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Physiological and Psychological Well-being During the Spring Season in Female Soccer Players

Adam Conrad Lowe
Louisiana State University and Agricultural and Mechanical College

PHYSIOLOGICAL AND PSYCHOLOGICAL WELL-BEING DURING THE SPRING SEASON IN FEMALE SOCCER PLAYERS

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Adam Conrad Lowe
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ABSTRACT

Female student-athletes are an understudied population that are exposed to athletic stressors in addition to academic and social stressors. This study is designed to investigate the physiological and psychological well-being during the spring season in female Division I soccer players. During the 2017 spring season, participants competed in five matches over five weeks and participated in three to four soccer training sessions in between match days. To measure well-being, both objective and subjective measures were used. Activation state was collected via the Activation Deactivation Adjective Checklist (AD-ACL) before all matches. Heart rate and heart rate variability were measured during all matches via Polar Team Pro System (Kempele, Finland). Sources and symptoms of stress, measured via Daily Analysis of Life Demands in Athletes (DALDA), and symptoms of upper respiratory tract infection measured via Wisconsin Upper Respiratory Symptom Survey (WURSS-21) were collected once each week. Monthly measures of sleep quality were collected via the Pittsburg Sleep Quality Index (PSQI). Results indicated that energy-arousal increased from the first to final match, and was directly related to pass success percentage and number of tackles in midfielders. Freshman found training stressors to be worse than normal more often and experienced more severe cold symptoms than other academic years. Players who incurred a larger amount of match time had a greater degree of trouble motivating themselves to complete tasks outside of soccer. These observations signify the link between physiological well-being and psychological well-being, in addition to the combined impact of these characteristics on athletic and academic performance. Soccer players and staff should be aware of the transfer of fatigue that may occur between athletic and academic endeavors.

CHAPTER 1.
INTRODUCTION

The well-being of an individual can be considered the conscious or subconscious condition of existence of a person. In a more general sense, the Centers for Disease Control [1] states that well-being reflects physical, mental/psychological, and social dimensions. While there is a lack of consensus as to wording of the definition of well-being, there is agreement as to the multidimensional nature of the concept. Specifically, well-being can be thought of as a constellation of physical/economic/social/emotional/psychological well-being along with aspects of development and activity, life satisfaction, satisfaction within a specific domain, and engaging in activities and work [2-8]. The importance of well-being is underscored by the fact that across different study designs, higher well-being is related to improved health, less illness, better immune functioning, and faster recovery, a proposed outcome of positive well-being [9-14]. These findings seem to be robust regardless of assessing well-being with subjective or objective measures [CDC]. The strength and consistency of these findings may be due, in part, to the heritability of well-being [15, 16], although the importance of environmental factors must be considered as well [17, 18].

When applied to National Collegiate Athletic Association (NCAA) student-athletes, in particular those competing at the Division I level, there are numerous substantial challenges to well-being that are encountered. Such demands include academic expectations (e.g., maintaining eligibility, class attendance, staying current with assignments relative to travel schedule, attending study halls) and athletic stressors (e.g., competition/practice, physical training in- and off-season, injury rehabilitation, team dynamics) as well as the normal challenges faced by college students including maintaining healthy behaviors (e.g., proper sleep, eating habits), illness, and socialization (e.g., developing friendships, extended periods away from family). In short, relative to the missions of both academic institutions and athletic programs, student-athletes evidently have considerable pressure to achieve in a short time. In addition to psychological stress, student-athletes experience extensive physiological stress when training and competing in their sport. While overloading, the concept of submitting your body to a greater physical stress than previously accustomed to elicit physiological adaptations, is necessary in sport training,

determining appropriate overload in terms of physiological stress can be difficult to determine and may differ between players.

The NCAA acknowledged these challenges to the student-athlete starting with the initial Growth, Opportunities, Aspirations and Learning of Students in College (GOALS) study in 2006 [19]. Reexamination of topics of the study, including both the college athletic and academic experience, social experience, and health and well-being have taken place in 2010 and most recently 2015. Results of the most recent survey administration are based on over 21,000 respondents across 600 institutions representing all NCAA divisions. It is interesting to note some of the study findings compared to dimensions of well-being. Specifically, when compared to the 2010 results, Division I student-athletes reported more time spent on both athletic (32 $hrs.wk^{-1}$ vs. 34 $hrs.wk^{-1}$) and academic activities (35.5 $hrs.wk^{-1}$ vs. 38.5 $hrs.wk^{-1}$); a majority noted devoting more time to athletic activities in the off-season than during the competitive season; female Division I student-athletes stated a desire to spend less time on athletics as well as more time to visit family and for socialization; and sleeping less (13 minute difference compared to 2010 findings) although no change in quality of sleep. These findings might help explain the prevalence of approximately 30% of respondents reporting mental health challenges within the past month, experiencing insufficient energy to carry on with tasks outside of their sport due to the sport-specific demands, and feeling mentally exhausted from the requirements of their sport. Despite these concerting results, the NCAA GOALS report does note positive responses relative to student-athletes who seek out mental health services [19].

The interaction between psychological and physiological stressors only serves to significantly challenge and potentially comprise the well-being of Division I student-athletes. Previous experimental research in student-athletes corroborates the assertion that this population experiences higher than average perceived stress due to their uniquely demanding schedules [20, 21]. This higher perceived stress and accompanying challenge to well-being is evidenced in findings across different athlete populations and measures of well-being.

Physical well-being is challenged over the course of a competitive season of training and competition, and only seems to be increasing according to the GOALS study [19]. The physiological impact of collegiate soccer matches can require recovery for several days, however this is very rarely

possible. Both male and female soccer players have been shown to average about 86% of maximal heart rate (HR_{max}) during matches lasting 90 minutes [22, 23], was well as 87±4% HR_{max} during 5 v 5 small-sided competitions [24]. Measures of heart rate and HR_{max} during small-sided matches are useful, as this form of training is used frequently in soccer training. Cardiovascular load, calculated by multiplying heart rate reserve (HRR; HR_{max} – resting HR) by duration (playing time), is another potentially valuable measure to examine the effects of training or matches relative to each player. Previous research states that changes in velocity as well as moderate decelerations were higher in 5 v 5 small-sided matches compared to typical 11 v 11 matches, indicating potentially greater muscle damage due to eccentric contractions [25]. Additional research on physical stress via heavy resistance training emphasizes the importance of adequate recovery [26]. Such evidence suggests that over a season, physical well-being may be more dependent on training and recovery than what happens in and around competitions.

Additional evidence of the outcomes of the physical demands of training and competition is the increase in secreted cortisol. Cortisol is a stress hormone that is generally elevated in preparation for or in response to a stressful event, enhancing proteolysis as well as reducing protein synthesis [27, 28]. Elevated cortisol during recovery diminishes the process of muscle rebuilding. Extremely elevated levels of cortisol have been shown in female collegiate soccer players during matches as well as in male soccer players more than half way through an 11-week in-season period [29, 30]. Cortisol levels have been shown to be related to decrements in essential power-based soccer performance measures [30].

High levels of stress hormones, such as cortisol, may potentially compromise the immune system of a player. Mucosal immunity is the first line of defense against airborne pathogens entering the respiratory tract, and therefore is a good indicator of infection risk. Secretory immunoglobulin A (SIgA) is an antibody secreted primarily in saliva that responds to the presence of a foreign antibody by way of an increased secretion rate. Physical activity that is high in volume**,** such as running a marathon [31], and repeated prolonged, strenuous physical activity, such as triathlon competition**,** [32] may cause a depression in SIgA. This sort of volume is characteristic of soccer training and competitions. For example, male soccer players have exhibited higher SIgA secretion rates prior to official matches compared to simulated matches [33], suggesting mucosal immunity may be sensitive to the nature of the stress. At this time, a lack of research examining the SIgA response in Division I female soccer athletes to similar stimuli

exists. The investigation of SIgA secretion rate over a series of matches would be valuable in determining the changes in physical well-being.

Alpha amylase (AA) makes up another component of mucosal immunity which prevents bacteria from binding in the oral cavity. AA activity was shown to increase following intermittent cycling at 100% VO_2max. At 5, 15, and 30 minutes after stopping, AA had decreased significantly [34]. Such a decrease exposes the body to an “open window” during which time antigens could more easily enter the bloodstream and cause illness or infection. Twelve weeks of soccer training significantly increased AA secretion rate [35], demonstrating enhanced mucosal immunity, yet the AA response may be different in female soccer players. Researchers [36] reported significant increases in AA post-exercise in females whereas previous research reported the opposite in males. Confounding this line of inquiry are studies reporting that female soccer players demonstrated depressed AA prior to a match compared to their baseline levels [37]. While there is a great deal of information concerning the changes in AA around exercise and competition, there is a lack of research examining the effects of multiple compeititons on AA, pariticularly in elite female soccer players.

Closely aligned with these physical well-being outcomes are findings specific to psychological well-being. If Division I student athletes have to cope with the physical demands of their sport, this could result in psychological decrements such as low energy levels and other measures of well-being. For example, professional rugby players remained in a low energy state throughout the entirety of a 28-day study period, including match play, training, and rest days [38]. Diurnal variations in energy arousal and tension arousal lead to lower energy in the mid- to late-afternoon. Given the academic and athletic demands of the Division I student-athlete, it is reasonable to assume that student-athletes could experience low energy for greater parts of the day. This may help explain how problem-assessment has been reported to be effected by low energy state, possibly stemming from elevated perceived stress in student-athletes [39]. “Burnout,” a psychological syndrome characterized by chronically decreased feelings of pride and vigor, tends to be exhibited in athletes losing engagement in their sport [40], suggestive of chronic low energy. It is worth noting that the NCAA included burnout questions in the 2015 GOALS survey, suggesting a relationship with well-being [19]. Furthermore, surrogate measures of well-being, such as life satisfaction [21] and life demands [3] in student-athletes show sensitivity to greater

perceived stress and increased training strain. To date, there does not appear to be research investigating the energy-tension arousal state of Division I female soccer players over an extended period of time such as a competitive season or semester.

Studies examining differences between winning/losing teams [41], recovery [42], and the stress response [29] from a single match have been published. Few studies have been published looking at similar measures over the course of a full season or multiple matches. Thus, there appears to be two primary voids in the literature: (a) a lack of research into changes in psychological and physiological well-being over the course of a season using reliable and validated objective and subjective measures of well-being, as argued previously [30] and (b) a gap in the extant literature regarding Division I female student-athletes. The purpose of this study is to investigate the physiological and psychological well-being of collegiate varsity women's soccer players during the spring season. Hypothesized outcomes include elevated salivary cortisol and depressed AA and SIgA compared to baseline over the course of a five-week season; progressively increased cardiovascular measures (%HRR and cardiovascular load) during matches over the course of a five-week season; elevated tension-arousal, associated decreased soccer-specific performance measures, and depressed energy-arousal, associated with decreased distance covered per minute of playing time, prior to matches over the course of a five-week season; increased daily life demands over the course of a five-week season; increased incidence of upper respiratory tract infection symptoms over the course of a five-week season and in players with high playing time; and decreased sleep quality during the month of competition compared to the month prior to competition and in players with high playing time.

CHAPTER 2.
REVIEW OF LITERATURE

There remains a general lack of information regarding the well-being of athletes, presumably because of the multidimensional nature of the construct. Thus, efforts need to be focused on areas that can improve the well-being of athletes, especially those athletes who have multiple threats to his or her well-being. One such population are female collegiate soccer players, particularly those playing at the National Colligate Athletic Association (NCAA) Division I level. The complex physiological and psychological demands placed on female student-athletes in their athletic setting are further compounded by the stresses of daily life and the strain of maintaining academic eligibility. This constellation of both on-field and off-field demands can make them female college athletes vulnerable to poor health and overall reduced well-being. Gaining an understanding on the effects of soccer training and competition during a spring season on physiological and psychological well-being of female collegiate soccer players may help coaches and the training staff with information as to how to design training to keep the athletes healthy

Success in any sporting endeavor entails significant amounts of physical conditioning and sport-specific preparation. Coaches and training staff design periods of training that challenge the athlete physically and mentally. “Overreaching” is another term found often in the literature, referring to excessive training over a short period of time (functional overreaching) [43], or long-term overreaching (non-functional overreaching), which can lead to performance decrements lasting weeks or months [44, 45]. Such prolonged decrements may then result in the more detrimental concepts of staleness or burnout. The terms “staleness” and “burnout” often arise in the conversation of athlete well-being, and their meaning is important for researchers to understand. Several authors have cited literature that describes burnout as a “negative emotional reaction to sport participation” and staleness as “affective and physiological maladaptive responses to intense training” [46-48]. These terms cover negative psychological and physiological outcomes to the well-being of an athlete. Past research points to high levels of staleness in elite and collegiate female athletes [49, 50] as well as higher levels of burnout in female athletes in NCAA Division I and II compared to male athletes [51, 52], making the need for research into this topic specifically concerning females even more necessary. Failure to be sensitive to the physical and psychological demands placed upon the female soccer player has dire consequences.

Both physiological and psychological stressors can negatively impact the overall well-being of a student-athlete, and signs/symptoms are not always visible. This brings up a crucial question: what are the major sources of stress for female collegiate soccer players and how do they impact this group? The purpose of this review is to investigate previous findings concerning the possible sources and symptoms of stress for female collegiate soccer players and the effect that these stressors have on psychological and physiological well-being.

2.1 Sources of Stress

While sources of stress may vary from player to player, previous research has revealed the primary stressors experienced by female collegiate soccer players. Competitive matches apply both acute and chronic physiological and psychological stress. Training for competitive matches consists of a higher volume of stress compared to the matches themselves, and various physiological and psychological changes may occur during this period. Such changes can be monitored through understanding of the cardiovascular, neurological, and biological markers that are indicative of positive and negative adaptations.

2.1.1 Competitive Match Play

In NCAA Division I women's soccer, two games are generally scheduled over the course of three days each week; a single recovery day and three days of training lead up to the next pair of games. High-level female soccer players have been shown to average between 9 and 11 kilometers during a 90 minute competitive match, including high-intensity running for an average of 1.3 miles [22, 53]. In addition, seasons may last up to 132 days, meaning countless practice hours on the field and in the weight room [54]. An intensive environment such as this will undoubtedly promote many physiological adaptations as well as challenge physiological systems and tax mental resources. In-season collegiate soccer training places substantial physiological demands on the student athletes. Playing two games per week is a quite prevalent for current soccer players [55], and this approach indicates that the limited training times available can become high-pressure situations.

