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# The Introduction of Yoga Recovery on Physiological and Psychological Stress and Performance in NCAA Athletes

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# THE INTRODUCTION OF YOGA RECOVERY ON PHYSIOLOGICAL AND PSYCHOLOGICAL STRESS AND PERFORMANCE IN NCAA ATHLETES

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Abstract

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NCAA student athletes face unique physiological and psychological stressors daily, which may contribute to overtraining, burnout, and other physical and mental health issues. However, NCAA institutions often leave recovery up to the individual athlete due to time restriction and Countable Athletic Related Activities (CARA) hour limitations on team mandated activities. Attention to methods to promote recovery from these training loads is increasing in NCAA institutions. A mind-body activity such as yoga is proposed to have physiological and psychological benefits for student athletes. The goal of this review is to identify which aspects of yoga promote the most effective recovery in measures such as: performance, physical biomarkers of stress, muscle damage, heart rate variability, sleep quality, mood state, anxiety, and depression. A recovery yoga protocol is presented, based on the current literature on the topic, to suggest a time- and cost-effective mind-body recovery modality for NCAA student athletes. The recommendation of this review concludes that, among other approaches, NCAA athletes are ideal candidates to undertake the practice of a yoga-based relaxation technique. As such, initial incorporation of yoga is recommended for 20 minutes twice weekly, with a third 60-minute practice each week for a more integrated mind-body yoga experience. From the literature, there is a scientific rationale to understand and anticipate physiological effects such as decreased muscle soreness, heart rate variability, and oxidative stress and psychological effects of improved mood, decreased anxiety, and depression in terms of yoga efficacy. Based on this rationale, introduction of yoga-based recovery is likely to improve some aspects of academic and athletic performance, as well as overall greater wellbeing upon completion of the recommended intervention. However, well-founded conclusions are tentative because explicit mechanistic research is sparse. Accordingly, outcomes based research is needed to confirm the extent to which introduction of these recovery-based approaches will benefit yoga novices.

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## Chapter 1: Introduction

### Introduction

In today's "better, faster, stronger" society, National Collegiate Athletic Association (NCAA) athletes are a highly stressed population. Collegiate athletes manage a difficult balance of hours-long sport practices, elite level competitions, intense weight lifting and conditioning sessions, lengthy film review sessions, acute injury treatment, rigorous course work, erratic travel schedules, and social pressures from coaches, teammates, and family experiences. All beginning at 18 years of age. Not only does this type of lifestyle cause great physical stress, but it has psychological impacts as well. For many athletes, the volume and intensity of training and student athlete life distract from the true goal of training, which is to increase performance. [1]. The overtraining principle relies on the body's ability to break down and adapt to the stresses it has experienced, assuming the body undergoes a complete recovery process. The number of athletes who are overtraining and accrue insufficient rest is increasing [2]. Inadequate physiological and psychological recovery from daily training loads may lead to overtraining and underperformance [3]. Effective recovery is crucial for athletes; it is necessary for their health, safety and balance in combating physical and mental stress. While decreasing training intensity and volume may not be an option, athletic programs should seek alternative ways to assure adequate reoperation for their athletes by providing modalities for recovery, both physiological and psychological, from the high stress and training loads of a busy athletic lifestyle. Novel approaches to improve the physical and mental interconnectedness, and the recovery thereof, are being sought in the realm of collegiate athletics and need to be further explored.

Physical health and recovery are prioritized in athletics, but increasing attention is now directed towards psychological recovery and mental health of college athletes [4]. Repercussions of poor psychological recovery consist of depression, anxiety, burnout, and unhealthy coping strategies like substance abuse or sleep disorders [5]. According to the National Institute of Mental Health, approximately 40 million people over the age of 18 are affected by anxiety on some level. Athletes with healthy amounts of anxiety or arousal can utilize psychological skills training to help them focus, concentrate, and perform. However, athletes that exhibit trait anxiety, or anxiety that overarches situations, may suffer from an anxiety disorder. Anxiety disorders have negative effects on athletic performance by impacting the ability to concentrate

and focus, primarily through distraction by physical and psychological symptoms. Athletes experiencing anxiety disorders attend to negative affects instead of positive [4]. For athletes experiencing symptoms of anxiety, practicing a modality that connects mind and body may regulate the level of arousal, and potentially mitigate mental and physical symptoms of anxiety disorders [6]. A mind-body activity such as yoga would be beneficial for all athletes to keep them performing in the optimal zone of arousal.

Therefore, activities that interface the recovery of mind and body need to be implemented in collegiate athletics. Unfortunately, NCAA institutions often leave recovery up to the individual athlete due to time restriction and Countable Athletic Related Activities (CARA) hour limitations on team mandated activities. Therefore, recovery is often overlooked, minimized, or deemphasized due to the other pressing demands athletes face. However, recovery is an extremely important part of an athlete's training protocol consisting of physical recovery from acute training loads and mental recovery from daily pressures and expectations from themselves and those around them. Having an appropriate outlet for recovery can make the difference between success and failure in sport [7]. Because athletes encounter demanding physical and mental situations, a recovery modality that combines mind and body needs to be considered.

There are numerous modalities that provide acute effects of recovery for athletes such as cold tub emersion or soft tissue massage therapy, however, in order to combat the physical and mental aspects of stress together, there needs to be an interface between the mind and the body [5] and sometimes the spirit [8]. The rationale exists that many different modalities can be beneficial for athletes' recovery when used appropriately. However, this project focuses on the most prevalent modality for recovery that encompasses various aspects of health and wellness: yoga. With growing popularity in the Western world, approximately 86% of all health clubs in the United States offer yoga practice [9]. In efforts to move away from pharmaceuticals in treatment for mental health conditions such as anxiety, yoga is studied as an alternative treatment [6]. Research has revealed outcomes in abating symptoms of anxiety as reported on validated scales such as State-Trait Anxiety Inventory (STAI) and Hospital Anxiety and Depression Scale (HADS), among others [10-12]. Further research is needed to extend these findings into athletes to improve mental health, recovery, and athletic performance. [10-12].

The practice of yoga for recovery in sport is beginning to emerge because of its numerous physiological and psychological benefits, many of which overlap the needs of athletes for

recovery. Yoga practice relates to improvements in performance parameters like flexibility, muscular strength and endurance, and cardiovascular performance [9, 13-15]. Physiological health factors such as heart rate, diastolic blood pressure, immune function, reductions in inflammation, and muscle soreness are studied in conjunction with yoga intervention [9, 14, 16-19]. Yoga positively affects psychological health measures such as anxiety, depression, stress, and mood states [20-23]. While gaining popularity with professional celebrity athletes and through anecdotal testimonials, collegiate athletes have positive expectations of how yoga will make their bodies and minds feel. The rationale exists that NCAA athletes should be taught the practice of yoga for the physiological and psychological benefits it may bring to their recovery and health. Physical recovery is a concern in collegiate athletics for some time, but attention is just being directed to psychological recovery and its implication on mental health [4]. "There's more to being a student-athlete than just physical preparation and performance" states NCAA chief medical officer, Brian Hainline [5], indicating the NCAA needs to increase efforts to promote mental health as well.

Recovery is a critical component of an athlete's training protocol: physical recovery from acute training loads and mental recovery from daily appraisal of pressures, expectations, and anxiety from themselves and those around them, which demonstrates the need for a mind and body recovery interface. Having an appropriate outlet for recovery can make the difference between success and failure in sport [7].

**Problem**

The lack of recovery modalities offered to NCAA student athletes continues to be a major problem in combating physical and mental stressors. Not attending to the needs for effective recovery often results in serious health detriments to the physical and mental wellbeing of the athlete. With a well-established understanding of physical recovery needs, increasing support for recovery and the benefits on mental health is yet to be fully articulated. Mental health is especially important in relieving symptoms of anxiety and its impact on athletic performance.

## Purpose

NCAA athletes experience significant physiological and psychological stress resulting from training, performance, academic, and social demands, therefore, mindfulness and relaxation techniques may be appropriate measures to counter the stress response. Yoga is one of the most utilized approaches because it includes the mind and body connection, which is vital for combined physiological and psychological recovery. The purpose of this work is to design a research-based eight-week recovery yoga protocol that can be utilized in any athletic department for NCAA athletes. The effects of mind-body wellness, combined with the aspect of the spirit, will be a tool for athletes to learn and utilize for individual health and athletic performance. An overarching goal of this paper is to develop a protocol that is also time and cost efficient, which are barriers of current recovery methods in the NCAA [24].

## Significance

Promotion of student athlete success while also working to better ensure health and safety is the main goal of every collegiate athletic department in the country. Promoting and facilitating an accelerated recovery is one way athletic departments can achieve the goal of combating physical and mental stress. When athletes are adequately recovered, their performance will improve, as will their physical and mental health. Helping athletes lead balanced lives may increase performance and thus increase winning in the school, which may be a secondary goal for an athletic department. Athletic performance influences all stakeholders in collegiate athletics, from the players to coaches, administrators to support staff, alumni boosters to corporate sponsors. Complete recovery is essential, but often under-realized for successful athletic performance. Adequately recovered athletes subsequently train harder and achieve more as competitors and students. If correct, key dependent outcome measures of these advances include improved psychological performance skills and consistently better academic and athletic performance [15] .

## Definition of Terms

**Recovery**: Recovery is an inter- and intra-individual multi-level process over time for the reestablishment of performance abilities. The multi-level process refers to subtopics such as

physiological, psychological, social, spiritual, etc. Recovery includes an action-oriented component and those proactive activities can by systematically used to optimize situational conditions and to build up and refill personal resources and buffers [7]. Recovery is dependent on the type and duration of stress, reduction of stress, changes in stress or a break from stress. Recovery is specific to the individual, depends on individual appraisal, and is closely tied to situational conditions. Modalities can be active or passive [3].

