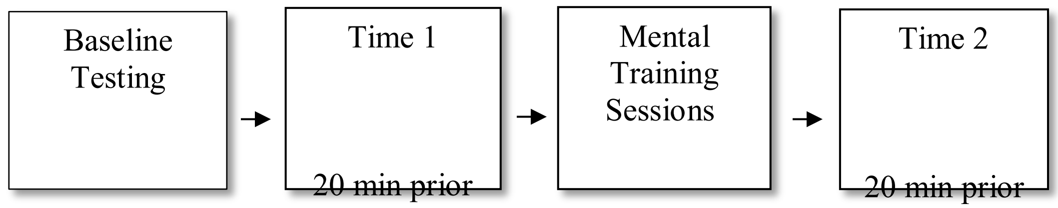


Figure 1. Timeline of salivary sample collection, CSAI-2R completion, and mental training sessions

<u>Baseline Testing</u>

Baseline (B) testing occurred in September of 2021 and took about 30 minutes for each participant to complete. Baseline testing to collect saliva samples and complete the CSAI-2R occurred prior to practice at the location of the practice, and following a 24 hour no-training period (Fernandez-Fernandez et al., 2015). At baseline testing, athletes needed to become familiar with how to provide a saliva sample and had questions, so this testing day took slightly longer than the others. After baseline testing, collection was quicker, but participants were not rushed. Participants were reminded to be as honest as possible in how they were feeling at that particular moment when completing the CSAI-2R. Saliva sample collection and CSAI-2R administering was done by Shelanda Kujala during every collection occasion. As each participant was assigned an identification number, only the participant ID number was attached to the saliva sample and CSAI-2R.

<u>Time 1 and 2 Testing and Data Collection</u>

Saliva sampling and CSAI-2R completion for Time 1 (T1) and Time 2 (T2) took approximately 10-15 minutes to complete and was completed in the same manner as the baseline testing. Time 1 was completed in September, 2021. Time 2 data collection was completed in October, 2021, after all of the mental training sessions had been completed. Both collections were completed within 20 minutes prior to a race start. Cortisol increases as competition gets closer, so it was important to sample as close to competition as possible, and to keep that consistent for all testing days (Van Paridon et al., 2017). Data collection occurred just after warm-up and about 10-20 minutes prior to race start, ensuring participants completed with enough time to finish preparing for their race (Fernandez-Fernandez et al., 2015). All collections occurred in the afternoon, except Time 2 for School A, which occurred in the morning. This was unavoidable as this was the only opportunity to test based on racing schedules, but testing still was completed 10-20 minutes prior to race to be consistent with other collections.

Intervention

Three mental training sessions were held between T1 and T2 testing, (Donovan & Radosevich, 1999; Williams, 2009). Participants were met at their school at a time scheduled with the coach. Each session took approximately 30-40 minutes with introduction, activities, and questions (Hatzigeorgiadis et al., 2014; Hogue, 2019). The mental training sessions focused on the topics of breathing and relaxation, imagery, and self-talk. There was time in the sessions for practice of the concepts, questions, and sharing. The outline for each session is included below and more detailed outlines are provided in the appendix.

Session 1: Stress and Performance Overview & Breathing and Relaxation

Session 1 included information about stress and how it can impact performance, and breathing and relaxation. By learning breathing and relaxation skills, athletes were able to reduce their levels of activation during practice and competition (Williams, 2009). Breathing properly from the diaphragm is something that can be very relaxing, help focus attention, and improve the amount of oxygen that is being carried to the systems of the body. When stressed, breathing can become shallow and quick. Learning how to breathe fully and slowly is something athletes can use anytime they notice they need to relax. Progressive relaxation was originally developed to help quiet the mind by relaxing the body. It includes contracting targeted muscle groups and holding for 5-7 seconds before relaxing. This technique teaches awareness for muscle tension, and lack of tension that arise, and a way to release those by focused contracting and release of muscles (Williams, 2009). This workshop provided athletes with a foundation on which they could build the skills of the following workshops.

Session 2: Imagery

Imagery is when someone uses all of their senses to either create or re-create and experience in their mind (Williams, 2009). Imagery is a powerful tool for athletes to have the ability to understand and use since the brain interprets imagery the same as a real situation. Knowing how to utilize this skill allows athletes to practice things mentally before actually physically completing them.

Session 3: Self-Talk

Self-talk is a mental training technique that has been shown to have positive results at reducing anxiety levels of endurance and other athletes before competition (Hatzigeorgiadis et al., 2009). Self-talk includes the things athlete’s say to themselves, whether it be out loud or inside their head (Kahrović et al., 2014). Self-talk is important in changing or developing thought patterns, which is important when considering the principle that people’s behavior is affected by what they say to themselves (Hatzigeorgiadis et al., 2009). The reason for the self-talk workshop was to help participants gain awareness of and control over their thoughts and internal dialogue to ensure self-talk is an asset and not a liability (Williams, 2009).

Data Analysis

IBM SPSS Statistics 25 software was used to complete statistical analyses. Prior to completing statistical analyses, an exploratory data analysis was conducted to identify any outliers. During this initial analysis, it was found that one participant did not complete any of the three MTS, although she did complete all three testing days. Due to several of the participants missing parts of the activity, I decided to include only those 9 participants who completed all three testing days and all three MT sessions in the statistical analyses that involved comparison of values over time.