2.1.2 Soccer Training and Practice

Athletes spend more time in training than in competition, potentially provoking a greater psychological and physiological stress response compared to competition. The Yo-Yo Intermittent

Recovery test involves repeated sprints at increasing intensity with 10 seconds rest in between each sprint. With this in mind, decreased maximal heart rate (HR_{max}) during Yo-Yo Intermittent Recovery test level 1 (Yo-Yo IR1) shown in elite male soccer players following both preseason ($p < 0.004$, ES: 1.68) and in-season ($p = 0.02$) training bouts [56, 57] would likely be reflected in female players. Coaches use a variety of training techniques such as technical, tactical, and modified-game training in order to prepare players for the high volume of the game schedule. Small-sided games have become a popular training tool for coaches due to the ability to incorporate technical, tactical, as well as game-type situational training. Various studies have demonstrated small-sided games during training elicit similar cardiovascular stress as those seen in matches [58, 59]. An average of 87.9 % HR_{peak} during small sided games of 3-, 4-, 5-, and 6-a-side has been reported in amateur male soccer players who trained two or three times per week [59]. Training strain is a measure of internal training load calculated as TL multiplied by monotony. The use of varying field dimensions for these small-sided games have been shown to elicit different levels of physiological strain, with higher levels exhibited during games in which fewer players were involved and the playing area is smaller [60, 61], specifically, 3 versus 3 players on any sized playing area compared to 4 vs 4, 5 vs 5, and 6 vs 6. This relationship is suggested to be caused by increased time on the ball, increasing energy expenditure [62], when fewer players are present.

Small-sided games may be beneficial to the players as well as the coaches due to the physiological benefits and glimpse into changes in physiological well-being. Though 6 vs 6 small-sided games have been shown to elicit the greatest cardiovascular stress response, specifically when the field is small as shown during 8 min 6-a-side in male soccer players (70±11% HR_{max} vs 76±10% HR_{max}, $p < 0.01$)[60], the decreased field size could decrease Rating of Perceived Exertion (RPE) in players [61]. RPE has been shown to correlate with $\%HR_{peak}$ ($\beta = 0.449$, $p < 0.001$) and blood lactate concentration ([BLA-] $\beta = 0.436$, $p < 0.001$), both traditional markers of physiological stress [59]. This study was conducted in male soccer players, and the same correlation was shown in males during treadmill and cycle ergometer protocols[63]. There is a lack of female soccer-specific studies examining the relationship between HR and [BLA-]. RPE could also offer a helpful reference point for detecting negative changes in well-being over a repeated practice plan in players that does not involve blood sampling; an elevation in a player's RPE following a similar training session could indicate a negative change in well-being.

Staleness in cyclists has been shown to significantly increase their RPE at a given workload [64]. There is a lack of research concerning changes in RPE while experiencing staleness in female athletes.

2.1.3 Cardiovascular Stress

Cardiovascular stress could be considered the intensity that the cardiovascular system is required to work at in order to match the physical requirements of training or a match. As is the case with most high-level endurance athletes, cardiovascular stress and adaptations are exhibited extensively in soccer players. While there is a lack of literature on the physiological profile of female soccer players, what is available well be reviewed and compared to the extant literature on elite male soccer athletes. The percent of maximal heart rate ($\%HR_{max}$) during competitive matches has been shown to be very similar in both male and female soccer athletes, approximately 86% [22, 23, 65]. Distances covered at high-intensity by elite male soccer players during tournament play have been shown to be significantly greater ($p < 0.01$) compared to elite female players (ES: 0.5) in the same tournament [66]. Speeds greater than 15 $km \cdot hr^{-1}$ were considered "high-intensity" in males; however with an approximately +3 $km \cdot hr^{-1}$ higher VO_2max speed seen in men, and similar distances covered at >12 $km \cdot hr^{-1}$, relative intensity of male and female soccer matches can be deemed comparable [66].

2.1.4 Neuromuscular and Biological Markers

As stated previously, two soccer games scheduled over three days is a common occurrence in female collegiate soccer, allowing for limited recovery. This short recovery period between games occurs between Fédération Internationale de Football Association (FIFA) Women's World Cup matches as well [67]. Neuromuscular markers of sprint performance and knee extensor and flexor strength show increased fatigue immediately following a match without returning to baseline for up to 51 hours in elite female soccer players. It makes sense for soccer players to experience fatigue following a match; the physiological mechanisms underlying this fatigue show the muscular damage and breakdown that are occurring. Uric acid is one of the primary antioxidants in plasma and high levels are indicative of catabolism [68]. Uric acid recovery is slow and has been shown to be elevated 69 hours post-match [67, 69]. Creatine kinase (CK) is another biological marker normally found in skeletal muscle, but leaks into the blood following muscle damage[70]. CK has been shown to be elevated alongside decreased anaerobic performance for up to 72 hours post-match. In two separate studies, peak CK levels were

reached 21 hours (451±59 $U \cdot L^{-1}$) in females [67] to 48 hours (950 $U \cdot L^{-1}$) in males [42] post-match. A decrease in total distance covered ($p < 0.01$), as well as distance covered at high-intensity (1651±47 m vs 1500±49 m, $p < 0.01$) during the first and second half of competitive matches, has been shown in female players as well [66]. Full recovery from the stresses of a competitive soccer match may not occur for three or more days, during which time maximal anaerobic performance is limited in addition to the neuromuscular fatigue and skeletal muscle damage [42]. Despite this conclusion, few times during a female collegiate soccer season is full recovery feasible.

2.1.5 Academic and Social Demands

Once outside of the realm of sport, female collegiate soccer players are still very much susceptible to threats to their overall wellbeing [71]. As student athletes, they are expected to maintain high academic standards in the classroom as well as maintaining good nutritional habits and getting proper sleep.

In a study examining burnout in elite athletes, all participants acknowledged school as an important stress factor [72]. Eligibility for NCAA Division I athletes is determined in part by maintaining “good academic standing”, and assistance that is not available to the rest of the student body, such as special tutoring services or additional study guides, is prohibited from being provided to student-athletes by the NCAA [73, 74]. As such academic pressures can quickly mount for student-athletes given the burden of training, travelling for their sport, and studying. Even the most academically driven students may struggle when the psychological stress that they experienced playing their sport negatively affects their ability to focus in the classroom; a decrease in attentional control induced by acute psychological stress has been shown to continue even after the source of the stress is removed [75]. In addition, academic stresses concerning eligibility and future career success can lead to student-athletes choosing a major that is “sport friendly” due to decreased level of difficulty or decreased study time [76]. An athlete may think that reducing academic responsibility will allow for more time to train/recover or will set themselves up to earn high grades, however this view may be short sighted. The value of time for the student-athlete at school is lessened, and upon entering the workforce, they have decreased flexibility to pursue their career goals.

Socially, high-level collegiate athletics can isolate student-athletes from their non-athletic counterparts. The demands placed on student athletes that come from areas of their life other than sport can be difficult to cope with, especially in their effort to develop an identity that is more complex than simply as an athlete [50]. This may give rise to the risk of developing a “unidimensional identity”. As suggested by Coakley [77], burnout was the root of stress in athletes, especially those in high performance environments, and the cause of burnout was rooted in sport-centered identities; the focus of society on sporting success in athletes does not allow for the development of other sources of identity, especially young athletes.

This issue may stem from the fact that once recruited to become a collegiate athlete, the schedule of a student-athlete will be very structured, from classes to practices. Time available for student athletes outside of practice can be extremely limited, with the NCAA capping athletic activities at 20 hours per week and up to 4 hours per day [78]. Even during the off-season, NCAA regulations allow for up to 8 hours per week of mandatory team activities [79]. Athletes have been reported as forming an “athletic subculture” [80] that their negative academic performance was attributed to in this particular study. Lower ($p < 0.001$) verbal and math SAT scores were found in high-commitment athletes (691.5±69.06 and 702.5±61.91, resp) compared to non-athletes (736.0±55.05 and 724.3±57.74, resp) in a sample of 1349 students from an Ivy League school and 422 students from a liberal arts college. The concept of the “athletic subculture” has been reported in previous research that argued the social support of teammates helped each other cope with the limited free time allowed to them. [81]. Many times, athletes live with his or her teammates off-campus, having similar schedules and already being part of the same subgroup. With so much time spent together, the social needs of the athlete are met primarily through teammate interaction that occurs in and around the athlete’s sport [81]. This could lead to a possibly volatile support system due to teammates graduating and/or changes in team chemistry from year to year.

2.2 Identifying Physiological Stress

How an athlete feels can be indicative of their overall well-being. Subjective measures, such as muscle soreness and perceived exertion can provide insight into the impact of a training session or match through an individualized perspective. Athletes can differ greatly when it comes to how training and

matches makes them feel physiologically; understanding these differences is directly related to understanding the well-being of an athlete.

Much more common in the athletic world of today is the use of objective measuring devices to gauge the physiological impact of training and matches on athletes. Although performance measures are a very common and widely used marker of recovery, as they apply directly to the desired outcome of optimal performance, performance measures do not assess recovery on the neurological, hormonal or enzymatic level. With the use of wearable technology such as heart rate monitors and global positioning systems (GPS) devices, tracking the exertion and workload of a players is easier than in the past. Besides wearable devices, non-invasive procedures such as saliva collection can provide valuable objective data concerning the physiological response to training and matches of a player.

2.2.1 Perceived Exertion

Subjective measures that are responsive to training load (TL), the external stimulus, are considered valid when measuring fatigue, as implied by the joint statement from the European College of Sports Science (ECSS) and the American College of Sports Medicine (ACSM) [82]. In a study with adolescent female soccer players, average monthly TL was shown to be significantly higher previous to illness (12,442 ±409 AU vs 12,627 ±403 AU, $p = 0.043$), demonstrating an association between chronic TL and increased risk of illness [83]. This finding is in support of previous evidence that training volume is not the primary cause of burnout and negatively-affected well-being, but a disproportionate training stress-to-recovery ratio [47, 50, 84]. Interestingly, a study conducted in 2016 with elite soccer players showed that perceived ratings of wellness increased significantly ($p < .01$, ES 0.6-0.9) with decreased daily TL ($p < 0.05$, ES = 0.7) in the days preceding a match. Submaximal HR, absolute HR reserve (HRR) and relative HRR (%HRR) during the last 30 seconds of a cycling test prior to each training session were not sensitive to TL ($p > 0.05$) [85]. Subsequent research showed ratings of perceived fatigue to be significantly correlated to TL measured daily ($r = -.51$, $p < 0.001$) [86]. Considering that TL was measured as training/match duration multiplied by session RPE in the formerly discussed Thorpe study (2016), while total high-intensity running (>14.4 km·hr-1) was used as the measure of TL in the later Thorpe study (2015), the relationship between TL and subjective measures of wellness is further validated.

The general goal of subjective measures is to investigate internal TL using a different perspective than objective measures, such as HR. Respiratory and muscular perceived exertion (RPE_{res} and RPE_{mus}, respectively) are both valid measures of internal load, as they separate perceived exertion experienced either “locally” in the muscle or experienced “centrally,” such as dyspnea and tachycardia [87]. Spanish professional players on a third tier team were shown to rate competitive matches as “very hard,” about twice as substantial in terms of TL as the hardest training day of the previous week [85, 87, 88]. In addition, RPE_{mus} was reported to be significantly higher than RPE_{res} (~7.4 vs ~6.4, $p < 0.05$) during matches in players who played more than 70 minutes among the same population of players, although the magnitude of difference (~3%) was small. The value that subjective measures provide, a non-invasive measure that provides a perspective on the potential cause for late-game performance decrements (i.e. leg fatigue), is shown through these data.

2.2.2 Sleep Quality

Sleep problems have been shown to indicate psychological difficulties such as anxiety and depression [89]. Specifically in women, feelings of tiredness in the morning and disturbed sleep due to nightmares were significantly associated with anxiety, while extended sleep latency and tiredness during academic hours were related to depression. Even subtle decrements to sleep may be impactful; following a night of deprived sleep, college students were found more likely to choose an easy math problem to solve compared to no sleep loss (mean level of difficulty: 2.59±1.03 vs 2.84±0.83, $p = 0.056$) [90]. Gaultney [91] surmised from this data that sleep-deprived students may chose easier courses in school, and perhaps sleep deprived athletes may chose low-effort behavior that negatively impact their well-being (eating fast food, not stretching, etc.).

A discrepancy may exist between athletes and non-athletes in measures of sleep. Increased sleep latency (mean differences: 13.2 minutes higher in athletes, $p < 0.05$), increased time awake (mean differences: 27 minutes higher in athletes, $p < .05$), and decreased sleep efficiency (mean differences: 8.1% lower in athletes, $p < 0.05$) has been reported in comparison to age and sex matched non-athletes, measured using wristwatch actigraphy [92]. Sex differences within the athletic population were reported in this study as well, showing increased time awake (mean difference: 12 minutes higher in males, $p < 0.05$) and decreased sleep efficiency (mean difference: 2.4 lower in males) compared to female athletes.

Training in the morning was shown by Sargent et al. [93] to reduce sleep duration and increase pre-training fatigue ($p \leq 0.01$) in athletes from a variety of different sports. These authors also showed reduced time in bed ($p = 0.001$) as well as amount of sleep during nights prior to training days ($p = 0.001$) compared to rest days, begging the question as to whether the benefits were worth the detriment to sleep. Sargent et al [94] published a similar paper examining the impact of early morning training on sleep in elite swimmers, finding that an average of 5.4 hours of sleep were attained in this population on nights prior to training sessions beginning at 06:00 hours. Frequent sleep problems as a symptom of nonfunctional overreaching/overtraining (NFOR/OT) have been shown in multiple athlete studies [45, 50, 95]. In these studies, NFOR indicates that the athlete has both a qualitative increase in training (volume or intensity), as well as a quantitative elevation in symptoms of physiological and psychological maladies. Staleness is a term that has been brought up previously, explained by Kentta, Hassmen, & Raglin (2013) [96] in their publication on staleness in youth athletes as a discrepancy between stress and sufficient recovery experienced by an athlete. These authors studied 287 young Swedish athletes and reported a mean of 2.3 (SD± 1.4) on a five-point Likert scale in the category of "Sleep disturbance" by athletes who had reported experiencing staleness in the past.

The build-up to and recovery from a competition are time periods that can certainly effect the sleep of an athlete. Physiological well-being has been discussed to be at its lowest in the 24 hours following a match. Progressive sleep improvements were seen in elite male soccer players throughout the week leading up to a match, while the substantial negative impact that the match had on the reported perceived sleep quality of the athletes were significant and apparent, as the worst night of sleep was reported the night following a match [85]. Prior to an important match, 62.3% of German athletes reported that their sleep suffered at least once in the last 12 months, the reason for which was "thoughts about the competition/game" and "nervousness about the competition/game" in 77% and 60% of the athletes respectively [97]. Among 103 marathon runners, made up of 63 females 68% reported a reduced quality of sleep than normal during the night prior to competition [98]. These findings emphasize the impact of psychological state on athlete well-being during high-stress periods throughout a season.