**Stress**: Stress is destabilization or deviation from the norm in a biological/psychological system; a deviation in psychophysical balance [7]. Stress represents a substantial imbalance between physical and psychological demand and response capability under conditions where failure to meet that demand has important consequences.

*Physiological Stress:* Physiological stress can refer to the actual load acting on the body, such as weight lifting. However, physiological stress also can be defined as the degree to which an individual feels the changes in perceived physiological activation from cognitive stress.

*Psychological Stress:* Also known as mental or cognitive stress, psychological stress concerns the degree to which one worries or has negative thoughts [25].

**Yoga**: Yoga is frequently defined as a way to join or unite together all aspects of a person: the physical self, metal self, emotional self, history, and goals for the future [26]. Learning to listen and respond to bodily sensations is the core message of yoga [27].

**Mind**: The mind relates to all mental and emotional processes. The mind is the control center that is credited for the genesis of thought, emotion and perception [28, 29].

**Body**: The term refers to the physical being and physiological function of humans. The body includes the brain, nervous system, endocrine system, immune system, muscular, and skeletal systems. Not merely the collection of complex systems but the union of how each one operates within the whole.

**Spirit:** The spirit and spirituality is defined as a sense of empowerment and personal control over one's self and responses to life, a sense of connectedness to one's deeper self and to others, a sense of purpose and meaning, and hope for the wisdom and capability to deal well with whatever comes. The spirit is the deepest sense of belonging and participation. The entity is not innately connoted with religious, moral, ethical, or psychic realms. Spiritual attitudes are highly individualized and can include these realms if desired by the individual [30].

## Chapter 2: Review of Literature

### Stress and Performance

Performance is influenced by many internal and external factors. In 2000, Gallwey presented a model describing factors that contribute to and deter from performance outcomes: $P=p-i$. $P$ refers to the performance that actually occurs on the day of competition. The $p$ refers to the potential of the individual, or the best possible outcome of the performance, while the $i$ refers to the interference the performer may encounter [31]. Interference can be any number of things, from physical stress, to mental stress, to environmental stress. The goal of training is to improve performance parameters of sport, minimize interference, and increase performance during competition. Threatening situations are appraised with a stress response, leading to a release of cortisol from the adrenal cortex into the saliva and blood stream. The presence of cortisol interferes with some cognitive processes, resulting in decreases in performance outcomes. Performers who made more errors in a tennis match, costing them the game, displayed higher levels of cortisol than the winner of the match [32]. However, some presence of cortisol is beneficial for preparing for the physical demands at hand. There is an optimal level of arousal or stress where performance is the highest, as illustrated in Yerkes and Dodson's "Inverted U" hypothesis. Too little stress and the performer will not appraise the situation as important. Too much stress, and performance will fall off due to imbalance of perceived pressure and self-efficacy to perform to the desired level of competition. [33]. Chronic exposure to the stress response can add detrimental outcomes to performance. Constant stress can manifest to impairments on physical and cognitive functioning [34].

Again, some level of stress is needed in order for an athlete to adapt to the training stimulus and grow as a performer, known as the supercompensation theory. However, if an athlete does not have an effective source of recovery to offset the constant stress of training, the athlete will no longer be experiencing supercompensation to stimulus, but begin to fall below the compensation curve, and may experience a wide array of physiological and psychological deficits that contribute to poor performance [3]. Overtraining syndrome, or staleness, is defined as performance deficits brought on by the inability to recover from intense training [2]. Exposure to chronic stress is marked by various physical and mental responses, many of which are quantifiable in terms of biometrics.

**Physical Stress**

*Overtraining:* The manifestation of physical stress in athletes can occur in many ways. When an athlete enters the realm of overtraining, he or she may experience any number of physical symptoms such as: severe fatigue, muscle soreness, increased vulnerability to injuries, reduced appetite, weight loss, disturbed sleep patterns, decreased libido, and immune system deficits [2, 3, 35, 36]. In a sport specific lens, overtraining in aerobic sports tends to develop changes in the parasympathetic nervous system, leading to fatigue, depleted energy stores, tissue injury, excessive cytokine release, and oxidative stress. On the other hand, overtraining in anaerobic sports tends to alter sympathetic nervous system control, resulting in physical symptoms such as insomnia, differential catecholamine sensitivity, increased resting heart rate, and decrease in maximal power output performance [1].

*Muscle Damage, Creatine Kinase, Oxidative Stress:* Physical stress such as muscle damage is readily observed though MRI, strength loss, activity myoglobin concentration, or myosin heavy chain fragment concentration [37] The most prevalent measurement of muscle damage is the level of circulating creatine kinase (CK) because its magnitude of increase after exercise enables one to track acute muscular damage. The presence of CK in the blood and serum occurs in proportion to muscular membrane disruption, and as such, is an established biometric of muscular damage [37-40]. Increases in CK activity in the blood are consistent with greater degrees of muscle soreness and force loss [37]. The neutrophil/lymphocyte ratio (NLR) also indicates the magnitude of systemic inflammation and the severity of muscle damage when measured after a bout of exercise. After completing a high intensity exercise protocol developed to mimic the demands of a soccer game, athletes displayed higher levels of CK and lactate dehydrogenase (LDH), but also increased lipid profile, glucose, lactate, and uric acid, which were indicative of aerobic and anaerobic metabolic stress [38].

Muscle damage and inflammation are a somewhat common consequence of acute participation in novel exercise. Levels of CK and LDH may remain elevated for 12-24 hours post-exercise, which is appropriate for acute recovery from training, but elevated levels for longer periods of time can be detrimental. The risk of chronic muscle damage and inflammation occurs because these responses produce reactive oxygen species (ROS), which contribute to oxidative stress and muscle fatigue [39]. Maximal workload in elite athletes increases generation

of reactive oxygen species, nitrogen species, and oxidative stress. The presence of (ROS) suppresses the natural limiters of nitric oxide (NO) production.

Therefore, a higher presence of NO is indicative of ROS. While acute elevations in oxidative stress are a vital part of the exercise-recovery-adaptive response, untoward ROS levels are sometimes suspected in highly trained populations [41]. Case in point, vigorous exercise with significant muscle damage causes acute inflammation from mononuclear cells and neutrophils in the tissue. Like CK, all acute exercise sessions produce brief inflammation and oxidative stress, which, as previously stated, are necessary outcomes to produce adaptations. Only chronically elevated baseline levels, as expected in overtraining or prolonged periods of muscle damage, indicate problematic redox imbalance [42]. A side effect of this inflammation from muscle damage is an increased amount of ROS, which by virtue of dose and magnitude, induce damage to lipids and proteins. Reactions such as these define the overused term "oxidative stress." Nonetheless, it is now clear that these sorts of time-extended redox reactions temporarily limit post-exercise rebuilding and recovery, and thus, mitigate the appropriate response to physical training [43]. Recognizing that ROS are a cornerstone of adaptation and that too much production is detrimental, increases in ROS are generally proportional to increases in training load and volume [1]. Pertinent to this discussion, at what point does ROS production become detrimental and how can a facilitated recovery attenuate the response? A yearlong study of biomarkers in elite water polo athletes by Varamenti et al. suggest that during their most intense period of training, basal levels of tbiobarbituric reactive substances (TBARS) and protein carbonyl concentration increase, indicative of oxidative stress. The chronically elevated basal levels of oxidative stress biomarkers suggest an extended state of incomplete recovery because oxidative stress biomarkers are typically only elevated in a post-exercise timeframe. In addition, lipid and protein oxidation increase due to fatigue from long periods of high volume training, and remain elevated until tapering of training begins, usually in preparation for play-off season [44]. All told, additional data are needed to confirm the relationship to recovery and yoga, but a rationale exists to indicate that NCAA athletes exhibit signs of incomplete recovery as evidenced by simple measures of circulating oxidative stress biomarkers.

*Cortisol, Testosterone, IL6:* Physiological responses to stress commonly include documentation of increased levels of salivary and serum cortisol [45-48]. Perna et al. studied elite cyclists and rowers, finding salivary cortisol increases more in subjects that experienced

higher life stress than the low life stress group as quantified by the Life-Event Scale for College Athletes (LESCA) [45]. Significantly elevated levels of cortisol were found in elite swimmers compared to a control group during the entire length of the season through baseline, overtraining, and tapered levels of training loads. Elevated cortisol levels are significantly correlated with depressed mood during overtraining periods ($r=.50$; $p<0.05$) [47]. Similar to muscle damage and inflammation responses, acute changes in these hormones after training are expected, but long-term elevation is not advisable [32]. Findings from more recent studies suggest no significant changes in cortisol following intense training [49], or even increases in cortisol and testosterone levels during overreaching training periods [1, 46]. Purvis et al. suggest further research examines the testosterone/cortisol ratio as a diagnostic tool for overtraining. The research team concluded that when testosterone concentration is higher than cortisol concentration, favorable outcomes in performance are likely [50]. Admittedly, these findings are limited methodologically, but repeated observations would be suggestive of the interrelationship between circulating hormone ratios and an athlete's recovery status.

Exercise up regulates IL-6, which when released from muscle is now held to exert anti-inflammatory properties and body-wide adaptations as part of the exercise training response. In contrast, chronically elevated circulating levels of IL-6 are common in over trained elite athletes, and are demonstrated to be part of a faceted inflammatory response. In this regard, the IL-6 parallels oxidative stress in that acute spikes are beneficial, chronic elevations deleterious. Accordingly, extended duration rises in circulating IL-6 are associated with inflammatory diseases, rheumatoid arthritis, and clinical depression. Whether there is a direct link between chronically elevated IL-6 and the occurrence of disease in athletes is not currently demonstrated, awaiting further study. Nonetheless, when athletes undergo high volumes of training and perhaps overtraining occurs, IL-6 is elevated and concluded to play a role in immunosuppression and decreased performance. Increased circulating concentration of sIL-6R, caused by prolonged exercise training, is correlated with higher perceived stress ($r=0.64$; $p=0.004$), worse mood ($r=0.49$; $p=0.02$), and impaired sleep quality ($r=-0.43$; $p=0.05$) on a wellness questionnaire [48].