Both study purposes were tested. The first hypothesis, that perceptions of stress and physiological markers of stress would increase or decrease at the same rate was assessed by a bivariate correlation between scores of the CSAI-2R subscales of somatic and cognitive anxiety and cortisol levels. The second hypothesis, that athletes who participated in mental training sessions would have lower cortisol levels and psychological stress levels after mental training, was tested through four one-way repeated measures ANOVA analyses. Results between the schools were compared. Independent variables were the times of testing (baseline, time 1 and time 2) and dependent variables were salivary cortisol and the threes subscales from the CSAI-2R. The level of significance was set at $p < 0.05$. I also conducted several ANOVAs to test if there were any statistically significant differences between cortisol, anxiety, self-confidence, and school, gender, and reported stress the week prior to testing at all three testing times.

CHAPTER FOUR: RESULTS

The mean data for anxiety, self-confidence, and cortisol for participants who completed different intervention activities are detailed in Table 8. When investigating the means of these variables for those who completed all 6 study activities, anxiety rose between B and T1 and then stayed consistent between T1 and T2. Cortisol had an increase from B to T2. And although self-confidence decreased overall, it had the least amount of change across the three time points. Those who participated in at least two MT sessions had a smaller change in both cognitive and somatic anxiety, as well as self-confidence between T1 and T2 testing compared to those who participated in less than 2 MT sessions. Additionally, anxiety and self-confidence levels remained more stable in those who had completed all MT sessions compared to those who did not attend all three sessions. In those individuals who attended at least two mental training sessions, anxiety levels dropped, and self-confidence increased from T1 to T2. Those who completed less than two MT sessions showed a larger increase in anxiety than either of the other two groups, but showed a slight increase in self-confidence between T1 and T2. While cortisol levels increased in the group where participants completed all MT sessions and those who completed less than two MT sessions, it dropped in the group that had completed 2 MT sessions.

Table 8. Group means for study variables at each time point

	All Participants	3 Testing Days & 3 MTS (n=9) *	3 Testing Days & 2 MTS (n = 7)	3 Testing Days & Less Than 2 MTS (n=2)
Cognitive Anxiety				
Baseline	19.81 (n=21)	18.22	21.14	23
T1	22.74 (n=19)	22.44	21.14	29
T2	22.20 (n=20)	22.67	19.71	30
Somatic anxiety				
Baseline	15.92 (n=21)	16.03	16.53	17.14
T1	21.28 (n= 19)	20.48	23.27	20
T2	20.71 (n=20)	20.63	20.41	22.14
Self Confidence				
Baseline	26.95 (n=21)	28.44	24.86	28
T1	24.32 (n=19)	28	20.86	18
T2	24.70 (n=20)	27.33	21.71	20
Cortisol (µg/dL)**				
Baseline	0.284 (n=20)	0.293	0.184	0.453
T1	0.351 (n=16)	0.297 (n=7)	0.368	0.444
T2	0.373 (n=19)	0.427	0.254	0.564

*Note: two participants who completed all activities did not produce sufficient saliva at Time 2, and therefore, were not included in the cortisol testing group
**Most studies report cortisol in nmol/L. The results I obtained from Salimetrics were in µg/dL. You can convert µg/dL to nmol/L by multiplying µg/dL by 27.59 to obtain nmol/L.

Correlational Analyses

To test the first purpose of the study, I conducted bivariate correlations to assess the relationships between the study variables. This analysis included the 9 participants who completed all six study activities. I hypothesized that perceptions of stress would be positively correlated to physiological markers of stress. When looking at the correlation table (Table 9.) for the different scales, the results indicated that there were several statistically significant correlations. Each of these relationships are explained below.

Table 9. Correlation table for 9 participants who completed all activities

	1	2	3	4	5	6	7	8	9	10	11	12
1. B Cognitive	--											
2. B Somatic	0.45	--										
3. B Self Confidence	-0.68*	-.74*	--									
4. B Cortisol	-0.17	-0.23	0.29	--								
5. T1 Cognitive	0.53	0.30	0.04	-0.15	--							
6. T1 Somatic	0.22	0.60	-0.48	-0.20	0.39	--						
7. T1 Self Confidence	-0.19	-0.52	0.69*	0.01	-0.42	-0.59	--					
8. T1 Cortisol	0.11	0.04	-0.14	-.86*	0.34	0.31	-0.16	--				
9. T2 Cognitive	-0.35	-.77*	0.55	0.59	-0.64	-0.15	0.19	-0.64	--			
10. T2 Somatic	-.84**	-0.17	0.50	-0.22	-0.31	0.15	0.27	0.35	0.15	--		
11. T2 Self Confidence	-0.15	-0.51	.67*	0.27	-0.17	-0.31	.71*	-0.36	0.35	0.06	--	
12. T2 Cortisol	-0.17	-0.31	0.26	0.59	-0.02	-0.28	-0.04	-0.29	-0.13	-0.13	0.04	--
Mean	18.22	16.03	28.44	0.29	22.44	20.48	28	0.23	22.67	20.63	27.33	0.43
SD	6.04	5.48	8.35	0.13	6.54	5.53	7.68	0.14	4.58	2.49	5.83	0.20
Alpha	0.61	0.76	0.91	--	0.77	0.78	0.95	--	0.56	-0.12	0.81	--
Range	10.00 - 28.00	10.00 - 25.71	18.00 - 40.00	0.137 - 0.525	14.00 - 36.00	10.00 - 30.00	20.00 - 40.00	0.139 - 0.560	16.00 - 28.00	18.57 - 25.71	20.00 - 38.00	0.130 - 0.782

The relationship between anxiety and cortisol had no statistically significant correlations at any of the time points. Cognitive anxiety had a slightly positive correlation at baseline with cortisol, and at both T1 and T2 had a slightly negative correlation with cortisol. For somatic anxiety, the relationship with cortisol was slightly negative at both baseline and T2, and slightly positive at T1.