2.2.3 Cardiovascular Stress

Understanding the cardiovascular stress that a training session imposes, as well as monitoring cardiovascular efficiency on a player-to-player basis, allows for improved training design and injury/excessive fatigue avoidance. A player exhibiting decreased capacity to perform at pre-established proficiencies relative to that player is an established and accepted identifier of staleness [96]. Resting heart rate has been shown to be an unreliable detector of overtraining in athletes [99]; examining cardiovascular changes during the training stress that the athlete experiences on a daily/weekly basis allows for better detection of adaptations.

Heart rate variability (HRV) has been validated as a tool for detecting acute fatigue following intense exercise [100], and is correlated with the frequently used TL parameters of RPE and excess post-exercise oxygen consumption (EPOC). Although RPE and EPOC cover both subjective and objective measures, RPE is not a physiological parameter and measurement of EPOC requires a laboratory setting or portable calorimeter [101]. Total power of HRV, which was calculated as the combination of high and low frequency power of the heart, has been suggested as best representing the summation of autonomic nervous system variation of the body based on data from interval running at varying intensities [101]. A drawback to the use of HRV in high-level athletics is that HRV data requiring after-the-fact analysis (i.e. after a practice is over). As such, HRV is not as valuable as immediate feedback on players as well as the need for trained interpretation.

Relative exercise load, cardiorespiratory fitness, and maximal cardiorespiratory function are all believed to be indicted by HR during submaximal exercise, and with a progressive decreases in mean training HR during extended exercise and sport training [57, 102]. Mean training session HR has been used to assess full recovery in Division I female soccer players 24, 48, and 72 hours following a high-intensity interval soccer training session [53]. In this particular study, no significant difference ($p < 0.05$) was exhibited between baseline and any of the three recovery periods, reporting average session HR to be 76.7±4.3% of HR_{max}. In male collegiate soccer players training 2 $d \cdot wk^{-1}$, Hodgson [24] found that small-sided games of 5-a-side elicited an average of 87±4% HRmax on a 1200 m^2 field area. Jastrzębski found [103] ranges of 89.4-90.6% HR_{max} and 88.9-90.2% HR_{max} exhibited in professional male and female

players during 4-a-side small-sided games. Games in this study were conducted on in a 1200 m^2 playing area similar to the study by Hodgson.

As discussed earlier, increasing the area per player generally increases cardiovascular stress in the players due to the increased time on the ball. Total distance was lower in the Jastrzębski study compared to the Hodgson study (4 vs 4, 5 vs 5, resp; 1941±148 m vs. 2299.7±188.23 m, resp.). Gaudino et al. (2014) [25] published a study showing greater total distances of 419±28 m, 443±37 m, and 466±45 m ($p < 0.01$), greater distances at high speed (considered >14.4 $km \cdot h^{-1}$) of 31±10 m, 50±18 m, and 85±24 m ($p < 0.001$, ES > 1.0) , and greater absolute maximum speeds of 19±1 $km \cdot h^{-1}$, 20±1, and 23±1 $km \cdot h^{-1}$ ($p < 0.001$, ES>1.0) in high level male soccer players when area per player increased from 5 v 5 to 7 v 7 to 10 v 10 respectively. Metabolic power, the amount of energy expended per unit of time, was used to suggest that small areas of play overload different physiological mechanisms, as the number of changes in velocity became greater with decreased field size. During small-sided games, greater distance has been shown to be run at high power (defined as >20 $W \cdot kg^{-1}$) compared to high speed, becoming more emphasized with greater decreases in field size. Findings such as these point to the need for a wider picture of the physiological impact to the overall well-being of athletes than simply cardiovascular measures.

2.2.4 Cortisol

Modern team sports have begun to utilize salivary cortisol as a non-invasive measure of stress response to training in players [102, 104]. Elevated cortisol has been reported both before and after athletic events, highlighting the anticipatory as well as physical stress response that glucocorticoid cortisol can be used to detect [29]. Glucocorticoids have been shown to enhance proteolysis, as well as reduce protein synthesis [27, 28]. Elevated cortisol, as part of the chronic stress response, can in addition lead to increased infection risk as well as well as maladaptive coping behaviors [105].

Cortisol measurements during and around the occurrence of sport specific stress of has been suggested as a better tool for evaluating the physiological impact of training and the “adaptive state” of the athlete compared to fasting measurements [106]. Elevated cortisol levels indicate a state of catabolism, the breaking down of tissue in the body, further compounding performance decrements from fatigue. During the competitive season, correlations between cortisol and jump height at week 3 and one

week post-season (r = -0.64, r = -0.59 respectively), sprint performance at week 3 (r = -0.78), and knee extension torque at baseline (r = -0.58) were shown in male collegiate soccer players [30]. Interestingly, these correlations were only seen in those designated as “nonstarters” at the beginning of the season, and no correlations between cortisol and physical performance was shown in those designated “starters”. Significantly elevated resting serum cortisol levels ($p \leq 0.05$) were found at week 8 compared to all other in-season measures in starters, with elevated levels (548.49 $nmol \cdot L^{-1}$ vs normal range 138–635 $nmol \cdot L^{-1}$) measured at the beginning of the season and maintained ($p > 0.05$) throughout the season. In female collegiate soccer players specifically, cortisol levels can become elevated by 250% during competitive matches compared to practice levels [29]. In a study of female soccer players playing in an international tournament, during which participants played 6 games over 3 days, serum cortisol became significantly elevated ($p < 0.01$) during the second (22.1±3.4 $\mu g \cdot mL^{-1}$) and third days (24.5±4 $\mu g \cdot mL^{-1}$) of competition compared to pre-tournament values (10±0.7 $\mu g \cdot mL^{-1}$) [107].

Moreover, daily training involving highly stressful workloads may induce an adaptive change in highly trained athletes. Research in male professional soccer players has shown sustained cortisol levels of normal levels during high-intensity exercise [108], a finding supported by the blunted response of plasma cortisol at given workloads demonstrated in highly trained runners compared to moderately trained runners by Luger et al. [109]. Reporting unique findings, Rimmele et al (2007). asked trained and untrained men to complete a psychosocial test that consisted of public speaking and mental arithmetic while being watched [110]. Despite a significant increase over time in salivary free cortisol ($p < 0.01$) in both trained and untrained men, the cortisol response of the trained group to the stress test was significantly lower compared to the untrained group.

High intensity or long-duration exercise can lead to increases in plasma cortisol levels and decreases in androgens such as testosterone, resulting in greater binding of cortisol to muscle tissue producing a catabolic state [111]. While in a catabolic state, recovery is severely hindered due to the breakdown, instead of rebuilding, of proteins in the athlete. salivary cortisol was found to peak the day following an Australian Rules Football match (ES 4.59 ± 1.28) in elite players [112], although there is high variability between study designs. Significantly higher ($p < 0.01$, d = 0.60) salivary cortisol values recorded in elite National Rugby League players 4 days after a match compared to pre-match [113]. Both

of these studies show an extended catabolic recovery period, likely leading to decreases in performance. Decreases in performance were concluded to not be automatically caused by increased cortisol levels or the occurrence of a catabolic state in elite cyclists [114]. In addition, a significant decrease in Testosterone:Cortisol ratio ($p < 0.05$) in a male soccer team following 7 weeks of a high-intensity training program was accompanied by an improved winning percentage of 71.4% from 58.8% [115]. The mood profiles of the players displayed high readings of vigor and low readings of tension, depression, anger, fatigue, and confusion according to the Profile of Mood States (POMS) as well as a high win percentage.

Cortisol, and the role it plays as a corticoid stress hormone, can have a significant impact on immune function. Gleeson identified stress hormones as strong regulators of immune function [105], in regards to findings by Cohen et al. (1991) that showed psychological stress was associated with increased risk of infection ($b = 0.13 \pm 0.05$, $p < 0.005$) in subjects intentionally exposed to respiratory viruses [116]. As discussed previously, the disruption to the homeostasis of an athlete may not always be due to physical stress, but psychological stress as well. Greek national female soccer players showed no significant decrease (6.3%, $p > 0.05$) in lymphocyte count following a two-hour training session averaging 75% HR_{max}, suggesting no greater vulnerability to viral infection following a single soccer training session [117]. During the first 6 weeks of a 9-week in-season training period, collegiate female soccer players experienced a greater occurrence of illness compared to regular college students (1 illness·week^{-1} vs. 0.3 illness·week^{-1}, $p \leq 0.05$), despite no differences in salivary cortisol [118]. Correlations were found between cortisol and injury ($r = 0.73$) during Week 5. The authors also suggested that relationships exist between indices of training (strain, monotony, and load) with incidence of illness, supported by the findings of Foster [119]. Foster reported that a high percentage of illnesses could be attributed to indices of training that exceeded individualized thresholds, specifically training strain. A spike in training strain preceding illness was reported to explain 89% of illness, while 77% of the occurrences of illness in the competitive athletes, observed over 6 months to 3 years, were preceded by a spike in training monotony. Considering the need for overload in training to elicit a positive training adaptation, this conclusion implies the potentially detrimental effect of 6 days a week of somewhat “hard” training sessions to immune system health, compared to 4 days a week of significantly challenging “hard” days and 2 “easy” days.

2.2.5 Alpha-Amylase

Alpha-amylase (AA) serves the body primarily through carbohydrate metabolism. The release of AA also enhances the defense of the body by binding bacteria and preventing them from binding to an oral cavity in an individual [120]. Acute stress has been repeatedly shown to lead to an increase in AA, which has been shown to react more rapidly than cortisol to stress [121], especially in populations that experience stress more often or are high-stress populations such as athletes and students [37, 122]. Increased AA secretion rate is attributed to elevated sympathetic activation and is a valid measure of psychological and physiological stress [123]; however conflicting research exists concerning the relationship between AA and the physiological stress markers catecholamine and cortisol [124, 125]. The circadian rhythm of an individual has been shown to effect AA, while the time course pattern of AA secretion appears to be opposite compared to cortisol. In university students, Rohleder et al. (2004) [126] and Nater et al. (2007) [125] showed AA upon waking measured the lowest quantity, increasing until the late afternoon, after which time values fell.

Acute stress may induce elevated AA secretion as a preparatory mechanism for sudden or impending danger. In skydivers, AA was significantly elevated (p <0.001) the morning of the jump, immediately before entering the plane and upon landing compared to control subjects [127]. Concerning exercise stress, a depression in AA was seen in well-trained men prior to intermittent cycling at VO_2max in a laboratory compared to 24-hours previously (188±62 $U \cdot ml^{-1}$ vs 367±99 $U \cdot ml^{-1}$, $p < 0.05$) [128]; this may be indicative of a stress-specific response. AA was reported to have progressively increased throughout the stages of a graded exercise test and dropped abruptly 5 min. into recovery demonstrating an intensity-dependent relationship in line with previous research [34]. Despite efforts to conduct exercise trials at the same time of day over the course of a trial, a limitation of many studies reporting exercise-induced changes in AA may be that they do not collect baseline AA at a time far enough prior to the exercise test to be performed, causing depressed baseline AA to be recorded. Circadian rhythm however has been shown to elicit no effect on AA response to longer duration (2 hr.) exercise [129].

Interestingly, chronic stress may be associated with elevated AA. Fifty participants previously diagnosed with chronic psychological stress were reported to have significantly higher AA levels compared to controls [130]. Contrary to this evidence, children with asthma (13.1±2.6 years) who

exhibited elevated home life stress also exhibited lower AA levels, a relationship not demonstrated in "healthy" children of a similar age with similarly elevated home life stress [131]. The authors suggest that lower AA levels predict lower sympathetic activation, thereby suggesting increased vulnerability to illness. This proposed relationship, in light of the evidence that sympathetic activation prompts elevated AA concentrations, could mean that chronic stress in athletes may lead to decreased sympathetic activation and lessened energy arousal for games and training as well as increased susceptibility to infection.

A sex-based difference in AA may exist. While Nater et al. (2007) [125] reported no diurnal sex-based differences in salivary alpha-amylase, and Takai et al. (2007) [132] found no sex-based differences in AA levels following a stressful video, there is evidence of altered alpha-amylase response to psychological and physiological stress between men and women. Concerning competition, significant decreases reported in pre-competition AA in female rowers compared to baseline ($p < 0.001$), with a similar depression not seen in male rowers. Cortisol and alpha-amylase were strongly correlated during competition in females ($rs = -0.31$ to -0.46, $p < 0.05$) as well, while no association existed before or after for men [37]. These same authors also found that feelings of dominance experienced by participants were associated with alpha-amylase and cortisol following competition ($R^2\Delta = .17$, $p < 0.01$), with greater feelings of dominance associated with lower levels of these two measures.

2.2.6 Serum Immunoglobulin A

Serum Immunoglobulin A (SIgA) is an antibody that is found secreted particularly in saliva, and is referred to as a natural antibody because the majority of SIgA has the ability to react with numerous pathogens [133]. Used often in studies that investigate incidence of infection, especially associated upper respiratory tract infections (URTI) [134, 135], SIgA in saliva can be used as a marker for immune health against both pathogens and non-pathogens of an individual [136]. This feature allows investigators to get a snapshot of the general immune health of an athlete at various time points in a day, training cycle, or competitive experience. Generally, SIgA is produced in large quantities in response to antigens detected in the body, while infection risk is greater when saliva flow rate is low or one is IgA deficient [137]. Typical resting levels of SIgA indicate the preparedness of the body to defend against infection.

Depressed SIgA may be seen in response to bouts of intense exercise and chronic stress. Research in elite athletes has shown that this population experienced decreased SIgA concentration and

secretion rate following strenuous exercise that was of a high volume [31], of maximal intensity in men and women [138], or consisted of repeated prolonged, strenuous exercise [32] i.e. marathon running, performance of a Wingate bike test, and triathlon racing respectively. These findings could show the vulnerability of the body to infection or “attack” following exercise, demonstrated by research on sailing athletes who exhibited three weeks of progressively depressed SIgA preceding a URTI ($p > 0.05$). SIgA levels during URTI were significantly lower compared to 4 weeks prior as well as 2 weeks post-URTI, with a relationship between magnitude of decline in SIgA and risk of URTI ($r = 0.54$, $p < 0.005$) [139].

Research in sex-based immune responses to exercise has provided data pointing to immunodeficiencies in females following similar exercise stimuli. In female wrestlers, 12 weeks of preparatory and competitive training, concluding with a wrestling competition, elicited a significantly lower SIgA/total protein ratio compared to male wrestlers ($p < 0.001$) participating in a training period of the same length and design [140]. An 8 minute arithmetic test that participants believed would determine their study compensation elicited a decreased SIgA secretion rate compared to rest in women (91±102 $\mu g \cdot min^{-1}$ vs 114±182 $\mu g \cdot min^{-1}$, $p < 0.05$) compared to an elevated secretion rate in men (144±188 $\mu g \cdot min^{-1}$ vs 105±114 $\mu g \cdot min^{-1}$, $p < 0.05$) [141]. Similar results were reported by Taylor et al. (2015) [96], who found that female field hockey players to have significnatly lower SIgA ($b = 0.37$, $p < 0.002$) during their regional competition season. No sex-based differences in SIgA were seen in swimmers before and after performance of maximal incremental 7x200m front crawl ($p > 0.05$) despite a significantly lower $CD4^+$ ($p < 0.005$) and $CD8^+$ ($p < 0.018$) response exhibited in females (16.08±2.53 years) [142]. The authors suggest that the large intra- and inter-individual variation in SIgA may be the cause for a lack of change in mucosal immunity compared to other measures of immune response. This limitation is reported frequently and indicates the need for research tracking the immune response of an individual over several stressful bouts.