*Heart Rate Variability:* Shifts in heart rate variability, specifically higher sympathetic activity, is indicative of the stress response and insufficient recovery from stress. Lower heart rate variability suggests adequate parasympathetic and sympathetic control, common with decreases in stress [16]. Patil's study very closely parallels the workload of college athletes using

eight training sessions per week. Increases in sympathetic and decreases in parasympathetic activity in the training group from pre to post and from the control group were observed. The training group reported higher stress and lower recovery as quantified by the Recovery Questionnaire for Athletes (RESTQ-SPORT). Decreased muscular performance in maximal strength tests occurred in the training group ($p<0.05$) [51]. The research design of this study holds high validity because many times due to scheduling demands, athletes must practice, and weight train in the same day, many times without effective recovery. Training eight times a week is a very realistic training schedule for NCAA athletes.

*Sleep:* Quality sleep is important for athletes to rejuvenate, rebuild, and recover from training loads. Number of sleep disturbances were significantly higher during high training periods in elite swimmers than at baseline training periods [52]. During peak training loads, elite rowers report significantly greater daytime sleepiness compared to control groups [49].

*Pain:* Chronic lower back pain may surface as a result of unrelenting stress responses in athletes, damaging performance. The presence of pain is a result of maladaptive coping with physical and mental stress. Furthermore, a spiral begins between stress caused by pain and pain caused by stress [34].

**Psychological Stress**

*Overtraining, Burnout:* When an athlete reaches overtraining, aerobic sport athletes may elicit increases in depression due to parasympathetic changes, while anaerobic sport athletes may experience disturbance in mood states such as increased irritability and elevated tension from changes in the sympathetic system [1, 35]. The drive to avoid shame of decreased performance cultivates doubts from cognitive, behavioral, and emotional experiences and the combined effects can be so amplified through heightened anxiety, that it cripples performance. The effects of psychological stress, paired with decreases in performance, cause emotional exhaustion, which often leads to burnout [53].

*Mood States:* Increased training is significantly linked to increases of negative mood states of athletes [1]. In addition, mood improvements were directly related to titration of the training load, independent of biological sex. These changes in mood state are attributed to various cardiovascular, enzymatic, endocrine, hormonal, and hypothalamic changes [35]. O'Connor et al. found alterations in tension, depression, anger, vigor, and fatigue across an entire training

season in elite swimmers. Global mood, or the sum of the Profile of Mood States (POMS), was significantly higher in the overtraining phase in these athletes ($p<0.05$) and was associated with larger performance decrements than those who did not exhibit large performance decrements [47]. Similarly, National-team caliber cyclists reported significant increases in emotional stress (as quantified by the LESCA) with increases in training load [45]. Elite rowers also reported significantly greater total mood disturbance on the POMS ($r=0.54$; $p<0.05$) compared to controls, regardless of training load, suggesting chronic training alters mood states [49].

*Mental Health, Depression, Anxiety:* Cognitive appraisal, or how the individual evaluates and gives meaning to an experience, plays a direct role in stress accumulation. According to the Self-Determination Theory, athletes have three psychological needs: autonomy, competence, and relatedness [54]. Threats to these needs can cause cognitive stress. Athletes experience threat appraisals or challenges to their mental health from the intensity, frequency, and duration of everyday organizational factors they encounter such as goals and development, logistics and operations, team and culture, and coaching and selection [55]. Athletes that enter overtraining levels report elevated depression symptoms [35]. The chronic presence of IL-6 is associated with clinical depression and worse mood in endurance trained athletes ($r=.49$; $p=0.02$) [48]. Another rationale implicates a role for anxiety in relation to the concentration of lactate in the blood as a result of exercise stress [56]. Stress of competition is demonstrated to increase cognitive anxiety and decrease self-confidence in tennis players, more so in the loser of the competition than the winner [32]. Symptoms of anxiety disorders in athletes may include feeling apprehensive, having a sense of panic, trembling, or feeling tired or weak. Another sign of anxiety is feeling powerless or loss of control, which would be plausible in athletes [5]. Athletes have little to no say regarding their practice, class, and travel schedules, which may leave them feeling without control of their sleep, eating, and study schedules, adding to anxiety and stress [4]. If an anxiety disorder is left untreated, it can lead to higher likelihood of heart disease and heart attack as well as chronic respiratory disorders and gastrointestinal disorders [5]. Therefore, drawing attention to problematic levels of anxiety in athletes can help protect their health and safety in the long term.

**Need for Effective Recovery**

Supercompensation refers to the breakdown process after a training load, followed by the recovery process. The concept is used by the majority of coaches and trainers in the NCAA.

Supercompensation is founded on the assumption that athletes are getting adequate recovery. The main cause of overtraining in athletes is the lack of sufficient recovery after heavy physical loads [2]. Coaches state practicality and accessibility, such as time and cost, as the most important factors when promoting recovery modalities to their athletes [24]. By incorporating recovery into training schedules, long-term performance is enhanced [3]. Inadequate recovery from increased training loads can result in decreases in self-reported physical recovery, self-efficacy, social relaxation, general wellbeing, and sleep quality. Increases in fatigue, decreases in maximal strength performance, and somatic complaints are observed [57-59]. Elite swimmers that report more positive recovery were more likely to compete with a performance that pleased them compared to others with a negative recovery report [60]. By understanding the physiological responses to training and the balance of recovery, coaches and trainers can create meaningful and purposeful workouts without fear of overtraining.

**Yoga as a Recovery Modality**

Five essential components of yoga practice are identified for the purpose of this project: mindfulness, asana or postures, the relaxation response, pranayama or yoga breathing, and resilience.

*Mindfulness:* An important component of yoga for recovery is mindfulness, which is a form of meditation focused on purposefully attending to the present moment [61]. The goal of mindfulness is not experiential avoidance or the suppression of negative thoughts, emotions, or pain, which can be an unhealthy way to cope with stressors and ultimately lead to psychological inflexibility. The goal of implementing mindfulness practice is to allow the athletes a healthy time to acknowledge stressful or negative notions, let them come up without judgment, and allow them to pass by, like a cloud rolling across the sky. Mindfulness practice teaches athletes to give attention to stimuli and allocate appropriate resources to deal with them, leading to improvements in cognitive processing like attention orientation, executive attention, and working memory, all of which can improve performance [62, 63]. Bulmyaer et al. suggest mindfulness may serve as an appropriate complementary recovery strategy, pending future research [64]. Mindfulness is also described as a mental training that facilitates more adaptive response to stress [61].

*Asana:* Adding movement of yoga, or asanas, to this practice of mindfulness is an important aspect of yoga for athletes due to their kinesthetic inclination. Athletes may prefer to learn mindfulness through movement and activity rather than through a static relaxation practice. [62]. Yoga is demonstrated to be as effective as other mindfulness modalities on the Comprehensive Inventory of Mindfulness Experiences scale (CHIME) [63]. Therefore, with the combined physiological benefits of yoga, this modality may be superior to sole meditation or mindfulness for athletes' psychological wellbeing. Some asanas elicit more of a relaxation response than others. Sarang et al. compared immediate relaxation response between two different yoga techniques. Cyclic Meditation, which is a combination of stimulating and calming postures, was compared to Supine Rest, which is solely a calming posture. Results illustrate that Cyclic Mediation is associated with a greater relaxation response than Supine Rest by improved performance in a perceptual motor skill task (24.0%; 13.9% respectively), supporting the need for movement as an important aspect of recovery yoga [20].

*Relaxation Response:* The relaxation response is the opposite of the fight-or-flight stress response in terms of physiological and psychological state. Inducing the relaxation response in subjects through mind-body interventions such as yoga reduces chronic stress and enhances wellbeing as evidenced by stress disorders like hypertension, anxiety, and insomnia. The relaxation response is attributed to changes in heart rate, blood pressure, oxygen consumption, norepinephrine responsivity, heart rate variability, and alterations in cortical and subcortical brain regions. Specifically, these biochemical changes are concluded to occur even after one bout of relaxation response practice caused by changes in gene expression [65]. Yoga is an effective modality because it combines two types of recovery: the relaxation response with stretching and active rest [2].

*Breathing:* Pranayama, or yoga breathing is an important pillar for recovery yoga. The attention towards breath associated with the practice of yoga helps induce the relaxation response. The practice of yoga breathing is associated with decreases in depression, anxiety, and post-traumatic stress disorder by inducing stress resilience [66].

*Resilience:* Resilience training, which can be incorporated into yoga mindfulness and meditation, can improve athletic performance and protect against the development of overtraining syndrome [1, 67]. Resilience to stress through yoga practice stimulates self-repair and self-regulatory systems that increase longevity and quality of life [66].

**Physiological Benefits of Yoga**

The mind-body interface is a unique aspect of yoga, meaning the benefits of yoga practice transcend the physical realm and into the psychological realm. Literature provides a host of physiological and psychological benefits through a variety of yoga interventions, over varied times, frequencies, and durations.

*Muscle Soreness, Pain:* A single bout of practice attenuates muscle soreness after novel, muscle damage inducing exercise using the Visual Analog Scale (VAS) ($p<0.001$) [68]. Pain tolerance is found to significantly increase after mindfulness intervention ($p<0.001$) [61].