At Baseline testing, there was a statistically significant negative correlation between both cognitive and somatic anxiety and self-confidence. This indicated that as both types of anxiety increased, self-confidence decreased. Although not statistically significant, there were small positive relationships between somatic and cognitive anxiety, as well as between cognitive anxiety and self-confidence and cortisol. Finally, a small negative relationship existed between somatic anxiety and cortisol. This was also not statistically significant.

During T1 testing there were no statistically significant relationships between any of the variables. Looking at the relationships, there was a slight positive relationship between cognitive and somatic anxiety as well as cortisol and cognitive and somatic anxiety. There was a slight negative relationship between cortisol and self-confidence, as well as between self-confidence and both cognitive and somatic anxiety.

At Testing T2, there were also no statistically significant relationships. During T2, slightly positive relationships occurred between cognitive and somatic anxiety, cognitive and somatic anxiety and self-confidence, and self-confidence and cortisol. Slight negative correlations existed between cortisol and cognitive and somatic anxiety.

When considering how variables correlated to themselves at different testing periods, self-confidence had the most statistically significant relationship at each time.

This positive relationship indicates that someone who had a high level of self-confidence at B also was likely to have had a high level of self-confidence at T1 and T2. For both Cognitive and Somatic Anxiety, these variables had a slightly positive relationship with Baseline at T1, and negative correlation at T2. This positive relationship between B and T1, then negative between T1 and T2 was also seen in Cortisol.

The most statistically significant correlations were found when looking at relationships between variables at different times. Baseline somatic anxiety and T2 Cognitive anxiety had the most statistically significant negative correlation. In addition, Baseline cognitive anxiety and T2 somatic anxiety had a statistically significant negative relationship, as did T1 cognitive anxiety and T2 somatic anxiety.

CSAI-2R Results

To test the second purpose of the study, I conducted four repeated measures one-way ANOVAs. For the ANOVAs, I hypothesized that athletes who participated in the three mental training sessions would have lower levels of psychological and physiological stress responses following the intervention than at T1.

The first ANOVA tested the effect of time on somatic anxiety (Wilks' λ = .66, $F(2,7) = 1.83$, $p = .229$). This function indicated that the level of change in somatic anxiety was not statistically significant at any of the three time points. Looking closer at the relationship of the variable on Figure 2., although there was a slight increase from baseline to T1, and a leveling off between T1 and T2, the change was not enough to be statistically significant.

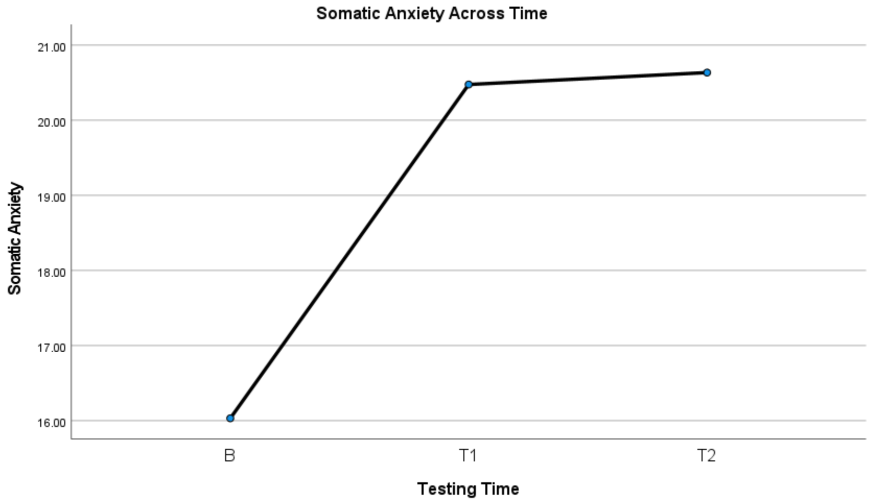


Figure 2. **Somatic anxiety across time for 9 participants**

The second ANOVA tested the change in cognitive anxiety across time and was also not statistically significant (Wilks' λ = .57, $F(2,7) = 2.63$, $p = .140$). Although there was a slight increase from baseline to T1, and a leveling off between T1 and T2, as can be seen on Figure 3 below, the change was not statistically significant.