Positive and negative psychological stimuli may also influence immune health of an athlete. Elevated SIgA was reported by Jemmott & Magloire [143] in undergraduate students who believed that they had adequate social support compared to those students who believed the contrary. On the other hand, Taylor et al. (2015) [133] showed male and female field hockey players demonstrated increased levels of SIgA when reporting feeling greater pressure, coercion, or powerlessness stemming from their

coach ($b = 0.27$, $p < 0.05$) as well as increased intentions to drop out of their sport ($b = 0.13$, $p < 0.05$) . The authors also suggest that even the thought of dropping out of sport, and the consideration of the potential loss of their identity and "social network" in the form of their teammates, may have led to the increased SIgA levels. Prior to official soccer matches, SIgA secretion rate was significantly higher ($p < 0.05$) in adolescent male soccer players compared to the SIgA secretion rate of the same players prior to simulated matches performed in training [33]. Elevated SIgA concentration and secretion rate, as well as salivation rate may indicate a "fight-or-flight" response to either positive or negative psychological stimuli; communication between the immune and nervous system occurs frequently [144] with research in rats shows parasympathetic and sympathetic control over IgA secretion [145].

2.3 Identifying Psychological Stress

Psychological stress can be defined as intra-individual stress arising from internal stressors [95]. In a 2014 study by Beauchemin et al (2014)[146], an outreach model was presented, emphasizing mental skills, such as relaxation, imagery, routines, self-talk, and concentration, that could be generalized and applied to overall well-being [147]. A link between good recovery strategies and the offsetting/prevention of burnout has been shown in addition to the previously discussed link between burnout and intensity of training [84, 148]. The processes of mental strength breakdown that an athlete may go through is full of indications that the above five skills are failing or not present. Once a stress stimulus occurs, the athlete assesses the demands being placed on them and determines if he/she has the ability to successfully cope. If he/she does not believe that this is possible, they may experience increased tension, insomnia, fatigue, and anxiety [40]. If the athlete continues to unsuccessfully cope with the situation, such as intense training, the cognitive-affective stress model ends with performance of the athlete suffering and potentially withdrawing from his/her sport. Case studies on endurance athletes and rugby players have shown the magnitude of stress in the process of burnout, adding support for this model and reinforcing the need to detect these signs before the overall well-being of the athlete is in decline.

2.3.1 Life Demands

Feeling as though the threat of a situation is more than one is capable of handling is the scientific way to consider stress [149] In a study with male collegiate soccer players that examined the impact of playing 1 or 2 games per week for 6 weeks, players assigned to the 2 games-per-week group had

significantly higher stress values at baseline compared to those in the 1 game-per-week group ($p < 0.001$) [55]. This was suggested to be due to the awareness within the 2 games-per-week group of the long period ahead. The authors went on to emphasize the reduced time for other life demands that a congested athletic schedule may cause. During a highly demanding season, potentially compounded with academic demands, the actual burden felt may be hard to measure or even realize due to its constant existence. When professional male handball players were given a weekend of passive recovery, the number of “worse than normal” responses on the Daily Analysis of Life Demands (DALDA) questionnaire was significantly reduced (ES = 0.84), in addition to likely improvements in HRV [150].

Chronic feelings or a personality of high stress, high demand during daily life have physiological implications. Mild hypercortisolism, that is elevated serum cortisol levels for an extended period, has been shown in both highly trained runners as well as those with depression and anorexia nervosa, though whether these elevated levels can be attributed to repeated strenuous exercise or “a specific personality profile” is difficult to conclude [109]. Moreira et al. (2011) [151] published data from male basketball players showing a correlation between symptoms of URTI collected using the WURSS-21 ($r = 0.79$, $p < 0.05$) and sources and symptoms of stress as collected by the DALDA ($r = 0.65$, $p < 0.05$) , as well as a positive relationship between salivary cortisol before ($r = 0.67$, $p < 0.05$) and after ($r = 0.75$, $p < 0.05$) a one week training period and sources and symptoms of stress. This consistency of psychological and physiological markers of stress suggestions the need for both sound psychological and physiological well-being in order to maintain either form of well-being. In a sample of students comprised of 156 predominantly young, healthy females (compared to 60 males), the belief that “stress is bad for you” at baseline was shown to predict somatic symptoms during stressful periods, represented by academic examinations ($\beta = 0.16$, $p = .012$) [149]. The slowing of the recovery process due to life event stress and perceived stress has been demonstrated by Stults-Kolemainen & Bartholomew [26] in students performing a 10-repatition maximum leg press test. Twenty, 40, and 60 minutes after the test, maximal isometric force was assessed and these chronic mental stress measures were demonstrated to moderate the recovery of this force (linear time: $p = 0.013$, squared time: $p = 0.050$); these data certainly having implications in soccer, for which each match lasts 90 minutes and near-maximal contractions are performed frequently. In what the authors believed to be the first study to report the typical training load

and psychophysiological stress in female professional futsal (form of indoor soccer) players, an R^2 of 0.64 to 0.81 was found between DALDA responses of "worse than normal" and training load and strain [152]. This data provides optimistic evidence that the DALDA could be used for detecting a similar relationship in female soccer players.

2.3.2 Energy and Tension Arousal

Mood, has a close association with "general bodily arousal," which can be categorized into energy and tension. Energy and tension are dimensions of arousal making up the extremes ends of scales extending to tiredness and calmness, respectively. Operating independently, four basic moods are found using these two scales; calm-energy and calm-tiredness are positive moods while tense-energy and tense-tiredness are negative moods [153]. Depression, low self-esteem, and negative thoughts can stem from these negative moods, while positive moods improve psychological and physiological health. How athletes demonstrate negative moods from energy and tension arousal is therefore very important to understand.

Our "energy" goes through diurnal changes throughout the day, besides being effected by the activities that make up our day. At those times of naturally low energy, problems have been shown to be interpreted as more serious than at other times of the day (i.e. mid- to late-afternoon) in college males and females ($p < 0.05$) [154]. These data could be extrapolated to mean that when athletes are in a low energy state, due to any number of factors, their stress appraisal may be greater and psychological well-being may be negatively affected. Lazarus [39] stated that stress and those responses that stress stimulates work in an ever-changing and fluctuating state based on the demands of our environment; one could add fluctuating energy state of an individual to this model, influencing stress and those concomitant responses. Exemplifying the relationship between energy arousal and tiredness, professional rugby players reported low measures in energy state throughout the study period (28 days), as well as tiredness and need for rest as being significantly "worse than normal" on rest, training, and match days [38].

Tension arousal is mainly cognitive mediated, interpreting danger in a general sense [154]. During times of low energy and high tension, problem perception has been shown to become significantly higher. There seems to be a high correlation between burnout, and changes in motivation [40]. Although "burnout" is sometimes used loosely to describe different afflictions, it is defined by Gould and Whitley

[40] as a psychological syndrome expressed through decreased feelings of pride and vigor, a measure of the Activation-Deactivation Adjective Check List (AD-ACL), especially for the preferred sport of an individual. Going along with this, it has been put forth that full engagement in sport is the exact opposite of burnout; confidence, dedication , and vigor are all seen in an athlete fully engaged in sport [40] and these are very similar qualities as those cited that are absent from a burned out athlete. Current research reported nonstarters having higher levels of confidence pre- and post-practice (ES = 0.87, ES = 1.25 resp.) as well as pre-game (ES = 1.92) compared to starters [29]. This is a very interesting finding, as one would expect levels of confidence to be equal when everyone is participating, unlike in a game.

Research in fatigability has shown that women may show greater fatigability when performing a cognitive task that stimulates greater arousal. One such study, conducted by Yoon et al. [155] in college aged males and females, used a 20% maximal voluntary contraction to measure time to fatigue, which was measured after 4 minutes of mental math, followed by measurement of arousal immediately after. In this study, the time to failure in women was reduced by 27.3±20.1% compared to 8.6±23.1% in men during the stressor session compared to control (p = 0.03). This could be a warning sign for female athletes, as well as their coaches, who are experiencing high amounts of cognitive stress that may lead to a potentially reduced ability to perform.

2.4 Conclusion

Beyond recognizing the physiological and psychological demands placed on student athletes, researchers must investigate which threats to well-being are associated with one another and how to achieve optimal well-being in all student athletes. It is important to remember that psychological responses and physiological responses to stress have been shown to have separate effects on performance [156], yet are co-dependent in maintaining well-being within the each other.

Researchers in the area of overtraining syndrome agree that too much training is not the cause of this syndrome, but rather inadequate recovery from training as well as non-training stimuli [50]. As suggested by Gould and Whitley, the process of recovery not only includes physically rest, but emotional and social recovery [40]. The goal of recovery should be to return the body and/or mind to homeostasis and to facilitate positive adaptation to occur. Physiological recovery involves ensuring adequate energy as well as water is consumed, taking adequate passive recovery time and night-time sleep, as well as

active recovery emphasizing blood flow to the muscles. Psychological recovery involves relaxation and finding emotional support in an effort to reduce training as well as non-training stressors [95].

The wide array of potential threats to well-being in female soccer student-athletes needs to be narrowed down by examining the changes in well-being seen over a series of games and weeks of training typical for a female collegiate soccer team. Much of the current research focuses on single games or acute bouts of stress in the lab. Research into how these findings transfer to individuals over the course of a season, as well as what predictors can be used to identify these threats over a full season is necessary.

CHAPTER 3.
MATERIALS AND METHODS

3.1 Participants

Eighteen members of the Louisiana State University Women's Soccer team were recruited to participate in this study. Members will be eligible for this observational study designed to examine the psychological and physiological well-being during five weeks of the spring season if they are deemed healthy and able to participate in Louisiana State University athletics by the Louisiana State University team physician. The study has been approved by the institutional review board for use of human subjects, and all players will provide their written informed consent prior to participation.

3.2 Procedures

Volunteers were recruited for this study using word of mouth and presentations to the team during team meetings. Interested athletes will be offered the informed consent and provided ample time to review the consent document. Potential participants will meet with study personnel and be provided a full description of study (structure of the study, study-related procedures, risks, benefits). Individuals who are still interested in participating in the study will be allowed the opportunity to ask questions. If a participant chooses to sign the consent, she will continue on to baseline data will be made available to study investigators to determine inclusion/exclusion criteria. The study will last 5 weeks, during which time 5 competitions will be played. Participants in this study will be monitored during and after practice, as well as during and after competition. At baseline, saliva will be collected on a day of light practice and questionnaires of sources and symptoms of stress, upper respiratory tract infection symptoms, and sleep quality will be administered.

Practices will be conducted under the direction of the soccer team coaches. Study staff will monitor and collect observational data. Players will wear global positioning system and physiological monitors for the duration of all practices during the study period. Questionnaires of weekly sources and symptoms of stress and upper respiratory tract infection symptoms will be administered weekly. Sleep quality will be assessed monthly using a questionnaire validated for monthly sleep quality assessment.

On the day of competition, saliva will be self-collected upon waking, one hour prior to competition and thirty minutes following the competition. One hour prior to competition, AD-ACL questionnaires will be

administered to all participants. During competitions, all participants will wear global positioning system and physiological monitors.

3.2.1 Psychological Well-being Measures

Once per week, sources and symptoms of psychological well-being was self-assessed using the Daily Analysis of Life Demands Questionnaire (DALDA) (Appendix C.) [157]. This measure assesses the degree of general psychological well-being that an athlete is experiencing, as well as psychological well-being related to their sport. The DALDA has been demonstrated to determine positive and negative stress responses to training, as well as the stress stimulus elicits optimal training effort. General psychological well-being is assessed using nine items that address home-life, school/work, friends, and training while the assessment of sport-based psychological well-being addresses muscle pains, irritability, boredom, and tiredness. Athletes are asked to characterize each source and symptom as “worse than normal”, “normal”, or “better than normal.”

Activation and arousal will be self-assessed prior to matches, and at a corresponding time point as pre-match saliva collection, using the Activation-Deactivation Adjective Checklist (AD-ACL) (Appendix B.) [158]. The AD-ACL is a twenty-item scale that uses adjectives to provide dimensions of energy arousal (i.e. sleep-energy continuum) and tension arousal (i.e. placidity-tension continuum). Participants report the degree to which they feel each adjective as “Definitely feel,” “Feel slightly,” “Cannot decide,” or “Definitely do not feel.” Adjectives include active and vigorous (Energy), sleepy and wakeful (Tiredness), jittery and clutched-up (Tension), and at-rest and quiet (calmness).

3.2.2 Physiological Well-being Measures

Global positioning system (GPS) data and physiological monitoring was collected with the use of a Polar Team Pro System (Kempele, Finland), utilizing monitors worn around the chest during the practice and competition sessions and resting periods. This monitor has the capacity to store and transmit data, such as acceleration, HR, and HRV, via Bluetooth. The device provides real-time feedback to a laptop computer so study investigators, athletic trainers, and coaches can monitor physiological exertion of the athlete. Global positioning system and physiological data will help to identify individual training outcomes (distance covered at various intensities and speeds, mean HR, HR recovery, etc.) and their effect on hormonal measures of training stress as well as states of psychological well-being.

Salivary samples were collected at the beginning of the spring season and before and after evening inter-conference games. Samples collected at the beginning of the spring season will be taken by the participant themselves immediately upon waking up, as well as 0900 hr., 1200 hr., 1800 hr., and 2100 hr. Research staff will collect the samples from participants and store them in a refrigeration unit at -80º Celsius. On the day of a game, saliva samples will be taken immediately upon waking (between 0600 and 0900 hr.). Prior to pre-game warm-ups and 30 minutes following each game, salivary samples will be taken from all players. At the end of the spring season, salivary samples will again be taken by the participant themselves immediately upon waking up, as well as 0900 hr., 1200 hr., 1800 hr., and 2100 hr. A synthetic swab placed under the tongue for 3 minutes will be used to collect salivary samples, once for time and once for saturation. If beverages other than water were consumed in the last 30 minutes, participants will be asked to rinse their mouth out twice with water. Enzyme-linked immunosorbent assay (ELISA) will be used to analyze salivary samples for SIgA, cortisol, and sAA [159-161]. Samples containing blood will be discarded. These hormonal measures of training stress will provide objective measures to compare and complement the various subjective measures of this project.