*Flexibility, Performance:* Yoga improves balance and joint range of motion, which can reduce risk of injury in athletes. Polsgrove et al. concluded a yoga intervention was associated with mitigated decreases in flexibility and joint angles in the non-yoga group, all while increasing flexibility and balance in NCAA soccer and baseball players. Yoga practice also improved muscle torque and decreased lower back pain [13]. Bi-weekly yoga practice for eight weeks was associated with increases in ankle flexibility (13%), knee extension (28%), shoulder elevation (155%), trunk extension (188%), and trunk flexion (14%) [14]. Astanga and Hatha yoga interventions increase dynamic trunk muscular strength and endurance, and flexibility [9]. After a 10-month yoga intervention, athletes were demonstrating increased performance at submaximal levels of exercise and at anaerobic threshold, as well as shoulder, hip, trunk, and neck flexibility improvements [15].

*HR, BP, HRV:* Demonstrating the improved physiological benefits of yoga in opposition to the stress response, a decrease in diastolic blood pressure was observed after a six-week yoga intervention, as well as significant decreases in resting heart rate from pre to post intervention [9, 13, 19, 21]. In an athletic population, decreases in heart rate variability were demonstrated as young competitive cyclists supplemented training with Hatha yoga practice [16]. Peter et al. demonstrated greater parasympathetic dominance in yoga practitioners. The mechanism behind this is concluded to be respiration, which is an important modulator of heart rate variability. The types of focused breathing during yoga influences parasympathetic control as evidenced by increased heart rate variability. Slow deep breathing, like practiced in yoga, impacts the autonomic nervous system through increasing parasympathetic tone [69].

*Immune Response, Oxidative Stress:* Concentrations of human beta-defensin 2 (HBD2), an enzyme which is predictive of mucosal immune function, are more elevated after an acute bout

of yoga than of passive rest. Defensins possess antibacterial, antifungal, and antivirus properties; therefore increases can lead to an increase in immune function which is beneficial in keeping athletes healthy, and specifically combats symptoms of overtraining [17]. Yoga and meditation practice are associated with mitigation of basal oxidative stress levels as measured by a decrease in lipid peroxidation and biophoton emission [18].

*Hormones:* Adrenaline and noradrenaline hormones are produced by the adrenal glands as a reaction to stress. Accordingly, these biomarkers are frequently measured in the urine pre- and post-yoga intervention through catecholamine concentration. Noradrenaline levels decrease significantly, along with reported psychological stress of the subjects after an acute bout of yoga [21]. Yoga intervention in athletes decreases noradrenaline, decreases salivary cortisol, improves immune response through CS8+T cells, attenuates of exercise-induced inflammation, and reduces recovery time from injury [64, 70]. After pranayama practice, athletes demonstrate significantly reduced levels of blood lactate and increased pyruvate to lactate ratio (P/L) at rest. Raju et al. suggests athletes who practice pranayama can achieve higher work rates without increases in blood lactate levels [71]. Long-term yoga practice is associated with less serum IL-6 production in response to stressors than short-term yoga practice ($r=0.33$; $p=0.02$), suggesting that yoga is a healthy coping mechanism for stress long-term [72].

*Sleep*: With the regular practice of yoga during a six-month intervention, subjects significantly increase sleep quality, decrease number of sleep disturbances, and decrease daytime dysfunction due to tiredness using the Pittsburg Sleep Quality Index, when compared to controls [73].

**Psychological Benefits of Yoga**

*Mood States:* Positive mood state scores increase following an acute bout of yoga [72]. Similarly, pranayama techniques increase perceptions of mental and physical energy and feelings of alertness and enthusiasm more effectively than other relaxation methods [22]. Yoga intervention is also linked to decreases in exhaustion and anger in self-reported surveys [19, 21]. When compared to a seated meditation intervention, Hatha yoga had a stronger effect on improving mood ($p=0.009$), suggesting that movement and asana of yoga play a role in improving mood states. [23].

*Stress*, *Depression*, *Anxiety:* Yoga is as effective as relaxation in reducing stress and anxiety, and more effective than progressive muscle relaxation in improving mental health after 10 weeks of practice [74]. Decreases in stress levels are reported across numerous studies [9, 19, 72, 75]. Goodman et al. found a 26% decrease in perceived stress in 26 NCAA Division I male athletes following a five-week Hatha yoga intervention [62]. Mindfulness intervention also decreases stress levels as quantified by the Profile of Mood States-Short Form (POMS-SF) [29]. Yoga intervention in athletes increases present moment awareness, flow, presence of clear goals, sense of control, and decrease anxiety. Yoga also improves performance due to lowered performance anxiety and less performance-inhibiting effects such as anxiety, tension, and depression levels [15, 21, 64]. Depression is more common in females, however decreases in depression levels on the IPAT Depression Scale after yoga intervention were observed in both females and males [15]. Depressive mood disorder symptoms may include low or sad moods, anger, helplessness, eating and sleeping disturbances, decreases in energy levels, decreases in concentration and motivation, and negative thinking. Any number of these factors can affect performance negatively [4]. A large component of depression is negative thinking. If during a yoga intervention, psychological skills training such as self-talk can be implemented, it may be beneficial for improving athletes at risk of depression and depressive mood states.

Khalsa et al. studied young musicians using yoga and meditation to combat high levels of stress, performance anxiety, and debilitating performance-related musculoskeletal disorders. After one year of intervention, the yoga groups demonstrated less performance anxiety, and significantly less general anxiety, tension, depression, and anger at the end of their program as evidenced by the Performance Anxiety Questionnaire (PAQ) and POMS [12]. The reduction in performance anxiety would be an important benefit for athletes. Similarly, Malathi et al. looked at the practice of yoga mindfulness on trait and state anxiety before examination in medical students. Results suggest decreases in both everyday anxiety and anxiety on the day of a valued outcome examination [10]. Again, decreases in pre-performance anxiety can be applicable to athletes but also the concept of lowering anxiety before school examinations. Student athletes may experience stress before competitions, but also before academic examinations, as making grades and staying academically eligible are also stressors athletes face. In a three year study by Miller et al., subjects who practiced mindfulness meditation and yoga reported fewer and less severe panic attacks due to trait anxiety than the control subjects [11]. If athletes can learn tools

and techniques through the practice of yoga to decrease anxiety, they can use these tools in all stressful aspects of their lives.

## Chapter 3: Methodology

### Review Focus and Method

The present work is an archived review of literature associated with yoga, mindfulness, postures (asana), and breathing (pranayama) explaining their elements, techniques, and effects. Literature reviews exploring the relaxation response, psychological skill, and resilience training are also included. Articles explaining physical and mental stress related to elite athletic training, performance, and recovery are also incorporated. Understanding the relationship between stress and recovery allows the reader to see how implementing a yoga protocol will assist NCAA institutions in promoting healthy, safety, and performance. The following review relies on primary published scientific journal articles, but also incorporates secondary sources such as books. The types or aspects of yoga that illustrate the most empirical evidence for complete recovery against physiological and psychological stress are synthesized and utilized to design a recovery protocol beneficial for NCAA student athletes. Literature supporting this project was found by using the University of Montana's online library database, and journal search engines PubMed, EBSCO, and Google Scholar.

### Findings From the Yoga Literature

*Types of Yoga:* Hatha yoga is the most prevalent style of yoga in scientific literature because it is comprised of three basic components: postures, breathing, and meditation [9]. Because of the accessibility of the style, many studies use Hatha as a base to create a specific modification to cater to the population of focus. For example, Chen et al. developed a "Silver" version of Hatha for older adults to accommodate the reduced body flexibility of elderly [73]. Astanga is a more aerobically intense style than Hatha yoga, utilizing vigorous, flowing sequences paired with Ujjayi breath [9]. Similarly, Kundalini yoga is focused on the physical aspects of yoga. The style is designed to stimulate blood flow and energy to the brain, nervous system, and endocrine glands by using breath integrated movements called Kriyas [21]. Kripalu is comprised of classical yoga postures, multiple breathing techniques, and meditation, but less focused on anatomical alignment and more so on the flow of breathing and introspective focus [12]. Even further toward the spectrum of relaxation is Restorative yoga. Restorative yoga includes light stretching while the body is supported with props like blankets, bolsters, or blocks to minimize

physical discomfort and allow deeper relaxation [76]. Similarly, Yoga Nidra is a form of deep relaxation utilizing body awareness, breath, and mindfulness meditation to experience intention, heartfelt desire, joy, and peace [77].

*Asana (Postures):* Yoga postures are categorized depending on their intended purpose in the yoga sequence. Rai et al. specifically chose to research the difference in oxygen consumption between what was classified as a "calming" or "stimulating" yoga posture. The study compares a standing posture, Virasana (Hero pose), with a horizontal supine posture, Savasana (Corpse pose). Virsana elicits significantly higher minute ventilation, tidal volume, respiration frequency, and oxygen consumption when compared to Savasana. Virsana enhances the sympathetic nervous system, leading to a temporary hypermetabolic state. The shift is inhibited during the resting Savasana posture [78]. Similarly, Golec de Zavala et al. chose to categorize postures into "low power" or "high power" and investigated the difference in sense of energy and self-esteem in subjects maintaining these postures. Tadasana/Samasthiti (Mountain pose) and Urdhva Hastasana (Upward Salute) were named "high power" because of the body is standing, open, and exposed in the front. Garudasana (Eagle pose) was deemed a "low power" posture because the arms and legs are wrapped in front, closing the front of the body off. Controlling for trait self-esteem, the standing, open front postures improved state self-esteem through increasing self-reported sense of energy and empowerment ($p<0.001$) in categories of feeling in control, in power, energetic, and empowered [79]. Findings from these studies suggest that asanas can be categorized to elicit different responses as an intentional progression within a given yoga session. However, much more scientific research is needed in order to quantify the influence of various asanas as stimuli of physiological and psychological effects.