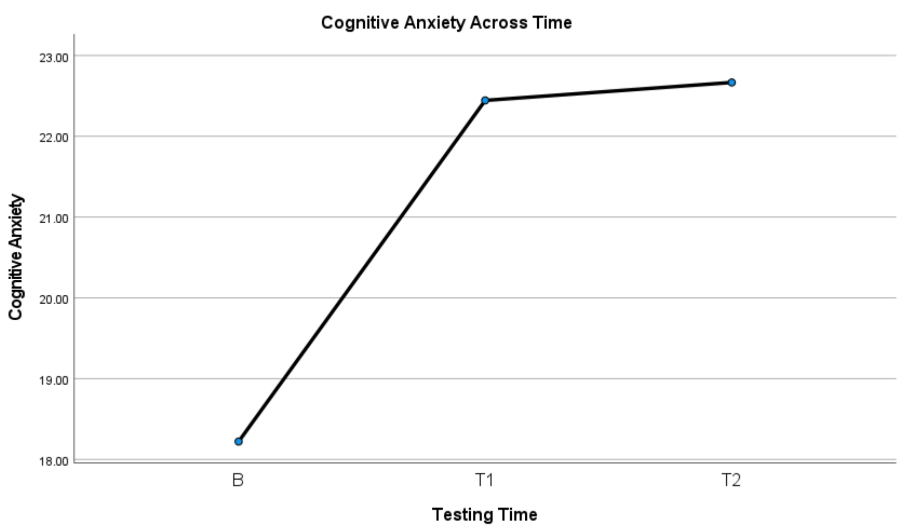


Figure 3. **Cognitive anxiety across time for 9 participants**

The third ANOVA investigated the change in self-confidence over time and was also non-significant (Wilks' λ = .96, $F(2,7) = .140$, $p = .871$). Investigation of the scores at each time point showed there was a very slight decrease from baseline to T2, and these results were non-significant (see Figure 4).

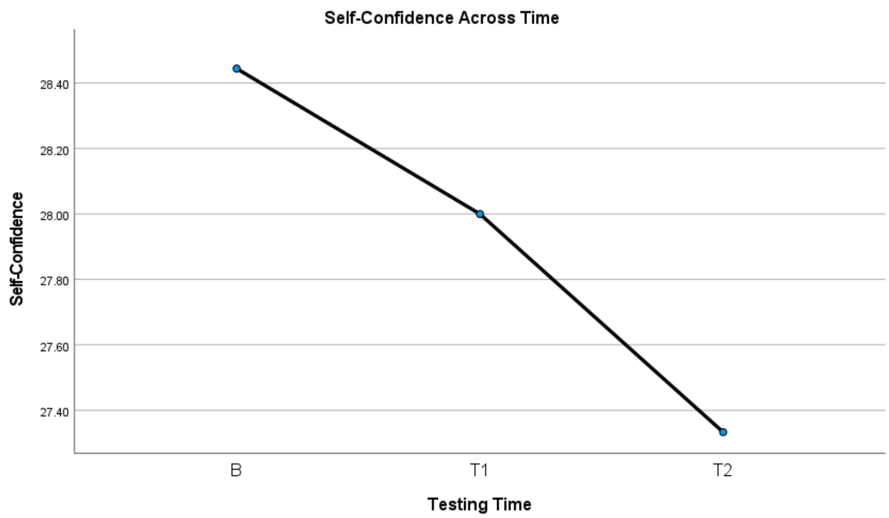


Figure 4. Self-confidence across time for 9 participants with complete data

The last results for the ANOVA that tested cortisol changes across time were non-significant as well (Wilks' $\lambda = .68$, $F(2,5) = 1.19$, $p = .378$). As can be seen when looking closely at each time point, although there was a slight drop from baseline to T1, and then an increase from T1 to T2, the change was not large enough to be statistically significant (see Figure 5). This analysis included data from 7 participants since two participants didn't have enough saliva for analysis at T1 testing.

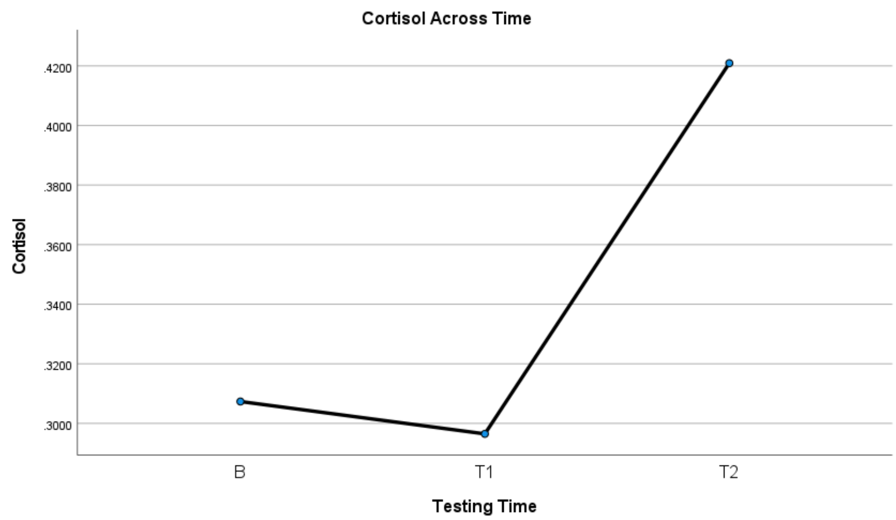


Figure 5. Cortisol across time for 7 participants

Cortisol, CSAI-2R and Demographics of School and Gender

In addition to the two primary purposes of the study, I conducted one-way ANOVAs to test if there were any statistically significant associations between school and cortisol, school and anxiety, and school and self-confidence. There was a statistically significant association between cortisol and school at B testing ([F=5.080], [p=0.037]). No other statistically significant results were found at any testing time. Table 10 below describes the mean cortisol levels according to school at each testing time.