Sleep quality will be self-assessed three times over the course of the spring season using the Pittsburg Sleep Quality Index (PSQI). This is a non-invasive, reliable, and validated measure that assesses dimensions of sleep quality, namely (a) overall sleep quality, (b) time to fall asleep, (c) sleep duration (d) daytime effects of sleep quality, and (e) sleep efficiency. This measure uses 19 items, consisting of open-ended questions (e.g., When have you usually gone to bed?) as well as pointed response options (e.g., During the last month, how often have you had trouble sleeping because you cannot get to sleep within 30 minutes?) of “Not during the last month,” “Less than once a week,” “Once or twice a week,” or “Three or more times a week” [4].

Upper respiratory infection symptoms will be self-assessed using the Wisconsin Upper Respiratory Symptoms Survey (WURSS-21). The WURSS-21 is a condensed version of the original WURSS-44, and has been argued by the authors to be more responsive than the original. This measure assesses the degree to which an athlete may experience upper respiratory complications (i.e. common cold-like symptoms). This measure, administered three times during the spring season, asks the participant to report how they are feeling that day as well as over the previous 24 hours using 8-point

Likert response options of “Not sick/Do not have this symptom/Not at all,” (0), “Very mildly,” (1), “Mildly,” (3), “Moderately,” (5), “Severely” (7). Participants will report how they feel, degree to which they have experienced various symptoms, degree to which their cold has interfered with daily functions, and how they felt compared to the previous day [9].

3.3 Statistical Analysis:

The statistical package JMP (SAS Institute) will be used for statistical analysis. Descriptive statistics (M±SD) will be computed for all dependent variables. A one-way analysis of variance (ANOVA) will be used to examine the differences in both (a) psychological and (b) physiological measures of well-being measures. Where appropriate, student *t*-test post hoc analysis will be conducted to examine pairwise comparisons. The square of the Pearson product-moment correlation coefficients will be calculated to test for associations between relative changes in salivary and psychological measures of well-being, cardiovascular and psychological measures of well-being, and salivary measures and symptoms of URTI. Statistical significance will be considered for alpha levels below 0.05 ($p < 0.05$).

CHAPTER 4.
ANALYSIS AND RESULTS

Descriptive statistics were calculated on participant characteristics for measures of age, height, weight, and HRR by field position as well as by academic year. Means and standard deviations for each variable within each field position and within each academic year are given in Table 4.1 and Table 4.2 respectively. Mean distance covered by field players who played at least 89 minutes of a match was 10.1 km (±0.7).

Table 4.1. Descriptive statistics (mean±sd) for age, height, weight, resting heart rate and heart rate reserve by player position.

	Goalkeepers (n=3)	Defenders (n=4)	Midfielders (n=7)	Forwards (n=4)	All Positions (n=18)
Age	20.7±1.5	19.8±1.0	20.1±1.2	20.3±1.3	20.2±1.2
Height (cm)	173.6±2.9	167.6±10.0	168.0±6.1	164.5±7.0	167.4±7.4
Weight (kg)	79.6±6.0	66.5±5.6	60.3±3.4	60.6±6.1	141.0±17.6
Resting HR (bpm)	53.0±11.1	58.3±4.7	59.8±5.2	60.3±9.3	59.3±4.7
HRR (bpm)	171.3±19.2	173.0±6.5	156.4±17.5	151.3±17.9	160.2±15.9

Table 4.2. Descriptive statistics (mean±sd) for age, height, weight, resting heart rate and heart rate reserve by academic year.

	Freshmen (n=10)	Sophomores (n=4)	Juniors (n=4)
Age	19.3±0.5	21.0±0.8	21.5±0.6
Height (cm)	167.1±6.5	167.0±7.6	171.5±7.9
Weight (kg)	63.6±5.6	66.4±12.5	66.9±12.1
Resting HR	56.2±8.4	57.75±2.2	64.3±2.2
HRR	166.4±19.1	161.0±5.6	149.5±17.1

4.1 Cardiovascular Measures

A one-way ANOVA adjusted for person was used to compare mean percent of HRR of field players who played at least 45 minutes between matches, with a level of significance set at $\alpha < 0.05$. Percent of HRR was not different between any of the matches ($p > 0.05$). The mean cardiovascular load [(%HRR /100) x playing time] of each match in players who played at least 45 minutes was compared using a one-way ANOVA, with a level of significance set at $\alpha < 0.05$. In players who played at least 45

minutes, the second match of the season elicited a significantly greater cardiovascular load compared to the third match (55.9, 95%CI [50.8, 61.0]; 45.2, 95%CI [36.7, 53.7], resp., $p = 0.03$) (Figure 4.1). There was no significant difference between all other matches ($p > 0.05$). The average percent of HRR and cardiovascular load of players who played at least 45 minutes of each win and loss was compared using a Student's t-test, with a level of significance set at $\alpha < 0.05$. There was no significant difference in average percent of HRR during wins and losses (70, 95%CI [60, 70]; 70, 95%CI [60, 70], resp., $p = 0.96$) nor was there a significant difference between cardiovascular load during wins and losses (53.9, 95%CI [50.3, 57.6]; 49.5, 95%CI [44.1, 55.0], resp., $p = 0.15$). The cardiovascular load of each match in field players who played at least 45 minutes was compared between academic classes using a one-way ANOVA, with a level of significance set at $\alpha < 0.05$. Juniors exhibited significantly higher cardiovascular load during matches compared to freshman (57.0, 95%CI [52.3, 61.8]; 45.7, 95%CI [39.8, 51.7], resp., $p = 0.02$) and sophomores (41.7, 95%CI [34.1, 49.4], $p = 0.01$).

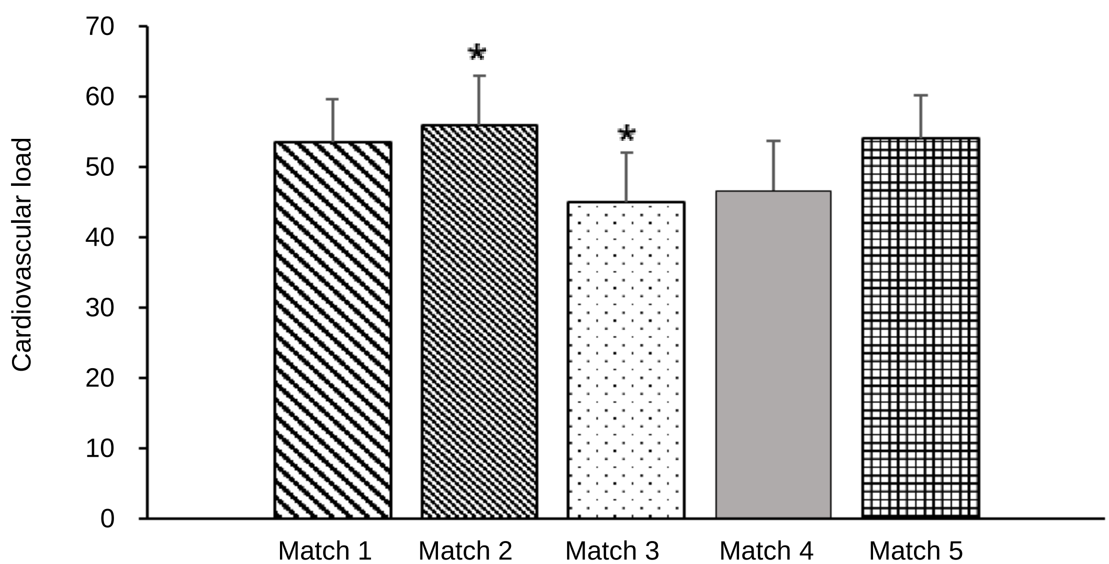

Figure 4.1. Cardiovascular load [(%HRR /100) x playing time] by match. The second match of the season elicited a significantly greater cardiovascular load compared to the third match (* $p = 0.03$).

Energetic, tiredness, tension, and calmness scores of each match were compared to cardiovascular load of that match using a linear regression, with a level of significance set at $\alpha < 0.05$. The first match revealed an association between low energetic score and greater cardiovascular load of the match ($p < 0.01$, $r^2 = 0.93$), as well as increased tiredness score (more tired) and increased cardiovascular load of the match ($p = 0.02$, $r^2 = 0.71$). All other matches showed a non-significant

relationship between energetic, tiredness, tension, and calmness scores and cardiovascular load ($p > 0.05$). There was no significant relationship between increased playing time and cardiovascular load in any of the matches ($p > 0.5$).

4.2 Activation-Deactivation

A linear regression was used to compare energetic, tiredness, tension, and calmness scores of players who played at least 45 minutes in the match to passing success percentage, completed tackles, and second-ball wins, with a level of significance set at $\alpha < 0.05$. Collapsed across matches, successful pass percentage decreased with increased tiredness score (more tired) in central midfielders who played at least 45 minutes ($p < 0.01$, $r^2 = 0.45$), but no other field position ($p > 0.05$). A linear regression was used to compare energetic, tiredness, tension, and calmness scores of players who played at least 45 minutes in the match to passing success percentage, completed tackles, and second-ball wins, with a level of significance set at $\alpha < 0.05$. Collapsed across matches, tiredness score and calmness score were significantly and inversely related to successful pass percentage ($p = 0.03$, $r^2 = 0.11$; $p = 0.03$, $r^2 = 0.11$ resp.) while energetic score was significantly and directly related with successful pass percentage ($p = 0.02$, $r^2 = 0.12$). The last match showed the only significant association between tiredness score and successful pass percentage, revealing an inverse relationship ($p = 0.04$, $r^2 = 0.47$) (Figure 4.2).

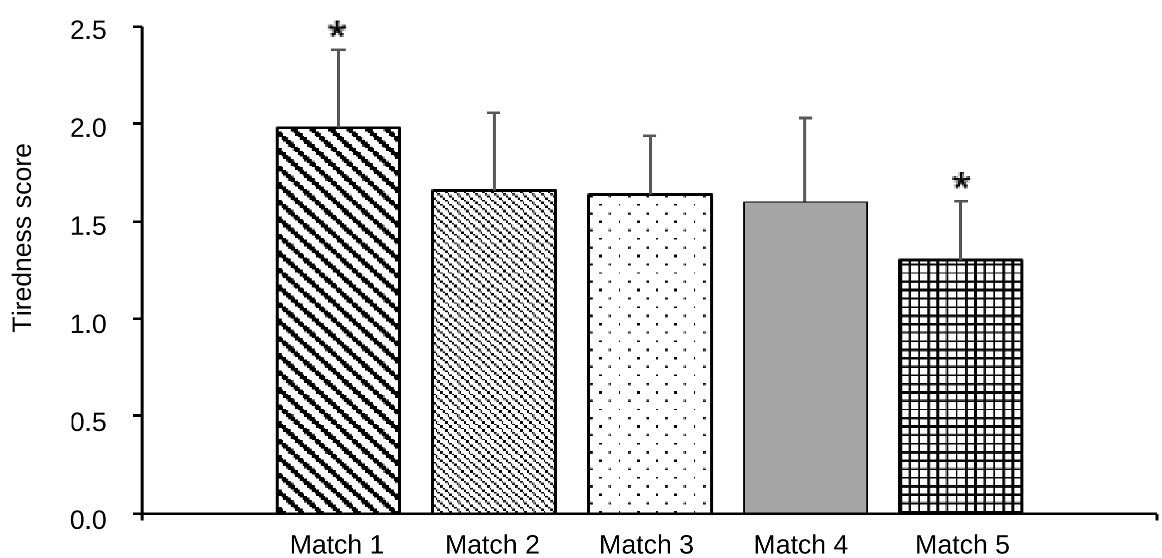

Figure 4.2. Tiredness score (0-4) by match. Tiredness score prior to Match 1 was significantly greater than tiredness score prior to Match 5 (* $p = 0.05$).

No other measure of performance was associated with activation-deactivation state ($p > 0.05$). Collapsed across matches, there was a significant, direct relationship between completed tackles and energetic scores in midfielders ($p = 0.02$, $r^2 = 0.24$). There was a significant, direct relationship between second-ball wins and tension scores in defenders ($p = 0.03$, $r^2 = 0.41$).

A one-way ANOVA was used to compare between matches the mean energetic, tiredness, tension, and calmness scores of players who played at least 45 minutes of the match, with a level of significance set at $\alpha < 0.05$. Tiredness scores significantly decreased (less tired) from the first match compared to the last match (1.9, 95%CI [1.4, 2.3]; 1.4, 95%CI [1.1, 1.6], resp., $p = 0.05$). The second match of the spring season elicited a significantly higher tension score compared to the first match (2.1, 95%CI [1.9, 2.4]; 1.8, 95%CI [1.5, 2.0], resp., $p = 0.03$), fourth (1.8, 95%CI [1.5, 2.0], $p = 0.03$), and fifth match (1.7, 95%CI [1.5, 2.0], $p = 0.02$). The second match also had the greatest standard deviation in playing time (40.1 vs 34.8, 31.6, 35.5, and 37.9) with 11 players contributing more than 75 minutes each.

A linear regression was used to compare energetic, tiredness, tension, and calmness scores of players who played at least 45 minutes in the match to distance run per minute of playing time, with a level of significance set at $\alpha < 0.05$. There was no significant relationship found between any of the four scores investigated and distance per minute of playing time ($p > 0.05$). Collapsed across matches, there was no significant relationship between any of the four investigated scores and distance per minute of playing time ($p > 0.05$).

4.3 Life Demands

A one-way ANOVA was used to compare the number of “worse than normal” and “better than normal” responses to training and general life stressors by week of the spring season, with a level of significance set at $\alpha < 0.05$. A significantly smaller mean number of “better than normal” responses to training stressors were reported following the fourth week of the spring season compared to the week prior to the beginning of the spring season (0.1, 95%CI [0, 0.4]; 1.2, 95%CI [0.4, 2.0], resp., $p = 0.02$). No other weeks were associated with significantly different “worse than normal” and “better than normal” responses to training and general life stressors ($p > 0.05$). A linear regression was used to compare average playing time over the season with mean number of “worse than normal” and “better than normal” responses to training and general life stressors, with a level of significance set at $\alpha < 0.05$. Lower average

playing time per match was significant associated with greater mean number of “worse than normal” responses to general life stressors, yet only during the third week of the spring season ($p < 0.001$, $r^2 = 0.85$). During no other week were the mean number of “worse than normal” or “better than normal” responses significantly associated with playing time ($p > 0.05$). A one-way ANOVA was used to compare the mean number of “worse than normal” and “better than normal” responses to training and general life stressors in each academic year by week of the spring season, with a level of significance set at α < 0.05. Collapsed across weeks, freshman reported a higher mean number of “worse than normal” training stressors compared to sophomores (3.9, 95% CI [2.9, 5.0]; 1.8, 95%CI [0.4, 3.3], resp., $p = 0.02$) and juniors (1.9, 95% CI [0.9, 3.0], $p = 0.03$) (Figure 4.3).