Not all studies explicitly listed the specific asanas that were used in the yoga intervention. However, from the studies that did list the postures included, Savasana (Corpse pose) was in most [14, 17, 29, 72, 74, 80-83]. Savasana involves lying on the ground in a supine position, with arms and legs extended and letting the body relax. The Savasana posture is deemed to be very important because the participant can integrate the work done earlier in the practice [84]. According to Kabat-Zinn, Savasana pose is extremely important in stress reduction because it is the time when the body and mind can integrate and relax [85]. Other popular asanas that span across different yoga styles and multiple intervention protocols are Vrikshasana (Tree pose)[9, 14, 29, 74, 76, 80, 86], Trikonasana (Triangle) [14, 17, 69, 80, 81, 86],

Anjaneyasana/Virabhadrasana A (Warrior I/II) [9, 14, 17, 74, 76, 80, 81], Suraya Namaskara (Sun Salutations) [9, 29, 74, 86], Sethu Bandhasana (Bridge) [9, 72, 80-82, 87], and Adho Mukha Svanasana (Downward Facing Dog) [17, 72, 81, 86, 87].

*Asanas in the Recommendation:* In attempts to include the most accessible, yet potent, asanas for the desired recovery effects, the recommendation consists mainly of asanas highly prevalent in the literature. Asanas that elicit or promote the relaxation response play an integral part in this recommendation. Other asanas were incorporated for the muscle groups they stretch or activate, considering a student athletes' need for physical movement and range of motion in sport.

*Pranayama (Breathing):* Pranayama is defined in the literature as the use and control of the vital life force, the breath. The integration of breath into yoga and mediation is essential. According to Swami Svatmarama, the author of the 15$^{th}$ century Sanskrit manual on Hatha Yoga, "Disturbed breath leads to a disturbed mind, hence cultivate a steady and quiet breath in order to control the mind and prolong the life" [88]. Svatmarama suggests the interface of mind and body, at the most basic level, is achieved through the breath. Studies incorporating the use of pranayama indicate psychological improvements such as increased perceptions of mental and physical energy, as well as feelings of alertness and enthusiasm when compared to trials of relaxation and visualization, Perhaps most importantly these outcomes were observed in as little as six sessions [22]. Long-term pranayama practice from one to two years also increases work rate, attenuates oxygen consumption per work unit, and decreases blood lactate levels at similar work rates after exercise. Raju et al. thus suggests athletes may be able to postpone anaerobic thresholds by incorporating this practice [71].

Similar to asanas, the style of pranayama may be used to elicit the intended physical or mental response. The brain associates certain breathing patterns with specific emotions [30]. For example, Ujjayi (Victorious breath) is thought to quiet the mind, while Shetali cools the body, and Nadi Sodhana causes arousal and alertness [66]. The heart rate responses were identified in four types of pranayama during a five-minute practice of each breathing style. Vibhaga and Mahatyoga revealed to increase heart rate, more so during inspiration than expiration. Savitri, which is explained as inspiration with a hold then expiration with a hold, did not significantly alter heart rate, nor did Nadi Sodhana: alternate nostril breathing. A possible explanation may be because both of these techniques have holding of the breath at the end of expiration. Telles et al.

suggests pranayama may be able to alter heart rate variability [89]. Sudarshan Kryia is an advanced form of cyclical breathing at varying rates. When combined with Ujjayi and other pranayama into Sudarshan Kryia Yoga (SKY), the practice is related to enhanced wellbeing, mood, attention, mental focus, and stress tolerance. SKY is also used to treat posttraumatic stress disorder (PTSD), depression, and substance abuse. Benefits occur with an intervention of 30 minutes each day as evidenced by mean decreases on the Hamilton Rating Scales for Depression (HRSD) [90].

In the Ujjayi technique, one partially closes the glottis over the esophagus during exhalation, to create a very slow resistance to the breath. Ujjayi brings a subjective feeling of physical and mental calmness [90]. Slow breathing with prolonged exhale has demonstrated to be effective for reducing physical and psychological arousal by skin resistance and subjective cognition respectively, in college students during situations of anticipation and confrontation, where anxiety may be present in as little as 90 seconds ($p=0.0013$) [91]. Slow breathing was associated with decreased short term blood pressure and resting heart rate, with increased tidal volume after 15 minutes [92]. However, Ujjayi is concluded to be even more beneficial than slow breathing alone because these effects may be enhanced by increasing vagal, parasympathetic activity through slow breath rate, laryngeal contraction, prolonged expiration mechanisms, and breath holds [66].

Little research has been conducted into the specific affects of pranayama on athletes. One promising study from Martarelli et al. identified diaphragmatic breathing, the “fundamental procedure” in pranayama yoga, as a practice to blunt exercise-induced oxidative stress in elite athletes. After an exhaustive training session, athletes either participated in diaphragmatic breathing and concentrating on their breath or sat in a quiet place as a control. The experimental group observed lower levels of ROS ($p<0.01$). There was also a decrease in cortisol levels after the intervention, as well as significantly higher melatonin levels that evening ($p<0.05$). Melatonin is an antioxidant, which may lead to the increase of Biological Antioxidant Potential (BAP), therefore decreasing the oxidative stress of the athlete. The decrease in ROS level could was attributed to the reduced neuroendocrine response, which was induced by the relaxation from the breathing intervention. Pranayama breathing practice is recorded as being easy to learn and perform, and also does not require any “moral conviction” [93].

While it may seem like lower levels of oxidative stress are a positive outcome of experimental intervention, it may not always be a performance benefit. Gomez-Cabrera and others have demonstrated dietary antioxidants or other recovery interventions intended to blunt acute oxidative stress during exercise also disrupt redox balance and, therefore, ROS-dependent training adaptations. ROS act as stimuli necessary for some cellular adaptations, such as endurance capacity [94-96]. Additional investigations are needed to confirm whether adaptive responses are also stifled by yoga practice.

*Pranayama in the Recommendation:* A combination of pranayama techniques are included in this recommendation, so the athlete can be exposed to and trained in different techniques. The athlete can decide which techniques work for them to up- or down-regulate arousal by experiencing the different forms of pranayama. The athlete can then use these breathing patterns as their "pocket practice", meaning they can utilize the techniques they have learned when they encounter situations where they need to regulate arousal, such as when experiencing pre-performance anxiety. The purpose of introducing a variety of pranayama techniques is so that athletes can have the tools in their tool belt and utilize the forms that are effective for them when they need to.

*Mindfulness:* The practice of mindfulness consists of directing attention to the present moment, with an attitude open to experience with curiosity, insight, and no judgment [63]. Mindfulness interventions are studied in correlation with physical recovery measures such as decreased salivary cortisol and decreased noradrenaline [70, 71, 83, 97]. Studies link mindfulness practice to attenuated resting values of oxidative stress and decreased levels of TBARS in the blood, which is indicative of a properly functioning immune system [18, 98]. Solberg et al. recognizes mindfulness for attenuating the increase in CD8+ T cells after maximum aerobic exercise ($p=0.04$), which may be indicative of immune system protection after strenuous physical activity. The findings suggest future research to evaluate whether mindfulness bolsters or facilitates the post exercise recovery [56]. Acutely decreased blood pressure and respiration rate were also demonstrated after a yoga intervention [61, 76]. On the psychological side, a plethora of studies demonstrate use of mindfulness techniques as a treatment for anxiety and depression, with promising results [11, 99-103]. Mindfulness-Based Stress Reduction (MBSR) protocol or adaptations of the popular method decrease perceived stress [99, 104, 105]. Other studies examined the effect of mindfulness on improved metrics of mood, happiness, and

compassion in those who practice it [104, 106-108]. While all these studies suggest carryover to the world of sport, specifically studies designed to quantify increased resilience, increased pain tolerance, and increased cognition as a mental training skill would be beneficial to see extended to a college athlete population, in hopes they might yield similar results as in the studies involving average college student and adult populations [61, 109, 110]. In an athletic population, mindfulness is used to decrease pre-performance stress and increase sports performance in elite college air pistol shooters by analyzing the Hypothalamic Pituitary Adrenal axis. The experimental intervention utilized mindfulness techniques such as a "body scan", where the participant slowly brings attention to each joint from proximal to distal, while noticing how it feels, without judgment or labeling. The subjects performed this intervention for 20 minutes in Savasana, each week for four weeks [83]. Goodman et al. found that following eight sessions of a 90-minute mindfulness intervention and a 60-minute Hatha yoga protocol in five weeks, NCAA athletes demonstrate greater goal-directed energy, greater self-reported mindfulness, and less perceived stress than before the intervention as quantified by the Adult Hope Scale (AHS), the Mindful Attention and Awareness Scale (MAAS), and the PSS, respectively [62].

There are an abundance of methods to practice and achieve mindfulness such as: body scan, visualization, noting, reflection, focused attention, loving-kindness, and skillful compassion. For example, when using a body scan, one brings the body and mind together by mentally scanning down the body from head to toes at an even pace to survey the body in segments. The goal is to focus attention on each part of the body and notice any sensations or feelings stored in the specific segment. One should remain objective, interested, and curious. The body scan method helps settle the body and mind, and increases awareness to feel more present in the world. Another mindfulness method is visualization, where one imagines a place that he or she enjoys and feels safe in. The goal is to focus on the feeling of being in that place, as opposed to the clarity of the image. Noting is also a technique in mindfulness when one realizes the mind has wondered off. Noting is pausing and identifying the cause of the distraction, then giving the mind clear and confident direction back to the object of attention. Next, reflection is encouraging a quiet clear space in the mind where one can ponder a question or problem. One does not have to answer the question or solve the problem, but merely observe what happens when one takes the time to acknowledge the problem. One can listen to the mind and enjoy the journey with curiosity. Similarly, focused attention is having an anchor such as a mantra or the breath. The

attentional state allows the mind to be free but maintain a sense of awareness of the anchor (breath or mantra). Onw should begin training focused attention for short periods of time. "Loving-kindness" is yet another type of mindfulness visualization. In this practice, one trains the mind to let go of hostility and anger and present unconditional kindness. One cultivates love and kindness, visualizes people in different scenarios, and pictures them being happy. By focusing on the happiness of others, one can let go of many things that cause unhappiness in their own mind. Similar to loving-kindness is skillful compassion. In skillful compassion, one puts the happiness of others before their own. One focuses on breathing in the difficulties of others and as he or she breathes out, picturing sharing good fortune with others. Sharing happiness with others can lead to a greater feeling of happiness in one's own mind [111].