Table 10. Mean cortisol and school for 9 participants

School	Mean cortisol (µg/dL)		
	B	T1	T2
A	0.346	0.297	0.440
B	0.192	0.406	0.281

I conducted one-way ANOVAs to test if there were any statistically significant associations between gender and cortisol, gender and anxiety, gender and self-confidence. No statistically significant associations were found at any testing time.

Cortisol, CSAI-2R and Stress Within the Past week

I conducted one-way ANOVAs to investigate the association between the reported stress experienced the week prior to testing and cortisol, anxiety, and self-confidence for all participants at B, T1 and T2. I found that while there was not an association for B or T1, there was an association that was statistically significant between cortisol and stress the week prior to testing for testing time T2 ([F=8.51], [*p*= 0.01]). Mean cortisol, group and time details can be seen in Table 11 below. There was also no association between reported levels of stress and anxiety for any testing time.

Table 11. Stress the week prior to testing and cortisol for all participants

Time	Group	Mean Cortisol (µg/dL)	N
B	0	0.265	12
B	1	0.312	8
T1	0	0.334	11
T1	1	0.358	3
T2	0	0.295	13
T2	1	0.542	6

Group
0= less than usual & usual stress 1= more stress than usual

CHAPTER FIVE: DISCUSSION

The current study had two main objectives: 1) explore how athlete's perceptions of stress and physiological markers of stress were related to one another; and 2) investigate the impact of a mental skills training program on athlete's perceptions of stress and physiological markers of stress. This is the first study to investigate the effects of mental skills training on prerace psychophysiological stress responses in high school endurance athletes, and answers the call of previous studies (Hogue, 2019; Hogue, 2020; Mehrsafar et al., 2019) to conduct these types of studies in authentic research environments instead of in the classroom or lab. In this discussion section I will discuss the results of testing as it relates to study purpose one and two, the significant results of stress the week prior to testing and cortisol, the lessons learned during the study, and the study's limitations and suggestions for future studies of this type.

To test the first purpose of this study, how athlete's perceptions of stress and physiological markers of stress would be related to each other, I conducted bivariate correlations that included data for all participants as can be seen in Table 9. The correlation results did not support the hypothesis that psychological perceptions of stress would be positively correlated to physiological markers of stress. The reason for this could include small sample size split between two schools, varying weather, and competition conditions. Overall, cortisol had a small correlation with all study variables at all time points that fluctuated between positive and negative depending on the variable and the time the variables were measured.

In addition to the primary purpose, there were several notable and statistically significant correlations between psychological stress measures that did not relate directly to the hypothesis. These results differ from the studies done by Filaire et al. (2001; 2009) in which statistically positive correlations were found between cortisol and somatic anxiety (Filaire et al., 2009), and cortisol and cognitive anxiety prior to competitions. The statistically significant positive correlations found in my study between self-confidence at T1 and T2 testing indicates that there was low variation in self-confidence scores from T1 to T2. If someone reported high feelings of self-confidence at T1, then they also reported high levels of self-confidence at T2. This result makes sense in that a competitor's self-confidence may not change that much during competition from time to time, or it could be due to a lack of effect of the MTS since there was not sufficient time between the MTS and T2. Other statistically significant results were the negative correlation between both cognitive and somatic anxiety and self-confidence, indicating that as anxiety increased, self-confidence decreased. These correlations make sense with respect to the CSAI-2R and indicate that the instrument was operating as expected and align with past studies.

To investigate the second purpose of the study, I investigated the impact of a mental skills training program on athlete's perceptions of stress and physiological markers of stress. I calculated repeated measure one-way ANOVAs with data from the 9 participants who completed all 6 MTS, except cortisol which included 7 participants because two participants didn't have data for one of the testing times. The results were not statistically significant for any of the variables (somatic anxiety, cognitive, self-confidence, and cortisol). This result means that these measures did not change significantly from T1 to T2 and the influence of the MTS was not seen in athlete scores among the 9 athletes who completed all portions of the research project. Investigation of the mean values for cognitive anxiety, somatic anxiety, self-confidence and cortisol for participants indicated all had very little change from T1 to T2. Again, possible reasons for this lack of change could be the small sample size and the small amount of time available to practice the mental training that was taught in the MTS.