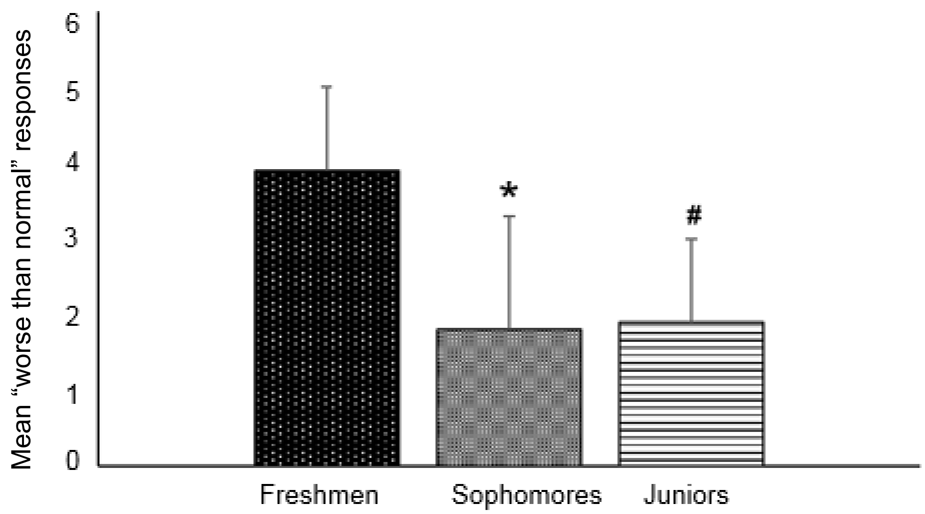

Figure 4.3. Mean number of “worse than normal” responses to training stressors by academic class. Freshman had a significantly greater number of “worse than normal” responses to training stressors compared to sophomores (* $p = 0.02$) and juniors (# $p = 0.03$).

A one-way ANOVA was used to compare the mean number of “worse than normal” and “better than normal” responses to training and general life stressors by field position, with a level of significance set at α < 0.05. Collapsed across weeks, defenders showed a significantly greater mean number of “better than normal” responses to general life stressors compared to midfielders (1.7, 95%CI [0.2, 3.1]; 0.3, 95%CI [0.1, 0.5], resp., $p < 0.01$) and goalkeepers (0.4, 95%CI [0.0, 1.0], p = 0.02). Defenders showed a significantly higher mean “better than normal” response to training stressors compared to midfielders (1.4, 95%CI [0.5, 2.4]; 0.3, 95%CI [0.0, 0.6], resp., $p = 0.01$) and goalkeepers (0.3, 95%CI [0.0, 0.7], $p = 0.02$).

4.4 Upper Respiratory Symptoms

Mean feelings of sickness across all weeks and players was 1.2 (SD= 1.7) on a scale of 0 to 7 indicating “very mild” feelings of sickness. A one-way ANOVA was used to compare the severity of cold symptoms by field position and academic year, with a level of significance set at $\alpha < 0.05$. No difference between field positions or academic years for feelings of sickness was found ($p > 0.05$), while freshman reported significantly greater severity of sneezing as a cold symptom compared to juniors (1.1, 95%CI [0.3, 2.0]; 0.00, 95%CI [0, 0] resp., $p = 0.04$). Midfielders reported significantly greater severity of feeling tired as a cold symptom compared to defenders (3.3, 95%CI [2.1, 4.4]; 1.3, 95%CI [-0.3, 2.9] resp., $p = 0.04$) and goalkeepers (0.9, 95%CI [0.1, 3.9], $p = 0.01$). There were no other significant relationships between field position and severity of cold symptoms (p > 0.05).

A linear regression was used to compare the severity of cold symptoms by playing time, with a level of significance set at $\alpha < 0.05$. At baseline, severity of sore throat ($p = 0.01$, $r^2 = 0.40$), hoarseness ($p = 0.03$, $r^2 = 0.29$), chest congestion ($p = 0.04$, $r^2 = 0.26$), impaired ability to sleep well ($p = 0.02$, $r^2 = 0.34$), and coughing ($p = 0.02$, $r^2 = 0.32$) as cold symptoms exhibited an inverse relationship with average playing time in matches (Figure 4.4). Players who averaged higher playing times per match over the five competitive matches reported few symptoms of a cold at baseline, however this relationship did not persist throughout the spring season. There was no relationship between average playing time during the season and upper respiratory tract infection symptoms at any other time point of the spring season (p >0.05).

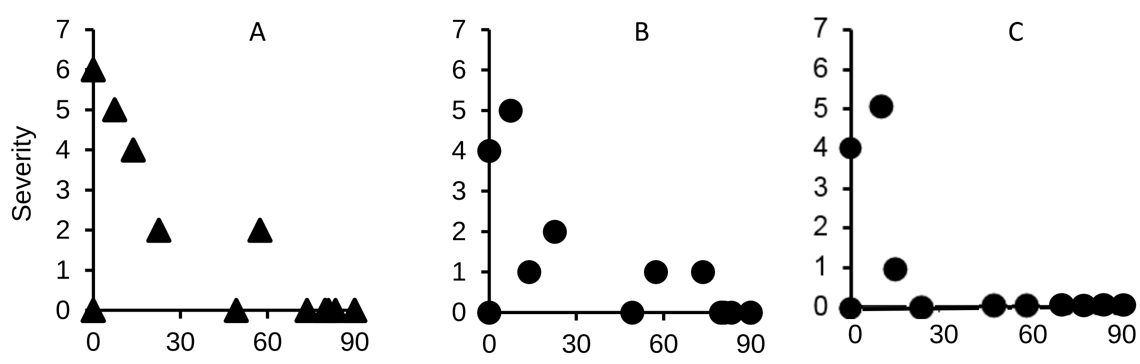

Figure 4.4. Severity of upper respiratory tract symptoms by average playing time. (A) Sore throat (p = 0.01), (B) coughing (p = 0.02), and (C) hoarseness (p = 0.03) all had an inverse, significant association with playing time.

4.5 Sleep Quality

A Student's t-test was used to compare mean frequency of various barrier to sleep between the month prior to competition, and the month of five competitive matches, with a level of significance set at $\alpha < 0.05$. No significant difference for mean frequencies of various barrier to sleep was found between months ($p > 0.05$). A linear regression was used to compare mean frequency of specific barriers to sleep and average playing time, with a level of significance set at $\alpha < 0.05$. Collapsed across the baseline month and the month of competition, low average playing time had a significant relationship with having trouble sleeping due to feelings of hotness ($p = 0.04$, $r^2 = 0.27$). Collapsed across months, average playing time and more frequently have trouble keeping up enthusiasm to get things done were directly and significantly associated ($p = 0.02$, $r^2 = 0.18$) (Figure 4.5). No other barriers to sleep had a significant relationship with average playing time ($p > 0.05$).

A linear regression was used to compare mean frequency of specific barriers to sleep and age, with a level of significance set at $\alpha < 0.05$. Not being able to fall asleep within 30 minutes was shown to have a positive relationship with age ($p = 0.02$, $r^2 = 0.37$). Having trouble staying awake while engaging in social activities, driving, eating, etc. exhibited a positive relationship with age ($p < 0.01$, $r^2 = 0.63$).

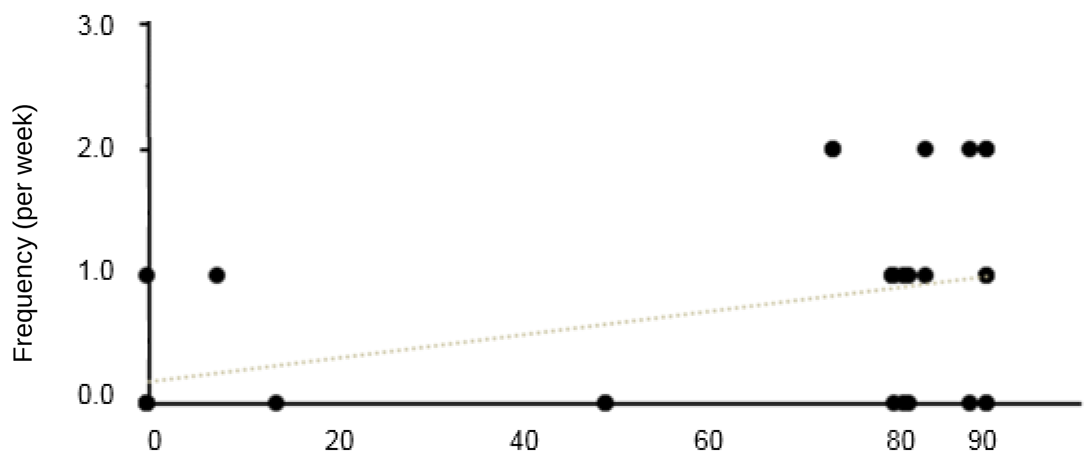

Figure 4.5. Frequency of difficulty maintaining enthusiasm to accomplish tasks per week by average playing time. There was a significant direct relationship between Average playing time and frequency of difficulty maintaining enthusiasm to accomplish tasks per week ($p = 0.02$).

A linear regression was used to compare mean frequency of specific barriers to sleep and average match cardiovascular load, with a level of significance set at $\alpha < 0.05$. Average match cardiovascular load was shown to have a significant and direct relationship with trouble putting forth

enthusiasm during the month prior to the beginning of competitive matches (p = 0.003, r^2 = 0.69) yet not the following month of competition (p = 0.35). Average match cardiovascular load was also associated with a decreased occurrence of bad dreams (p = 0.007, r^2 = 0.62). No other barriers to sleep had a significant relationship with cardiovascular load (p > 0.05).

CHAPTER 5.
DISCUSSION AND CONCLUSIONS

Previous research has indicated that student-athletes are a high-risk population for greater physiological and psychological stress. Female student-athletes are an under-researched sub-population of student-athletes, yet there is evidence that this population may be at a comparable or greater risk to experience elevated stressors compared to their male counterparts. Cardiovascular stress from matches and training [22, 65], sport-induced immunosuppression [124, 126, 128], as well as academic and life stressors [162, 163] have all been shown elevated and/or to negatively impact performance and well-being specifically in female athletes and female student-athletes. Female student-athletes are a vulnerable population, yet understudied in research.

This study was designed to determine the physiological and psychological well-being of collegiate varsity women's soccer players during the spring season. Cardiovascular load and tension arousal were highest in the second match of the season, while low energy-arousal was exhibited in the first match, shifting to higher energy arousal prior to the last match. Freshman characterized the largest number of training stressors as "worse than normal." Interestingly, greater playing time was associated with decreased severity of upper respiratory tract infection symptoms, in addition to less frequent trouble sleeping due to hotness. Players who averaged more playing time also experienced decreased ability to maintain enthusiasm to accomplish tasks. Freshman and players who averaged few minutes per match exhibited a greater number of cold symptoms and sleep dysfunction respectively.

HRR is argued to be the most reliable indicator of physiological intensity, as well as allowing for greater inter-study and inter-individual comparisons [164]. Contrary to what was hypothesized, the current study showed no differences in percent of HRR between any of the matches, and while cardiovascular load decreased significantly in the match following the most cardiovascular-demanding match, there were no significant difference between cardiovascular load of any other match. Although phases of the matches were not analyzed in the present study, the 15^{th} through 30^{th} minute of a match were reported to elicit the highest cardiovascular intensity in elite male soccer players on an Under-20 (years old) team [165]. Future research should examine the effects of pre-match energy-arousal on this period of the match and associated performance measures.

Low pre-match energy-arousal was associated with increased cardiovascular load that was not associated with increased playing time. The cause for this relationship is unclear, however a possible explanation could be sympathetic activation due to feelings of being unprepared or not up for the task of playing the upcoming match. Perceived readiness was shown to be the best predictor of cognitive anxiety and self-confidence in intercollegiate middle-distance runners [166].

Higher energy-arousal states were associated with increased number of tackles in midfielders while high tension-arousal was associated with fewer second-ball wins in defenders. High levels of mental effort have been associated with poor performances in student-athletes [167]. Perhaps elevated tension-arousal caused a cognitive backup, causing defenders in this case to think instead of act and fight to win the ball. In the present study, lower energy- and tension-arousal states were associated with decrements in passing percentage during competition throughout the team. This is an interesting finding, as one would expect low tension-arousal to make players composed when they have the ball and are looking to pass. According the Processing Efficiency theory, worry causes both a reduction in the ability of an individual to store and process memory for a simultaneous task, as well as (b) increases on-task effort and action towards improving performance [168]. This theory could perhaps be applied to this finding, as a lack of tension arousal, or elevated calmness, could indicate a lack of cognitive drive to achieve maximal soccer-specific performance.

Circadian rhythm may be an even more important contributor to performance than previously thought. Maximal impairment of neurobehavioral functioning was shown to occur during the end of a wake episode of the participants, specifically following 10 hours to 13 hours 20 minutes of wakefulness, in a sleep desynchrony study [169]. Mean wakeup time in the present study was 06:10 (±00:06) hours, indicating that the time period of maximal impairment discussed would occur between approximately 16:00 and 19:30 hours; the second and third match began within this range. In the present study, tension was significantly higher in the second match, occurring at 19:00 h, compared to all other matches except for the third match, occurring at 18:00 h. Conversely, a study of diurnal variation in soccer-specific tasks showed that juggling performance, dribbling, and accuracy of ball kicks peaked between 16:00 h and 20:00 h [170]. In the present study, there was no difference in successful pass percentage between match times.

Greater severity of upper respiratory tract infection symptoms at baseline in players who participated in fewer minutes of the match is a very interesting finding, while not contrary to what was hypothesized. Research in young females who were either tennis players or non-athletes showed that the highest and lowest daily energy expenditure (≥ 17,322 kJ/day, ≤ 10,047 kJ/day resp.) suffered the greatest occurrence of upper respiratory tract infection symptoms, while the girls whose energy expenditure was between 12,290 and 16,410 kJ/day experienced the lowest severity of these symptoms [171]. A reasonable assumption could be that the fringe players were on the lower end of this range, while those who contributed a great deal of minutes in matches were similar to the group between 12,290 and 16,410 kJ/day. Another possible explanation could be that this population follows the S-shaped curve proposed for various levels of training status and infection risk. Along this curve, infection risk drops from low to moderate exercise load, followed by highly trained athletes who have a high exercise load and possess the highest odds ratio for infection, ending with elite level athletes who maintain the highest workload and possess the lowest infection risk [172]. Mean distance covered during matches in players who essentially played the entire match was within the range given by Ademovic (2016)[173] for elite male soccer players and was similar to the mean total distance covered in international and domestic league matches in elite female soccer players [174]. Perhaps the starters and players playing large portions of the match belong in the category with elite athletes who maintain the highest exercise load, while the more symptom-susceptible fringe players could be considered highly-trained, yet do not maintain such a high exercise load.