*Mindfulness in the Recommendation:* A variety of mindfulness interventions are integrated into this recommendation for the purpose that mindfulness can be highly individualized. Some athletes will relate better to one mindfulness technique over another. Exposing athletes to a plethora of mindfulness techniques allows the athlete to explore and find the techniques they most easily relate to, as well as experiment with the techniques they find challenging. Again, the purpose is to provide athletes with the tools so they can choose the most effective mindfulness intervention to employ in their daily lives or specific stressful situations.

*Relaxation Response:* The relaxation response is the innate repose to stress. The relaxation response is the opposite of the fight-or-flight response the body goes into during times of stress. The fight-or-flight response is completely appropriate and necessary for times of threat or perceived threat. However, when the body stays in this stress response for a prolonged time periods, the sympathetic control of the nervous system is increased. During the relaxation response, sympathetic nervous activity reduces, heart rate decreases, breathing rate slows and metabolism slows [112]. There are many ways to elicit the relaxation response through protocols such as: diaphragmatic breathing, progressive muscle relaxation, autogenic training, mindfulness meditation, imagery, visualization, and other mind-body activities [30]. According to the literature, four elements need to be available to achieve the response. The first is a quiet environment, the second is a mental device such as a word, phrase or object to dwell, the third is a passive attitude, and the fourth is a comfortable position. If these four objectives are achieved, it is suggested one will begin to elicit the relaxation response within 10-20 minutes [112]. General benefits of the relaxation response include increased resilience, improved work

performance, social satisfaction, and improved health in terms of decreased billable medical treatment visits [113, 114].

Telles et al. compared the relaxation response from two yoga relaxation protocols and found that cyclic mediation, which alternates periods of activity with periods of rest, is more effective in reducing breath rate and oxygen consumption, and increasing breath volume than a trial of supine rest in Savasana. Each intervention lasted 20 minutes. The results suggest that integrating isometric contraction or stretching with passive rest will elicit a deeper relaxation response than rest alone by the decrease in oxygen consumption observed ($p<0.001$) [115]. A sequential study by Sarang et al. found that subjects in both the cyclic mediation and Savasana trials, saw increases in perceptual motor skills post-relaxation, with cyclic mediation demonstrating a greater increase in performance [20]. The more one practices eliciting the relaxation response, the less effort and time it takes to achieve. There is evidence to support relaxation response practice alters temporal gene expression, even after one session, but increasing with length of practice of down-regulating [65].

*Relaxation Response in the Recommendation:* When the body and mind are in a relaxed state, it is said one reaches an altered level of consciousness. The relaxed state is considered to be the peak time for gentle suggestion or visualization about optimal performance because it can be more fully recognized [30]. Hence, mindfulness, the relaxation response, and Psychological Skills Training are interconnected regarding their incorporation into the recovery yoga protocol for this recommendation.

*Psychological Skills Training (PST):* PST is a systematic and consistent practice of mental, cognitive, emotional, or psychological skills for the purpose of optimizing performance, increasing enjoyment, or achieving greater self-satisfaction in sport, physical activity, or otherwise [116]. Athletes need to be able to cope with high training volumes and constant stressors over their years of participation. The high performance density evokes pressure and potential fear of failure, which can be addressed in PST. Thus, athletes can alter or influence their state to be in the direction of an optimal performance state. Literature outlines the most important skills to enhance performance for high intensity sports as: self-skills, personal development, and life skills, arousal-regulation skills, volitional skills, motivational skills, and recovery skills [117]. Maleki, et al. found that the difference between elite and sub-elite basketball players and gymnasts were the elite athletes demonstrated basic mental skills,

psychosomatic skills, and cognitive skills, which the sub-elite athletes seemed to lack (p=0.000). The findings suggest these skills are imperative for athletes to move past sub-elite status and achieve elite status [118]. Similarly, Rothlin et al. claim the most important psychological skills for athletes are imagery, goal setting, and arousal regulation. Mindfulness meditation can also be used in PST and is concluded to be as effective in increasing performance and decreasing performance anxiety as a PST including imagery, goal setting and arousal regulation [119].

*PST in the Recommendation:* Understanding that some athletes may have specific psychological skills they wish to improve upon, this recommendation aims to expose athletes to the psychological skills that research suggests to be most effective for increasing performance, in attempts to give athletes a basic PST education. Once again, athletes can take home and practice the skills they specifically want to improve upon.

*Resilience Training:* Resilience is defined as the capability and accessibility of the dynamic process to adaptively overcome stress and adversity without physiological or psychological strain [120]. Literature highlights there are four main principles of resilience. The first principle is to increase the sense of empowerment and personal control, not of environment but of response to environment and situations. The second principle is to improve a sense of connectedness and acceptance to self, others, the earth, and to the divine. The third principle is to cultivate a sense of meaning and purpose such as vision for potential and enjoying the process of growth and creativity. The fourth principle is hope, meaning one has positive expectations, confidence about one's ability to deal with whatever situations arise, and power to envision what one truly desires [30]. Hartfiel et al. used a Dru yoga intervention weekly for six weeks on working adults, finding participants displayed improvements of clear-mindedness, composure, energy, and confidence, while reporting having increased life purpose, satisfaction, and feelings of greater self-confidence during stressful situations as evidenced by the Inventory of Positive Psychological Attitudes (IPPA) [121]. Similarly, a mindfulness intervention demonstrated similar results in working class adults. Participants of a seven-week workplace-tailored mindfulness intervention reported significant reductions in perceived stress on the PSS as well as improvements in scores of resiliency, vigor, and mindfulness compared to the waitlisted control group as quantified by the Connor-Davidson Resiliency Scale, the Shirom Vigor Scale and the Five Facets of Mindfulness Questionnaire [109]. While these studies examined global resilience in one's life based on the aforementioned principles, it is also important to investigate resilience

in the realm of sports. Schinke et al. claim these skills can be taught, leading to the development of a resilience training protocol for athletes focusing on three main skills: the evaluating of assumptions, disputing, and de-catastrophizing [67]. Evaluating personal assumptions refers to how an incident in sport is followed by a thought about performance, accompanied by an emotion, resulting in some type of behavior. In order to teach this skill, the athlete should be encouraged to learn how to identify the behavior-evoking incidents, consider the relationship between the incident and the thoughts that follow, contemplate the emotion attached to the preceding thoughts, and finally correlate the behavior to all the steps that came before it. The athlete should then understand that the first three steps are easily regulated, thus feeling a sense of hope for positive behavior change in the future when similar incidents occur. Disputing negative thoughts should be considered by teaching the athlete to examine how they evaluate circumstances, encouraging them to create evidence-based evaluations, identify potential inaccuracies in their evaluations, consider their appraisal to be perhaps more positive than remembered, and find an optimistic reflection procedure to replace overly critical and negative review habits. Athletes often perform to their expectation, which is why understanding de-catatrophizing is crucial for a resilience protocol. Athletes should be taught to acknowledge the worst possible outcome of their performance, identify the likelihood of said occurrence, generate a wider range of possible outcomes, consider what is most likely to occur, and prepare for optimal performance of self in each circumstance [122]. The importance of practice for the development of resilience skills must be emphasized. It is recommended to integrate resilience curriculum into practice or training culture for at least six month so athletes can make habit of such thought processes. Another suggestion for resilience training is a top-down approach, meaning coaches and support staff should participate in resilience training so they may create resilience-producing environments to facilitate the intervention for their athletes. However, it is concluded the most important component of resilience education is the athlete's awareness and intention to become more resilient [123].

*Resilience Training in the Recommendation*: The principles of resilience training are separated and will be taught and practiced in gradual succession during the recommendation intervention. Resilience training transcends athletics and is useful in almost any stressful life situation. The overarching goal is to encourage athletes to understand resilience training and incorporate resilience into their mindset towards athletics, school, and other situations.

**Design of Recovery Yoga Protocol for NCAA Athletes**

*Objectives*: The main objective is to create a yoga protocol recommendation that incorporates mechanisms of physiological and psychological recovery found in the research. The second objective is to include the mind-body-spirit connection and how it relates to NCAA student athletes. The third objective is to teach tools and modalities that can be taken with the athlete upon the completion of the session and of the program. The more practice the athlete has, the better they will get, the more automatic the process will become, and the more benefits they will reap [72]. Intervention can actually change behavior, attitude, and wellbeing. The fourth objective is to make this recommendation as time- and cost-effective as possible, as to eliminate any barriers as to why coaches or athletic departments would not utilize it.

*Goals for the Mind*: Once the athletes are in the mindful state, bringing attention inwards to themselves, it is appropriate to use this level of consciousness to incorporate Psychological Skills Training (PST). The techniques implemented will start as simply as breathing skills to control anxiety during competition, and progress to concepts such as self-talk, imagery, and goal setting as the program continues [119]. PST takes practice, so implementing the skills with the practice of yoga will help solidify the mind and body connection.