In terms of the change associated with cortisol, there was more of a range in cortisol results than CSAI2R results. This larger range could be expected since cortisol release is related to physiological activation or arousal, in addition to anxiety, so a small rise in cortisol is not necessarily a negative aspect before a race. In fact, an increase in cortisol levels before a race can help facilitate a better performance. However, managing physiological arousal before a race is important for athletes, since some athletes can have levels of cortisol that can interfere with their performance (Siart, et al., 2017). Further, Cortisol results at T2 had a wider range than either B or T1. Both the minimum and maximum values for cortisol occurred on T2 (0.130 – 0.782 μg/dL). Cortisol levels were likely higher at T2 because the T2 testing for School A occurred in the morning when cortisol rates are naturally higher (Kalman and Grahn, 2004). Filaire et al. (2009), tested cortisol at different times of the day with tennis players and their results indicated that morning cortisol rates were all higher than afternoon or evening results. One way to eliminate these differences is to normalize the T2 results due to the differences in time of data collection. Specifically, the T2 cortisol levels of School A can be adjusted for time of day by subtracting the middle of the range for the expected afternoon cortisol levels (0.130 μg/dL) (Salimetrics, 2019), from the cortisol levels from T2 for participants from

School A. This documented effect of time of day justifies normalizing the scores for school A. After this adjustment, cortisol levels for School A are similar to School B, and the T2 value for participants who completed 3 MTS was 0.310 µg/dL instead of the higher than previous testing score of 0.427 µg/dL. Due to the exploratory nature of the study, I ran the repeated measure ANOVA with the adjusted cortisol scores and I found the same non-statistically significant result. This non-significant result was likely due to the fact that there were only seven participants in the cortisol analysis.

In addition to the larger range of cortisol in T2, the ANOVA test indicated there was a significant difference in cortisol between the two schools at baseline testing. Specifically, School A had a higher average cortisol level 0.346 µg/dL at baseline testing and School B had an average cortisol level of 0.192 µg/dL at baseline. One reason for this difference could be that school A had baseline testing during a sudden rainstorm. The participants from school A were cold at baseline testing, even though they were under a tent and school B had baseline testing on a warm and sunny afternoon. Since cortisol is released as part of the warming process when the body gets cold (Shida et al., 2020), the weather was likely to have influenced cortisol results, making them higher than they would have been had testing occurred on a sunny afternoon. Cortisol levels can be impacted by numerous factors. It is important to understand what is happening in our bodies, sometimes without our minds being aware of the changes, as cortisol can impact performance. Controlling for temperature and time of day of testing likely would have resulted in similar cortisol numbers between the two schools.

In an ideal study, all participants would have completed all 6 activities and been given sufficient time in practice to attempt skills between mental training sessions. That being said, subjects did report that they were utilizing the MT skills taught. During discussion before MTS 2 and 3, a number of subjects commented on how they had used the relaxation and breathing that was taught in the first MTS at times other than races. For example, subjects reported that the techniques taught in the first MTS had helped them relax before going to sleep at night. While more time to practice the skills taught in MTS 2 and 3 between T1 and T2 would have been ideal, the schedule didn't allow it. Additionally, school schedules, COVID, and other commitments resulted in only 9 subjects completing all 6 activities. Seven of those nine participants were from school A, and two were from school B. Further complicating this number was the fact that two of those 9 had no saliva for cortisol testing at one testing time. In terms of delivering MTS, the schedule did not allow subjects very much time to practice the mental skills they had learned before T2. Both schools completed their last MTS the day prior to T2. The initial sample size was small at 21, and participant issues resulted in a loss of more than 50% of the sample. This small sample size was a similar problem for other studies that included competitive athletes (Mehrasafar et al., 2019). While the low number of participants impacted the likelihood of finding statistical significance, I was able to find one interesting statistically significant result related to reported stress the week prior to testing and cortisol.

After looking at the two study purposes, I wanted to also look at the relationship between the study variables and self-reported stress within the past week. I found a statistically significant relationship between those who reported higher than normal stress and cortisol at T2, but not at the other two times. In addition, I found no association between cortisol and anxiety or self-confidence at any time controlling for reported stress. A number of factors could account for the relationship between reported stress and cortisol levels. First, the T2 race itself was more important than the previous races, as it was the last race before Regionals. Second, the correlation could indicate that there is a threshold point at which someone will notice their physiological stress. Third, perhaps athletes who had participated in the MTS were better able to self-assess their stress because of their participation in the MTS. Often, athletes and coaches focus on how athletes can utilize mental training to minimize anxiety on the day before, or during a competition, but this result suggests that it is also important to look at managing stress weeks and days prior to a competition, and even implementing a season long mental training program for athletes.

Working with cross-country running athletes during the competitive season allowed for a short window of time to conduct a study since the season runs from mid-August to the end of October. The short time frame I had available to conduct my study was likely one of the factors that contributed to the lack of statistically significant results. There have, however, been a number of similar studies with longer study time frames that have found significant results. The study by Mehrasafar et al. (2019), lasted over eight weeks. The intervention included working with subjects' multiple times per week. Subjects were also provided with multiple resources such as a workbook, smartphone app, and cd to help with work on the mindfulness intervention at home. Mehrasafar et al. (2019) found significant reductions in cortisol, and anxiety and increases in self-confidence after their intervention and these positive changes were still evident at a two-month follow-up. Similarly, a study by Coelho et al. (2014) saw a significant drop in cortisol in volleyball players after an intervention that included imagery, relaxation and video modelling in which they worked with athletes three times per week for five weeks. Additionally, Hatzigeorgiadis et al. (2014) saw improvements in performance with swimmers after a 10-week intervention of self-talk. to A long-term approach to mental training that includes multiple sessions per week and provides athletes with tools to help with practice at home could be the key to seeing reduction in anxiety and cortisol and increase in self-confidence. Working with competitive athletes over a long time period of weeks or months in a study setting presents a number of potential challenges, a number of which I come across in this study.