The present study showed that higher playing time was significantly associated with having trouble keeping up enthusiasm to get things done. This finding is understandable considering the greater psychological stress experienced by playing more minutes. The psychological investment of playing soccer appears to diminish the ability of players to invest psychologically in activities outside of soccer. Physically demanding exercise has been reported to impair cognitive processing as measured by various paper tests in patients with chronic fatigue syndrome [175]. There is substantial evidence for the reverse relationship, indicating that physical fatigue and mental fatigue could be part of a vicious cycle. Time to exhaustion attributed to mental fatigue was significantly reduced in high-intensity cycling after 90 minutes of a cognitively demanding task [176]. Shot speed, accuracy, as well as distance run in the Yo-Yo

Intermittent Recovery Test Level 1 was reduced in experienced soccer players following a mentally fatiguing test [177]. Even short duration air travel has been shown to diminish points scored in a netball competition [178], and considering that three of the five matches in the present study were “away” matches, travel may have compounded the physiological impact of the match itself.

This study is unique in its analysis of physiological and psychological well-being over a multiple competitive matches making up an athletic season. Evaluating the combined effects of physiological and psychological stressors on the well-being of female soccer players has not but reasonably studied. The present study showed that maintaining energy-arousal prior to and during a match should be a focus of players and team staff. Players who are spending their first year training at a collegiate level (i.e. freshman) or players who are not at an elite level of fitness may require additional attention from medical staff and trainers. Academic motivation may be a struggle for players who experience greater mental load during matches (i.e. players who play the majority of minutes), as mental fatigue may limit mental investment in tasks after matches.

Limitations of this study include the use of a single team and investigation of only eighteen players. Seeing as only 11 players may play at a time, playing few minutes can be difficult to analyze and provide an inconsequential physiological and psychological impact, and many analysis must be conducted excluding the goalkeeper, there was a limited amount of data that could be collected from a single game. With different teams and more players, the effects of playing time would have been much easier and provide even stronger data. Analysis of only pre-game arousal state did not allow us to properly examine the impact of the game on energy- and tension-arousal, potentially insightful data considering no other questionnaires were administered post-game.

In conclusion, a five-match spring season appeared to affect groups of players differently, instead of as a whole as was hypothesized. Cardiovascular load showed a greater effect on psychological factors of well-being compared to percent of HRR. High energy-arousal improved passing performance and increased from the first to last match of the season. Infection risk was greater in players who played fewer minutes in matches, appearing to follow the S-shaped curve. The mental fatigue of soccer matches appeared to affect players who played the most to a greater effect by decreasing their motivation to make progress on daily life tasks.

REFERENCES

1. *Well-Being Concepts*. Health-Related Quality of Life (HRQOL) 2016 [cited 2017 June 10].

2. Frey, B.S., & Stutzer, A., *Happiness and economics* 2002, Princeton University Press: Princeton, N.J.

3. Diener, E., *Subjective well being: the science of happiness and a proposal for a national index.* American Psychologist, 2000. 55(1): p. 34-43.

4. Csikszentmihalyi, M., *Flow: the psychology of optimal experience*. 1991, Harper Perennial: New York, NY.

5. Kahneman, D., Krueger, A.B., Schkade, D.A., Schwarz, N., & Stone, A.A., *A survey method for characterizing daily life: the day reconstruction method.* Science, 2004. 306: p. 1776-1780.

6. Eid, M., *Measuring the Immeasurable: Psychometric modeling of subjective well-being data*. The science of subjective well-being, ed. M. Eid, Larsen, R.J. 2008, New York: Guilford Press.

7. Dupuy, H.J., *Self-representations of general psychological well-being of American adults*. 1978: Paper presented at the American Public Health Association Meeting Los Angeles, October.

8. Kaplan, R.M., & Anderson, J.P., *The quality of well-being scale: Rationale for a single quality of life index*, in *Quality of Life: Assessment and Application*. 1988, MTP Press: London. p. 51-77.

9. Pressman, S.D., & Cohen, S., *Does positive affect influence health?* Psychological Bulletin, 2005. 131: p. 925-971.

10. Ostir, G.V., Markides, K.S., Black, S.A., et al., *Emotional well-being predicts subsequent functional independence and survival.* Jornal of the American Geriatric Society 2000. 48: p. 473-478.

11. Ostir, G.V., Markides, K.S., Peek, M.K., et al., *The association between emotional well-being and incidence of stroke in older adults.* Psychosomatic Medicine, 2007. 63: p. 210-220.

12. Tov, W., & Diener, E., *The well-being of nations: Linking together trust, cooperation, and democracy*, in *Cooperation: The psychology of effective human interaction*, B.A. Sullivan, Snyder, M., Sullivan, J.L., Editor. 2008, Blackwell Publishing: Malden, MA. p. 323-342.

13. Frederickson, B.L., & Levenson, R.W., *Positive emotions speed recovery from the cardiovascular sequelae of negative emotions.* Cognition and Emotion, 1998. 12: p. 191-220.

14. Diener, E., & Biswas-Diener, R., *Happiness: Unlocking the mysteries of psychological wealth*. 2008, Malden, MA.: Blackwell Publishing.

15. King, L.A., *Interventions for enhancing subjective well-being: can we make people happier and should we?* , in *The Science of Subjective Well-Being*, M.L. Eid, R.J., Editor. 2008,Guilford Press: New York, NY. p. 431-448.

16. Nes, R.B., Roysamb, E., Tambs, K., Harris, J.R., & Reichborn-Kjennerud, T., *Subjective well being: genetic and environmental contributions to stability and change.* Psychological Medicine, 2006. 36: p. 1033-1042.

17. Myers, D.G., *Close relationships and quality of life*, in *Well-Being: The foundations of hedonic psychology*, D. Kahneman, Diener, E., Schwarz, N., Editor. 2003, Russel Sage Foundation Publications: New York. p. 374-391.

18. Helliwell, J.F., & Huang, H., *How's your government? International evidence linking good government and well-being.* British Journal of Political Science 2008. 38: p. 595-619.

19. *NCAA GOALS study of the student-athlete experience: initial summary of findings*. 2016, National Collegiate Athletic Association

20. Cohen, S., Kamarck, T., & Mermelstein, R., *A global measure of percieved stress.* Journal of Health and Social Behavior, 1983. 24(4): p. 386-396.

21. Surujlal, J., Van Zyl, Y., & Nolan, V.T., *Perceived stress and coping skills of university student athletes and the relationship with life satisfaction.* African Journal for Physical, Health Education, Recreation and Dance 2013. 19(4:2): p. 1047-1059.

22. Krustrup, P., Mohr, M., Ellingsgaard, H., & Bangsbo, J., *Physical demands during an elite female soccer game: importance of training status.* Medicine and Science in Sports & Exercise, 2005. 37(7): p. 1242-8.

23. Torreno, N., Munguia-Izquierdo, D., Coutts, A., Saez de Villarreal, E., Asian-Clemente, J.,& Suarez Arrones, L., *Relationship between external and internal loads of professional soccer players during full matches in official games using global positioning systems and heart rate technology.* International Journal of Sports Physiology and Performance, 2016. 11(7): p. 940-946.

24. Hodgson, C., Akenhead, R., & Thomas, K., *Time-motion analysis of acceleration demands of 4v4 small-sided soccer games played on different pitch sizes.* Human Movement Science, 2014. 33: p. 25-32.

25. Gaudino, P., Alberti, G., & Iaia, F.M., *Estimating metabolic and mechanical demands during different small-sided games in elite soccer players.* Human Movement Science, 2014. 36: p. 123-133.

26. Stults-Kolehmainen, M.A., & Bartholomew, J.B., *Psychological stress impairs short-term muscular recovery from resistance exercise.* Medicine and Science in Sport and Exercise, 2012. 44(11): p. 2220-2227.

27. Rooyachers, O.E., & Nair, K.S., *Hormonal regulation of human muscle protein metabolism.* Annual Review Of Nutrition, 1997. 17(1): p. 457.

28. Pansters, N.A., Langen, R.C., Wouters, E.F., & Schols, A.M., *Synergistic stimulation of mygenesis by glucocorticoid and IGF-I signaling.* The Journal of Applied Physiology, 2012. 114(9): p. 1329-1339.

29. Haneishi, K., Fry, A.C., Moore, C.A., Schilling, B.K., Li, Y., & Fry, M.D., *Cortisol and stress responses during a game and practice in female collegiate soccer players.* Journal of Strength and Conditioning Research, 2007. 21(2): p. 585-588.

30. Kraemer, W.J., French, D.N., Paxton, N.J., Hakkinen, K., Volek, J.S., Sebastianelli, W.J., Putukian, M., Newton, R.U., Rubin, M.R., Gomez, A.L., Vescovi, J.D., Ratamess, N.A., Fleck, S.J., Lynch, J.M., & Knuttgen, H.G., *Changes in exercise performance and hormonalconcentrations over a Big Ten soccer season in starters and nonstarters.* Journal of Strength and Conditioning Research, 2004. 18(1): p. 121-128.

31. Nieman, D.C., Henson, D.A., Gagoaga, O.R., Utter, A.C., Vinci, D.M., Davis, J.M., Nehlsen & Cannarella, S.L., *Change in salivary IgA follwing a competitive marathon race* International Journal of Sports Medicine 2002. 23(1): p. 69-75.

32. Libicz, S., Mercier, B., Bigou,N., Le Gallais, D., & Castex, F., *Salivary IgA response of triathletes participating in the French Iron Tour.* International Journal of Sports Medicine, 2006. 27(5): p. 389-394.

33. Freitas, C.G., Aoki, M.S., Arruda, A.F.S., Franciscon, C., & Moreira, A., *Monitoring salivary immunoglobulin A responses to official and simulated matches in elite young soccer players* Journal of Human Kinetics, 2016. 53: p. 107-115.

34. Gallina, S., Di Mauro, M., D'Amico, M., D'Angelo, E., Sablone, A., DiFonso, A., Bascelli, A., Izzicupo, P., & Di Baldassarre, A., *Salivary chromogranin A, but not a-amylase, correlates with cardiovascular parameters during high-intensity exercise.* Clinical Endocrinology, 2011. 75: p. 747-752.

35. Starzak, D.E., Konkol, K.F., & McKune, A.J., *Twelve weeks of soccer-specific training: effects on mucosal immunity, salivary alpha-amylase and body composition in male African youths.* Sport Science and Health, 2016. 12: p. 269-276.

36. Shiraiwa, K., Nagatani, I., & Tanaka,S., *Gender differences in salivary alpha amylase responses to exercise.* Rigakuryoho Kagaku, 2013. 28(4): p. 451-455.

37. Kivlighan, K., & Granger, D.A., *Salivary a-amylase response to competition; Relation to gender, previous experience, and attitude.* Psychoneuroendocrinology, 2006. 31: p. 703-714.

38. Nicholls, A.R., Backhouse, S.H., Polman, R.C.J., & McKenna, J., *Stressors and affective states among professional rugby union players* Scandinavian Journal of Medicine, Science, and Sports, 2009. 19: p. 121-128.

39. Lazarus, R.S., *Stress and emtion: a new synthesis* 1999, New York: Springer.

40. Gould, D., & Whitley, M.A., *Sources and consequences of athletic burnout among collegeathletes* Journal of Intercollegiate Sports, 2009. 2: p. 16-30.

41. Moreira, A., Arsati, F., Lima-Arsati, Y.B.O., Simones, A.C., & De Araujo, V.C., *Salivary Cortisol in top-level professional soccer players* European Journal of Applied Physiology, 2009. 106: p. 25-30.

42. Ispirlidis, I., Fatouros, I.G., Jamurtas, A.Z., Nikolaidis, I., Douroudos, I., Margonis, K., Chatzinikolaou, A., Kalistratos, E., Katrabasas, I., Alexiou, V., & Taxildaris, K., *Time course of changes in inflammatory and performance responses following a soccer game.* Clinical Journal of Sport Medicine, 2008. 18(5): p. 423-429.

43. Faigenbaum, A., *Overtraining in young athletes: How much is too much?* ACSM's Health and Fitness Journal 2009. 13(4): p. 1-6.

44. Kreher, J.B., & Schwartz, J.B., *Overtraining syndrome: A practicle guide.* Sports Health, 2012. 4(2): p. 128-138.

45. Matos, N.F., Winsley, R.J., & Williams, C.A., *Prevalence of nonfunctional overreaching/overtraining in young english athletes.* Medicine and Science in Sports & Exercise, 2011. 43(7): p. 1287-1294.

46. Raglin, J.S., & Wilson, G.S., *Overtraining in athletes*. Emotions in sport, ed. Y. Hanin. 2000, Champaign, IL: Human Kinetics.

47. Gustafsson, H., Kentta, G., Hassem, P., & Lundqvist, C., *Prevalence of burnout in competitive adolescent athletes.* The Sport Psychologist, 2007. 21: p. 21-37.

48. Alves, R.N., Costa, L.O.P., & Samulski, D.M. *Monitoring and prevention of overtraiing in athletes*. Revista Brasileira de Medicina do Esporte 2006. 12.

49. Morgan, W.P., Brown, D.R., Raglin, J.S., O'COnnor, P.J., & Ellickson, K.A., *Psychological monitoring of overtraining and staleness.* British Journal of Sports Medicine, 1987. 21(3): p. 107-114.

50. Birrer, D., Lienhard, D., Williams, C.A., Rothlin, P., & Morgan, G. *Prevalence of non-functional overreaching and the overtraining syndrome in Swiss elite athletes*. Schweizerische Zeitschrift Fur Sportmedizin & Sporttraumatologie, 2013. 61, 23-29.

51. Cremades, J.G., & Wiggins, M.S., *Direction and intensity of trait anxiety as predictors of burnout among collegiate athletes.* Athletic Insight: The Online Journal of Sport Psychology, 2008. 10(2).

52. Harris, B.S., & Smith, M.L., *The influence of motivational climate and goal orientation on burnout: An exploratory analysis among Division I collegiate student-athletes.* Athletic Insight: The Online Journal of Sport Psychology, 2009. 11(2).

53. Sjokvist, J., Laurent, M.C., Richardson, M., Curtner-Smith, M., Holmberg, H., & Bishop, P.A., *Recovery from high-intensity training sessions in female soccer players.* The Journal of Strength and Conditioning Research 2011. 25(6): p. 1726-1735.

54. *Length of playing season*, in *17*, N.C.A. Association, Editor. 1997: Legislative Services Database.

55. Rollo, I., Impellizzeri, F.M., Zago, M., & Iaia, F.M., *Effects of 1 versus 2 games a week on physical and subjective scores of subelite soccer players.* International Journal of Sports Physiology and Performance, 2014. 9(3): p. 425-431.