*Goals for the Body*: Including movement-based yoga asanas to fully elicit the relaxation response is important for athletes. Athletes are generally more kinematic learners because they use movement in their sport. Research supports the hypothesis that using movement to teach mindfulness and the relaxation response is more beneficial for athletes than static relaxation techniques or meditation [62]

*Goals for the Spirit*: The spirit component will focus on the athletic department's philosophy and ask athletes to reflect on these values in their everyday lives. Athletes will be able to reflect on their purpose and goals during mindfulness practice. The University of Montana Athletic Department states their core values to be "Integrity, Excellence, and Loyalty" [124]. Values can be incorporated into the mindfulness portions of the recommendation. Institutions can insert their own core values if this protocol extends to Universities beyond the place of its inception. Community and self-reflection of core values will be stressed as the spirit component of this intervention. A central goal for this program is inclusiveness. All athletes, across all sports, including injured athletes, will partake in this modality (modified if necessary), together, to build a sense of universality and community in the department. Knowing that others are going through

the same stresses, will build camaraderie throughout the entire department. The main goal of the spirit component is to build a culture of toughness and togetherness within the University of Montana Athletic Department. Spirit has no religious connotation in this purpose, however, spirit can mean whatever an athlete wishes. If an athlete would like to extend the spirit component to a religion or divine entity, this is an athlete's individual choice and right. No religion or divine entity will be explicitly addressed or supported by this recommendation to achieve inclusiveness, making it appropriate for all public universities.

*Duration*: The recommended intervention protocol is as follows. The intervention will be continued for a period of eight weeks, with the option to extend for 12 weeks. If extending for 12 weeks, athletes should repeat weeks five through eight for a second time. The intervention is easily implemented in a single semester, understanding students may not be participating the first few or last few weeks of the semester due to changing schedules, final examinations, etc. The more practice student athletes acquire in yoga, mindfulness, PST, and the relaxation response, the greater the results of the intervention will be. While benefits are quantifiable after a single bout of yoga, the most favorable interventions last at least eight weeks, with most benefits observed by six weeks of intervention (Appendix A).

*Frequency*: There will be three weekly sessions. The sessions can be completed in any order during the week. The sessions can also be performed on any days desired throughout the week and at any time of the day.

*Time*: Two of the weekly sessions will be 20 minutes in length. The third session will be 60 minutes in length. Athletes will be encouraged to practice the relaxation response and mindfulness on their own time each day throughout the week. Home practice can be completed with the help of a mindfulness app such as, "Headspace" [108] A short amount of time, between 10 and 20 minutes, is an appropriate amount of time for home practice [112]. The more home practice the athlete can afford, the greater the results will be [97].

*Type:* The type of yoga used for this intervention will be Hatha based, incorporating aspects of Restorative Yoga and Yoga Nidra. The focus of the short sessions will be pranayama, mindfulness, and the relaxation response. The focus for the longer session will be a full yoga practice of asana, pranayama, and mindfulness, while incorporating PST and resilience into Savasana relaxation. The specific agenda for each session can be seen in Figure 1 for weeks one through four and Figure 2 for weeks five through eight. The relaxation response is not included

in the daily agenda because the goal is to reach the relaxation response each session through the other items on the agenda (asanas, pranayama, mindfulness).

**Implementation in NCAA Institutions**

The implantation of this recovery yoga protocol will be financially feasible as well as operationally manageable. There is little to no expensive equipment required. Yoga mats may be used, or another type of mat or cushion if the ground is not supportive and comfortable in Savasana. Any quiet facility will suffice such as a gym, a meeting room, even a quiet hallway. Coaches can be creative and find a space that suits the needs of the number of athletes they have practicing. The short 20-minute sessions can be easily implemented directly after a sport practice, weightlifting or conditioning session to down-regulate the central nervous system and jump start the recovery process, while the longer 60-minute sessions can be offered any time throughout the training week.

It is recommended that the intervention be first implemented during the off-season phase of an athlete's annual plan, as to not introduce novel movement during competition that may interfere with performance at first. Once introduced, the protocol may be continued into the in season to maintain physical and mental improvements.

The facilitator of this intervention will ideally have a working understanding in the areas of the protocol such as yoga, psychological skills and resilience training. A wide net of professionals can qualify for this position. A member of the athletic staff such as a coach with the proper resources and training or a community member like a registered yoga instructor who is well versed in the unique needs of an athletic population may examples of candidates for the position. It should also be noted that the intervention may be altered as needed to suit the strengths of the facilitator.

Appropriate physiological measurements indicative of recovery are heart rate variability, blood pressure, salivary cortisol, and flexibility or mobility by sit and reach or joint goniometers. While flexibility is not necessarily a traditional measure of recovery, an athlete's availability of range of motion is an indicator of successful athletic performance and mitigation of injury. These measurements would be cost-effective and easily obtainable at most collegiate institutions with the help of the Health and Human Performance Department equivalent. Psychological recovery measures could consist of Profile Of Mood States (POMS), self-reported recovery, symptoms of

anxiety, depression, energy, mindfulness, and/or resilience. Scores could be collected pre- and post- single bout, or pre- and post-intervention. Results could be published or simply used to determine which aspects of this protocol are beneficial to specific athletes. Quantification of these measures would help modify transform this recommendation into a more effective recovery tool for NCAA athletes.

## Conclusion

NCAA student athletes are a highly and uniquely stressed population. With continued research on athletic populations and college-aged students, it is anticipated that NCAA student athletes will be educated and supported in recovery techniques to mitigate from physical and mental stress. Yoga should be considered as a beneficial method for recovery based on the rationale that the yoga properties (asanas, pranayama, relaxation response, mindfulness, and resilience) may contribute to physiological and psychological health and performance outcomes. If evidence of physical and psychological stress such as overtraining, injury, burnout, anxiety, and depression need to be resolved within college athletic departments, yoga should be considered as one of the mandated recovery approaches. Individual results may vary based on the athlete and his or her perceived value in the recommendation and the coach or trainer leading the intervention and his or her perceived value in the recommendation. In addition, there is a rationale to suspect that some sport specific applications may exist, though these sorts of outcomes are not yet supported empirically, due to a paucity of published findings, but serve as the foundations for future research.

## Recommendations for Future Research

Controlled, randomized studies of yoga interventions with subjects from athletic populations need to be increased in order to determine the most effective recovery protocols for college athletes and their unique stresses. While it is difficult due to hectic schedules and obligations, involving NCAA student athletes will benefit the research by utilizing the specific population for which the interventions are designed. The student athlete population needs recovery interventions, which will be facilitated and improved by conducting controlled experiments. New data is needed to determine whether yoga-based recovery will assist athletes and coaches in

understanding what aspects of recovery methods are most effective for student athletes. The outcomes following this protocol may also provide insight to the interaction between these identified aspects of yoga recovery. Data collected in support or defense of recovery protocols will help the athletic world mitigate overtraining and promote optimal performance, leading to better health, safety, and satisfaction of student athletes. Ideally, the protocol designed for and outlined in this study will be brought to life and tested on an NCAA athletic population in the near future. From there, the recommendation can be individualized to maximize recovery protocols for athletes as the research in this field advances.

A large barrier for this project was the lack of randomized, controlled studies for the effects of different asanas. Yoga and Ayurveda have rooted beliefs about each asana pacifying different Dosha personalities, massaging organs, or evoking emotions, however research that attempts to support these claims are few and far between. Yoga is an ancient practice and many people believe the science of life, Ayurveda, does not need to be explained except by the generations of tradition that came before [125]. Perhaps this explains why there may be a resistance to bring yoga into the world of peer-reviewed literature. However, in order to link specific asanas with benefits or effects, each one needs to be studied individually, in a controlled and randomized fashion. Explicit research on asanas and their physiological and psychological effects are the next frontier in this developing field of research.

**Concluding Thoughts**

Much of the preliminary research featured in this document incorporates multi-method research approaches that span social/psychological, clinical and basic science research sub-disciplines. Holistic research approaches are likely to help achieve a better understanding of whether yoga-based recovery can be a successful modality to facilitate recovery in athletes. Identifying current literature that encompassed only one of the desired aspects of this recommendation was difficult. A high crossover between all aspect of yoga seems to be present (mindfulness, relaxation response, asana, pranayama, and resilience), which brings the question to light: can yoga be dissected? Is the whole greater than the sum of its parts? Can each aspect of yoga operate individually or do all parts need to be combined in order for outcomes to be seen? While attempting to understand each aspect of yoga, is the importance of the integration of all these moving parts overlooked? If the mind-body interface is what makes yoga unique and

possibly effective, then how can one expect to separate the psychological and physiological effects and still observe the same benefits?