The challenges I encountered in conducting this study, which occurred in an authentic competitive environment, provided valuable learning opportunities and lessons. The first is the importance of, and difficulty in maintaining, desired consistency in all aspects of the study, including: time of day of testing, sufficient time between the MTS and T2, and weather. The coaches were working around schedules at school to schedule the MT sessions, so the options of days and times to conduct the MTS were limited. It was not possible to control weather and testing times because weather varies as did preset race times. The race times also dictated the testing times. Baseline and T1 testing times were consistent for both schools, and occurred at approximately the same time in the afternoon. T2 testing for school B occurred in the afternoon, but T2 for school A occurred in the morning. Also, school A had B testing during an unexpected thunderstorm, whereas school B had B testing on a sunny afternoon. The cool weather at B testing and cold morning race likely impacted cortisol levels at B and T2 for school A. While I did not have a control group to compare an intervention group with, I was able to compare cortisol results between both schools to find differences for time of day and weather which is in line with previous research (Filaire et al. 2001, Filaire et al. 2009). In addition, although subjects were asked not to eat or chew gum prior to saliva collection, there was no way to ensure they all complied. Any gum chewing or food eaten less than 30 minutes before saliva collection could impact cortisol levels.

Another lesson learned during the course of this study was the need to plan all aspects of the study far enough in advance and build enough time into the schedule to allow changes where they might come up, even though it is impossible to know when unexpected things will impact the schedule. Having extra time in the schedule could allow for more opportunities to change days of activities if they are needed, and still have enough spacing between activities for participants to practice the mental skills. The support of the coaches was key to being able to complete this project, especially since the schedule was largely at the discretion of the coaches. In addition to facilitating the schedule of activities, the coaches ensured athletes were present for each MTS if they were available. The coaches communicated with me in a very timely manner and provided a location for all activities, as well as ensured athletes connected with me on testing days, even though they were busy supporting their entire team on those days. The athletes were also very diligent about making sure they came by to provide saliva and fill out the CSAI-2R on testing days. They reminded other teammates to do the same if they had forgotten. Each of the teams was very supportive of the project. While I was stationed at each team's warm-up area when conducting the testing, the coaches and athletes helped me find any athletes who weren't around to make sure I didn't miss anyone. In all, there was only one athlete who was missed at one testing day because they were not near the team warm-up area when I was there. This study was conducted with two different schools, and I was working closely with coaches to schedule around COVID-19, and other illnesses, school, personal, and race schedules. There were four MTS scheduled, but because of schedules, the goal setting session was eliminated. One of the schools requested this MTS be completed after their final T2 testing day, and I was happy to provide that service even though the study was over. The challenges overcome and lessons learned in this study provide useful information to build off of for future studies of this type.

Limitations and Future Studies

Although this study was able to investigate the effects of mental training on psychophysiological stress responses in competitive endurance athletes, it was not without limitations. This study had a small sample size of 21 total participants, only 9 of those athletes completed all six activities over the course of the study, and two of those were missing cortisol for the T2 testing time. We had no incentive to offer for participation, but future studies should include incentives for participants based on activities completed as this might help ensure higher participation levels. By increasing the number of participants, it would increase the power of each analysis and the likelihood of finding statistically significant results.

Also, even though there was not a decline in anxiety between T1 and T2, there was a leveling off of anxiety in the group of 9 participants from T1 to T2. This might have been because of the influence of the MTS, but without a control group no comparisons could be made, so future studies should consider including a control group.

Furthermore, the study was short in duration, lasting only four weeks, with a small amount of time between the mental training sessions and T2 testing. This short time frame impacted the participants' ability to practice the mental training before T2 testing. The four weeks between baseline and T2 testing was not long enough to allow time to work around school schedules and fit in all the MTS with time to practice between each MTS and T2 testing. While I was able to schedule a week between MTS1 and MTS2, school B had the MTS3 the day before T2. School A had the MTS2 and MTS3 the two days before T2. Page, Sime and Nordell (1999) suggested a longer study time frame could have changed results of the impacts of imagery on anxiety in swimmers over a 5-week study and future studies should allow more time for athletes to work on implementing and practicing the mental skills they learned to try to maximize the impact of the intervention.

Conclusion

This study provides an additional step forward into investigating the impacts of mental skills training on prerace psychophysiological stress responses in high school endurance athletes. The significant relationship between high cortisol and high levels of stress the week prior to the race after mental training suggest the need for longer mental training programs and stress management over the entire season rather than just prior to or during competition. Finally, past studies have advocated future researchers should investigate the impact of MTS training in real sporting settings (Hogue 2019, 2020), instead of simulated environments and include both male and female subjects (Mehrsafar et al. 2019). While this study did those things, working with athletes in an authentic sport setting instead of a lab proved to be a logistical challenge. Because the setting was authentic, however, all the experiences were practical, and the flexibility that was required to complete the project was representative of the what athletes and those working with athletes face on a regular basis.

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APPENDIX A

Mental Skills Training Outlines

Session 1: Stress and Performance Overview & Breathing and Relaxation

Session 2: Imagery

Session 3: Self-Talk

Session 1: Stress and Performance Overview & Breathing and Relaxation

Three Learning Outcome Goals:

1) Understand stress and how it can negatively impact performance

2) Understand importance of complete breathing and muscle relaxation

3) Practice complete breathing and relaxation techniques

Order of session:

- Introductions
- Write down three things that went well for themselves on that day or three things for which they are grateful. This will ensure the session starts on a positive note.
- Introduce topics of the session:
  - Stress and Performance Overview
  - Breathing and Relaxation
- Exercise 1 – Increasing breathing awareness
  - The purpose of this exercise is to have participants gain awareness of their current way of breathing and to help them learn how to take slow, deep breaths from the belly that can generate a feeling of relaxation.
- Exercise 2 – Progressive muscle relaxation
  - The purpose of this exercise is to help participants learn to have awareness of what tension and absence of that tension feels like. By doing this exercise they also learn how to recognize unwanted tension and release, which can be especially helpful in stressful situations.

Estimated time spent on each activity during the session:

Introduction of stress and performance, and breathing and relaxation (7-10 minutes)

Increasing breathing awareness (5 minutes)

Progressive muscle relaxation (25-30 minutes)

Review and questions (5-10 minutes)

Total time: 42-55 minutes

Session 2: Imagery

Three Learning Outcome Goals:

1) Understand imagery and the relationship between controlling thoughts and performance

2) Identify current imagery skills

3) Practice using imagery

Order of session:

- Write down three things that went well for themselves on that day or three things for which they are grateful
- Introduce topics of the session:
  - Imagery
- Exercise 1 - Arm as an iron bar
  - The purpose of this exercise is to help participants become more aware of the power of mental imagery.
- Exercise 2 - Vividness
  - The purpose of this exercise is to help participants become more aware of how utilizing all of their senses when using imagery can help create a much clearer image in their mind's eye.
- Exercise 3 - Controllability
  - The purpose of this exercise is to help participants understand how they can control and change their images
- Exercise 4 - Self-awareness
  - The purpose of this exercise is to help a participant become aware of their underlying thoughts and feelings that can impact their performance.
- Exercise 5 - Sample pre-race imagery
  - The purpose of this exercise is to help walk the participants through a practice pre-race imagery exercise.

Estimated time spent on each activity during the session:

Introduction of imagery (7-10 minutes)

Arm as an Iron Bar (5 minutes)

Vividness, Controllability, Self-Awareness (15 minutes)

Sample pre-race imagery (5-7 minutes)

Review and questions (5-10 minutes)

Total time: 37-47 minutes

Session 3: Self-Talk

Three Learning Outcome Goals:

1) Identifying self-talk

2) Understand the relationship between thoughts, self-talk, confidence and performance

3) Controlling self-talk and creating cue words

Order of session:

- Write down three things that went well for themselves on that day or three things for which they are grateful
- Introduce topics of the session:
    - Self-Talk including thoughts, feelings, behaviors
- Identify self-talk imagery and writing in log
- Exercise 1 – ABC Cognitive restructuring exercise: Identifying self-talk and Controlling self-talk
    - The purpose of this exercise is to provide the participants tools they can use to take any situation, and change their self-talk and reaction to it by going through the steps in the exercise.
- Exercise 2 - Creating cue words to use self-talk to our advantage
    - The purpose of this exercise is to help participants create cue words that are significant for themselves related to their pre-race routine.

Estimated time spent on each activity during the session:

Introduction of self-talk (5 minutes)

Confidence and self-talk, thoughts, feelings, behaviors explanation (5 minutes)

Identifying self-talk imagery and writing in log (7 minutes)

ABC cognitive restructuring (15 minutes)

Cue Words (5 minutes)

Review and questions (5-10 minutes)

Total time: 42-47 minutes

APPENDIX B

Revised Competitive State Anxiety-2R Survey

Scoring key:
Somatic anxiety: 1,4,6,9,12,15,17
Cognitive anxiety: 2,5,8,11,14
Self-confidence: 3 7,10 13,16

Subscale score is obtained by summing, dividing by number of items, and multiplying by 10. Score range is 10 to 40 for each subscale. If an athlete fails to respond to an item, merely sum and divide by items answered.

Revised Competitive State Anxiety-2R (CSAI-2R)

A number of statements that athletes have used to describe their feelings before competition are given below. Read each statement and then circle the appropriate number to the right of the statement to indicate how you feel right now - at this moment. There are no right or wrong answers. Do not spend too much time on any one statement, but choose the answer which describes your feelings right now.

	Not at all	**Some what**	**Moderately so**	**Very much so**
1. I feel jittery.	1	2	3	4
2. I am concerned that I may not do as well in this competition as I could.	1	2	3	4
3. I feel self-confident.	1	2	3	4
4. My body feels tense.	1	2	3	4
5. I am concerned about losing.	1	2	3	4
6. I feel tense in my stomach	1	2	3	4
7. I am confident I can meet the challenge.	1	2	3	4
8. I am concerned about choking under pressure.	1	2	3	4
9. My heart is racing.	1	2	3	4
10. I'm confident about performing well.	1	2	3	4
11. I'm concerned about performing poorly.	1	2	3	4
12. I feel my stomach sinking.	1	2	3	4
13. I am confident because I mentally picture myself reaching my goal.	1	2	3	4

14. I'm concerned that others will be disappointed with my performance.	1	2	3	4
15. My hands are clammy.	1	2	3	4
16. I'm confident of coming through under pressure.	1	2	3	4
17. My body feels tight.	1	2	3	4