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**Table 1**

| Session | Agenda | A: 20 minutes | B: 20 minutes | C: 60 minutes |
|---|---|---|---|---|
| Week 1 | Asanas | Savasana | Savasana, Adho Mukha Svanasana | Savasana, Adho Mukha Svanasana, Uttanasana, Utkatasana, Suraya Namaskara |
| | Pranayama | Diaphragmatic | Diaphragmatic | Diaphragmatic, Ujjayi |
| | Mindfulness | Body Scan | Body Scan, Noting | Body Scan, Noting |
| | PST | | | Self-talk |
| | Resilience | | | Personal assumptions steps: 1-4 |
| Week 2 | Asanas | Savasana, Adho Mukha Svanasana, Tadasana | Savasana, Adho Mukha Svanasana, Tadasana, Suraya Namaskara | Savasana, Adho Mukha Svanasana, Uttanasana, Utkatasana, Suraya Namaskara, Anjaneyasana, Trikonasana |
| | Pranayama | Diaphragmatic | Diaphragmatic, Nadi sodhana | Diaphragmatic, Ujjayi |
| | Mindfulness | Body Scan, Noting, Resting awareness | Body Scan, Noting, Resting awareness | Resting awareness, Reflection |
| | PST | | | Self talk, Intention |
| | Resilience | | | Personal assumptions steps: 1-4 |
| Week 3 | Asanas | Savasana, Adho Mukha Svanasana, Tadasana, Suraya Namaskara | Savasana, Adho Mukha Svanasana, Tadasana, Suraya Namaskara | Savasana, Adho Mukha Svanasana, Uttanasana, Utkatasana, Suraya Namaskara, Anjaneyasana, Trikonasana, Vrikshasana, Sethu Bandhasana, Dekasana, Arhda Dhanurasana |
| | Pranayama | Diaphragmatic | Diaphragmatic, Nadi sodhana | Diaphragmatic, Ujjayi |
| | Mindfulness | Focused attention | Resting awareness, Focused attention | Skillfull compassion |
| | PST | | | Intention |
| | Resilience | | | Disputing strategies steps: 1-3 |
| Week 4 | Asanas | Savasana, Adho Mukha Svanasana, Tadasana, Suraya Namaskara, Sethu Bandhasana | Savasana, Adho Mukha Svanasana, Tadasana, Suraya Namaskara, Sethu Bandhasana | Savasana, Adho Mukha Svanasana, Uttanasana, Utkatasana, Suraya Namaskara, Anjaneyasana, Trikonasana, Vrikshasana, Sethu Bandhasana, Dekasana, Arhda Dhanurasana |
| | Pranayama | Diaphragmatic | Diaphragmatic, Nadi sodhana | Diaphragmatic, Ujjayi |
| | Mindfulness | Resting awareness, Focused attention | Resting awareness, Focused attention | Loving kindness |
| | PST | | | Self-talk, Intention, Imagery |
| | Resilience | | | Disputing strategies steps: 1-5 |

**Table 2**

| Session | Agenda | A: 20 minutes | B: 20 minutes | C: 60 minutes |
|---|---|---|---|---|
| Week 5 | Asanas | Savasana, Adho Mukha Svanasana, Tadasana, Ananda Balasana | Savasana, Adho Mukha Svanasana, Tadasana, Ananda Balasana, Ardha Bhekasana | Savasana, Adho Mukha Svanasana, Uttanasana, Utkatasana, Suraya Namaskara, Anjaneyasana, Trikonasana, Vrikshasana, Sethu Bandhasana, Dekasana, Arhda Dhanurasana, Saavas Rakshi Asana, Ustrasana |
| | Pranayama | Diaphragmatic, Savitri | Diaphragmatic, Sudarsha kryia | Diaphragmatic, Vibhaga, Ujjayi |
| | Mindfulness | Resting awareness, visualization | Reflection, Visualization | Body scan, Noting |
| | PST | | | Goal setting |
| | Resilience | | | Disputing strategies steps: 1-5 |
| Week 6 | Asanas | Savasana, Adho Mukha Svanasana, Tadasana, Ananda Balasana, Ardha Bhekasana | Savasana, Adho Mukha Svanasana, Tadasana, Ananda Balasana, Ardha Bhekasana | Savasana, Adho Mukha Svanasana, Uttanasana, Utkatasana, Suraya Namaskara, Anjaneyasana, Trikonasana, Vrikshasana, Sethu Bandhasana, Dekasana, Arhda Dhanurasana, Saavas Rakshi Asana, Ustrasana |
| | Pranayama | Diaphragmatic, Savitri | Diaphragmatic, Sudarsha kryia | Diaphragmatic, Vibhaga, Ujjayi |
| | Mindfulness | Resting awareness, visualization | Resting awareness, Focused attention | Skillful Compassion |
| | PST | | | Imagery, Goal setting |
| | Resilience | | | De-catastrophizing steps: 1-3 |
| Week 7 | Asanas | Savasana, Adho Mukha Svanasana, Tadasana, Ananda Balasana, Ardha Bhekasana | Savasana, Adho Mukha Svanasana, Tadasana, Ananda Balasana, Ardha Bhekasana | Savasana, Adho Mukha Svanasana, Uttanasana, Utkatasana, Suraya Namaskara, Anjaneyasana, Trikonasana, Vrikshasana, Sethu Bandhasana, Dekasana, Arhda Dhanurasana, Saavas Rakshi Asana, Ustrasana, Hasthasna |
| | Pranayama | Diaphragmatic, Savitri | Diaphragmatic, Sudarsha kryia | Diaphragmatic, Vibhaga, Ujjayi |
| | Mindfulness | Body scan, Focused attention | Resting awareness, Visualization | Loving kindness |
| | PST | | | Self-talk, Imagery |
| | Resilience | | | De-catastrophizing steps: 1-5 |
| Week 8 | Asanas | Savasana, Adho Mukha Svanasana, Tadasana, Ananda Balasana, Ardha Bhekasana | Savasana, Adho Mukha Svanasana, Tadasana, Ananda Balasana, Ardha Bhekasana | Savasana, Adho Mukha Svanasana, Uttanasana, Utkatasana, Suraya Namaskara, Anjaneyasana, Trikonasana, Vrikshasana, Sethu Bandhasana, Dekasana, Arhda Dhanurasana, Saavas Rakshi Asana, Ustrasana, Hasthasna |
| | Pranayama | Diaphragmatic, Savitri | Diaphragmatic, Sudarsha kryia | Diaphragmatic, Vibhaga, Ujjayi |
| | Mindfulness | Focused attention, Visualization | Resting awareness, Focused attention, Visualization | Loving kindness |
| | PST | | | Self-talk, Imagery, Goal setting |
| | Resilience | | | De-catastrophizing steps: 5 |

**Appendix A** *DNS= Did not specify

| Study | Duration | Frequency | Time | Type | Dependent Variables | Classification |
|---|---|---|---|---|---|---|
| Altman 2001 | 4 weeks | 1x week | DNS | DNS | BP, HR, Respiration Rate | body |
| Boyle 2004 | single bout | 1x week | 90 min | Kripalu | DOMS | body |
| Eda 2013 | single bout | 1x week | 90 min | yoga stretching (no breath) | HBD2 | body |
| Fishman 2009 | 2 years | 7x week | 10min | 10 poses | Bone density | body |
| Galantino 2004 | 6 weeks | 2x week | 60 min | Hatha (CLBP mod) | Balance, flexibility | body |
| Lu 2016 | 10 years | 7x week | 12 min | DNS | Bone lose | body |
| Patil 2013 | 4 weeks | 7x week | 60 min | DNS | HRV | body |
| Peter 2005 | 6 months | 7x week | 60 min | DNS | HRV | body |
| Polsgrove 2016 | 10 weeks | 2x week | 60 min | DNS | Flexibility | body |
| Tran 2001 | 8 week | 2+x week | 85 min | Hatha | Strength, endurance, flexibility | body |
| | | | | | | |
| Beddoe 2009 | 7 weeks | 1x week | 75 min | mindfulness based Iyengar | Percieved stress, anxiety | mind |
| Berger 2012 | 12 weeks | 1x week | 80 min | Hatha | Mood | mind |
| Cohen 2007 | 8 weeks | 4x week | 30 min | Hatha | Mood | mind |
| Eastman 2013 | 8 weeks | 1x week | 55 min | yoga nidra | Depression, worry, mindfulness | mind |
| Fallon 2008 | 6 weeks | 2x week | 50 min | Hatha based | Stress | mind |
| Falsafi 2016 | 8 weeks | 1x week | 75 min | Hatha vs mindfulness intervention | Depression, anxiety, stress | mind |
| Goodman 2014 | 5 weeks | 1.6x week | 60 min | Hatha | Mindfulness, stress | mind |
| Gothe 2012 | single bout | 1x week | 20 min | Hatha | Executive function | mind |
| Khlasa 2009 | 8 week | 3x week | 90 min | Kripalu | Performance anxiety | mind |
| Malathi 1999 | 12 weeks | 3x week | 60 min | DNS | Test anxiety | mind |
| Rani 2012 | 6 months | 5x week | 35 min | yoga nidra | Anxiety, depression | mind |
| | | | | | | |
| Baldwin 1999 | 8 weeks | 1x week | 75 min | Hatha (moderate) | Mood state, stress | both |
| Chen 2010 | 24 weeks | 3x week | 70 min | Silver (hatha mod) | Sleep | both |
| Cowen 2004 | 6 weeks | 2x week | 75 min | Hatha vs Astanga | Strength, flexiblity, stress, anxiety, BP | both |
| Granath 2006 | 10 weeks | 1x week | DNS | Kundalini yoga vs cognitive behavior therapy | Stress | both |
| Markil 2012 | single bout | 1x week | 30 min/60 min | yoga nidra vs Hatha | HRV | both |
| Ray 2001 | 10 months | 3x week | 60 min | Hatha | HR, BP, anxiety, health | both |
| Rizzolo 2009 | single bout | 1x week | 30 min | Restorative | HR, BP, anxiety | both |
| Saper 2013 | 12 weeks | 1 or 2x week | 75 min | DNS | CLBP, pain, disability | both |
| Sharma 2009 | 1 week | 4x week | 30-40 min | Hatha | Recovery | both |
| Smith 2006 | 10 weeks | 1x week | 60 min | Hatha vs Progressive Muscle relaxation | Anxiety | both |
| Tekur 2008 | 1 week | 7x week | 7 hours | Integrated approach to Yoga Therapy | CLBP, pain, flexibility | both |
| Telles 2001 | 1 week | 14x week | 150 min | DNS | Arthritis pain, disability, grip | both |
| Wood 1993 | 1 week | 2x week | 30 min | Yoga breath+stretch vs visualization vs relaxation | Energy, mood | both |