56. Boullosa, D.A., Abreu, L., Nakamura, F.Y., Munoz, V.E., Dominguez, E., & Leicht, A.S., *Cardiac autonomic adaptations in elite spanish soccer players during preseason* International Journal of Sports Physiology and Performance 2013. 8: p. 400-409.

57. Buchheit, M., Voss, S.C., Nybo, L., Mohr, M., & Racinais, S., *Physiological and performance adaptations to an in-season soccer camp in the heat: Associations with heart rate and heart rate variability* Scandinavian Journal of Medicine, Science, and Sports, 2011. 21: p. e477-e485.

58. Gabbett, T.J.M., *Time-motion analysis of small-sided training games and competition in elite women soccer players.* The Journal of Strength and Conditioning Research, 2008. 22(2): p. 543-552.

59. Coutts, A.J., Rampinini, E., Marcora, S.M., Castagna, C., & Impellizzeri, F.M., *Heart rate and blood lactate correlates of perceived exertion during small-sided soccer games.* Journal of Science and Medicine in Sport, 2009. 12: p. 79-84.

60. Tessitore, A., Meeusen, R., Piacentini, M.F., Demarie, S., & Capranica, L., *Physiological and technical aspects of "6-a-side" soccer drills.* Journal of Sports Medicine and Physical Fitness, 2006. 46(1): p. 36-43.

61. Rampinini, E., Franco, M., Impellizzeri, F.M., Castagna, C., Abt, G., Chamari, K., Sassi, A., & Marcora, S.M., *Factors influencing physiological responses to small-sided soccer games.*Journal of Sports Sciences, 2007. 25(6): p. 659-666.

62. Reilly, T., & Ball, D., *The net physiological cost of dribbling a soccer ball.* Research Quarterly for Exercsie and Sport, 1984. 55: p. 267-271.

63. Hetzler, R.K., Seip, R.L., Pierce, E., Snead, D., & Weltman, A., *Effect of exercise modality on ratings of percieved exerction at various lactate concentrations.* Medicine and Science in Sports & Exercise, 1991. 23(1): p. 88-92.

64. Morgan, W., *Psychological components of effort sense.* Medicine and Science in Sports & Exercise, 1994. 26(9): p. 1071-1077.

65. Datson, N., Hulton, A., Andersson, H., Lewis, T., Weston, M., & Drust, B., *Applied physiology of female soccer players: An update.* Sports Medicine 2014. 44.

66. Bradley, P.S., Dellal, A., Mohr, M., Castellano, J., & Wilkie, A., *Gender differences in match performance characteristics of soccer players competing in the UEFA Champions League.* Human Movement Science 2014. 33: p. 159-171.

67. Andersson, H., *The physiological impact of soccer on elite female players and the effects of active recovery training*, in *School of Health and Medical Sciences*. 2010, Orebro University: Orebro, Sweden. p. 70.

68. Nowak, R., Ruryta, R., & Kostrzewa-Nowak, D., *The search for new diagnostic markers of metabolic response to aerobic exercise: analysis of creatinine, urea, and uric acid levels in football players.* TRENDS in Sport Science 2016. 4(23): p. 167-175.

69. Gravina, L., Ruiz, Fatima, Lekue, J.A., Irazusta, J., & Gil, S.M., *Metabolic impact of soccer match on female players.* Journal of Sports Sciences, 2011. 29(12): p. 1345-1352.

70. Brancaccio, P., Maffulli, N., Limongelli, F.M., *Creatine kinase monitoring in sport medicine* British Medical Bulletin 2007: p. 1-22.

71. Martens, M.P., Dams-O'Connor, K.D, & Beck, N.C., *A systematic review of college student athlete drinking: Prevalence rates, sport-related factors, and interventions.* Jornal of Substance Abuse Treatment, 2006. 31(3): p. 305-316.

72. Gustafsson, H., Hassmen, P., Kentta, G., & Johansson, M., *A qualitative analysis of burnout in elite Swedish athletes.* Psychology of Sport and Exercise, 2008. 9: p. 800-816.

73. *Impermissible academic assistance*, in *14.02*, N.C.A. Association, Editor. 2016.

74. *Good academic standing and progress toward degree*, in *14.02*, N.C.A. Association, Editor. 2003.

75. Liston, C., McEwen, B.S., & Casey, B.J., *Psychosocial stress reversibly disrupts prefronal processing and attentional control.* Proceedings of the National Academy of Sciences of the United States of America, 2008. 106(3): p. 912-917.

76. Kulics, J., Kornspan, A.S., & Kretovics, M., *An analysis of the academic behaviors and beliefs of division I athletes: the impact of the increased percentage toward degree requirements.* College Student Journal, 2015. 49(1): p. 1-12.

77. Coakley, J., *Burnout among adolescent athletes: A personal failure or social problem?* Sociology of Sport Journal, 1992. 9: p. 271-285.

78. *Daily and weekly hour limitations -- playing season*, in *2003-16*, N.C.A. Association, Editor. 1991.

79. *Playing and practice seasons*, in *2005-136*, N.C.A. Association, Editor. 2005. p. 242-243.

80. Aries, E., McCarthy, D., Salovey, P., & Banaji, M.R., *A comparison of athletes and non-athletes at highly selective colleges: Academic performance and personal development.* Research in Higher Education, 2004. 45(6): p. 577-602.

81. Miller, P.S., & Kerr, G., *The athletic, academic and social experiences of intercollegiate student athletes.* Journal of Sport Behavior, 2002. 25(4): p. 346.

82. Meeusen, R., Duclos, M., Foster, C., Fry, A., Gleeson, M., Neiman, D., Raglin, J., Rietjens, G., & Urhausen, A. , *Prevention, diagnosis, and treatment of the overtraining sydrome: Joint consensus statement of the European College of Sports Science and the American College of Sports Medicine.* Medicine and Science in Sports & Exercise, 2012. 45(1): p. 186-205.

83. Watson, A., Brickson, S., Brooks, A., & Dunn, W. *Subjective well-being and training load predict in season injury and illness risk in female youth soccer players*. British Journal of Sports Medicine, 2016. DOI: 10.1136/bjsports-2016-096584.

84. Gould, D., & Tuffey, S., *Burnout in competitive junior tennis players: III. Individual differences in the burnout experience* Sport Psychology, 1997. 11(3): p. 257.

85. Thorpe, R.T., Strudwick, A.J., Buchheit, M., Atkinson, G., Drust, B., & Gregson, W., *Tracking morning fatigue status across in-season training weeks in elite soccer players.* International Journal of Sports Physiology and Performance, 2016. 11(7): p. 947-952.

86. Thorpe, R.T., Strudwick, A.J., Buchheit, M., Atkinson, G., Drust, B., & Gregson, W., *Monitoring fatigue during the in-season competitive phase in elite soccer players.* International Journal of Sports Physiology and Performance, 2015. 10(8): p. 958-964.

87. Los Arcos, A., Mendez-Villanueva, A., Yanci, J., & Martinez-Santos, R., *Respiratory and muscular percieved exertion during offical games in proffessional soccer players.* International Journal of Sports Physiology and Performance, 2016. 11(3): p. 301-304.

88. Los Arcos, A., Yanci, J., Mendiguchia, J., & Gorostiaga, E.M., *Rating of muscular and respiratory perceived exertion in professional soccer players.* Journal of Strength and Conditioning Research, 2014. 28(11): p. 3280-3288.

89. Eller, T., Aluoja, A., Vasar, V., & Veldi, M., *Symptoms of anxiety and depression in Estonian medical students with sleep problems.* Depression and Anxiety, 2006. 23(4): p. 250-6.

90. Engle-Friedman, M., Riela, S., Golan, R., Ventuneac, A.M., Davis, C.M., Jefferson, A.D., & Major, D., *The effect of sleep loss on next day effort.* Journal of Sleep Research 2003. 12(2): p. 113-124.

91. Gaultney, J.F., *The prevalence of sleep disorders in college students: Impact on academic performance* Journal of American College Health, 2010. 59(2): p. 91-97.

92. Leeder, J., Glaister, M., Pizzoferro, K., Dawson, J., & Pedlar, C., *Sleep duration and quality in elite athletes measured using wristwatch actigraphy.* Journal of SPorts Sciences, 2012. 30(6): p. 541-545.

93. Sargent, C., Lastella, M., Halson, S., & Roach, G.D., *The impact of training schedules on sleep and fatigue of elite athletes* Chronobiology International 2014. 31(10): p. 1160-1168.

94. Sargent, C., Halson, S., & Roach, G.D., *Sleep or swim? Early-morning training severly restricts the amount of sleep obtained by elite swimmers.* European Journal of Sport Science, 2014. 14(Suppl 1): p. S310-S315.

95. Kentta, G., & Hassmen, P., *Overtraining and recovery: A conceptual model.* Sports Medicine, 1998. 26: p. 1-16.

96. Kentta, G., Hassmen, P., & Raglin, J.S., *Training practices and overtraining syndrome in swedish age-group athletes.* International Journal of Sports Medicine, 2001. 22(6): p. 460-465.

97. Erlacher, D., Ehrlenspiel, F., Adegbesan, O.A., El-Din, H.G. , *Sleep habits in German athletes before important competitions or games.* Journal of Sports Sciences, 2011. 29(8): p. 859 866.

98. Lastella, M., Lovell, G.P., & Sargent, C., *Athletes' precompetitive sleep behaviour and its relationship with subsequent precompetitive mood and performance.* European Journal of Sport Science 2014. 14(S1): p. 123-130.

99. Wyatt, F.B., Donaldson, A., & Brown, E., *The overtraining syndrome: A meta-analytic review.* Journal of Exercise Physiology, 2013. 16(2): p. 12-23.

100. Mourout, L., Bouhaddi, M., Tordi, N., Rouillon, J., & Regnard, J., *Short- and long-term effects of a single bout of exercise on heart rate variability: Comparison between constant and interval training exercises.* European Journal of Applied Physiology, 2004. 92(4-5): p. 508-517.

101. Kaikkonen, P., Hynynen, E., Mann, T., Rusko, H., & Nummela, A., *Heart rate variability related to training load variables in interval running exercises.* European Journal of Applied Physiology, 2012. 112(3): p. 829-838.

102. Buchheit, M., Racinais, S., Bilsborough, J.C., Bourdon, P.C., Voss, S.C., Hocking, J., Cordy,J., Mendez-Villanueva, A., & Coutts, A.J., *Monitoring fitness, fatigue, and running performance during a pre-season trainng camp in elite football players.* Journal of Science and Medicine in Sport, 2013. 16(6): p. 550-555.

103. Jastrzebski, Z., Radziminski, L., & Stepien, P., *Comparison of time-motion analysis and physiological responese during small-sided games in male and female soccer players.* Basic Journal of Health and Physical Activity, 2015. 7(4): p. 42-50.

104. Cormack, S.J., Newton, R.U., McGuigan, M.R., & Cormie, P., *Neuromuscular and endocrine responses of elite players during an australian rules football season.* International Journal of Sports Physiology and Performance, 2008. 3(4): p. 439-453.

105. Gleeson, M., *Immune function in sport and exercise*. Illustrated ed. 2006: Elsevier Health Sciences. 322.

106. Ramson, R., Jurimae, J., Jurimae, T., & Maestu, J., *Behavior of testosterone and cortisol during an intenseity-controlled high-volume trainng period measured by a training task-specific test in emn rowers.* Journal of Strength and Conditioning Research, 2009. 23(2): p. 645 651.

107. Aizawa, K., Nakahori, C., Akimoto, T., Kimura, F., Hayashi, K., Kono, I. & Mesaki, N., *Changes of pituitary, adrenal and gonadal hormones during competition among female soccer players.* Journal of Sport Medicine and Physical Fitness, 2006. 46(2): p. 322-327.

108. Bosco, C., Tihany, J., & Viru, A., *Relationship between field fitness test and basal serum testosterone and cotisol levels in soccer players.* Clinical Physiology, 1996. 16(3): p. 317 322.

109. Luger, A., Deuster, P.A., Kyle, S.B., Gallucci, W.T., Montgomery, L.C., Gold. P.W., Loriaux, D.L., & Chrousos, G.P., *Acute hypothalamic-pituitary-adrenal responses to the stress of treadmill exercise.* The New England Journal of Medicine 1987. 316: p. 1309-1315.

110. Rimmele, U., Zellweger, B.C., Marti, B., Seiler, R., Mohiyeddini, C., Ehlert, U., & Heinrichs, M., *Trained men show lower cortisol, heart rate and psychological responeses to psychosocial stress compared with untrained men.* Psychoneuroendocrinology, 2007. 32(6): p. 627-635.

111. Adlercreutz, H., Harkonen, M., Kuoppasalmi, K., Naveri, H., Huhtaniemi, I., Tikkanen, H., Remes, K., Dessypris, A., & Karvonen, J. , *Effect of training on plasma anabolic and catabolic steroid hormones and thier response during physical exercise.* International Journal of Sports Medicine, 1986. 7: p. 27-28.

112. Cormack, S.J., Newton, R.U., & McGuigan, M.R., *Neuromuscular and endocrine responses of elite players to an Australian rules football match.* International Journal of Sports Physiology and Performance, 2008. 3(3): p. 359-374.

113. McLean, B.D., Coutts, A.J., Kelly, V., McGuigan, M.R., & Cormack, S.J., *Neuromuscular, endocrine, and perceptual fatigue responses during different length between-match microcycles in professional rugby league players.* International Journal of Sports Physiology and Performance, 2010. 5(3): p. 367-383.

114. Hloogeveen, A.R., & Zonderland, M.L., *Relationships between testosterone, cortisol and performance in professional cyclists.* International Journal of Sports Medicine, 1996. 17(6): p. 423-428.

115. Filaire, E., Bernain, X., Sagnol, M., & Lac, G., *Preliminary results on mood state, salivary testosterone:cortisol ratio and team performance in a professional soccer team.* European Journal of Applied Physiology, 2001. 86(2): p. 179-184.

116. Cohen, S., Tyrrell, D.A., & Smith, A.P., *Psychological stress and susceptibility to the common cold.* New England Journal of Medicine 1991. 325(9): p. 606-612.

117. Avloniti, A.A., Douda, H.T., Tokmakidis, S.P., Kortsaris, A.H., Papadopoulou, E.G., & Spanoudakis, E.G., *Acute effects of soccer training on white blood cell count in elite female players.* International Journal of Sports Physiology and Performance, 2007. 2(3): p. 239-249.

118. Putlur, P., Foster, C., Miskowski, J.A., Kane, M.K., Burton, S.E., Scheett, T.P., & McGuigan, M.R., *Alteration of immune function in women collegiate soccer players and college students.* Jornal of Sports Science and Medicine, 2004. 3(4): p. 234-243.

119. Foster, C., *Monitoring training in athletes with reference to overtraining syndrome.* Medicine and Science in Sports & Exercise, 1998. 30(7): p. 1164-1168.

120. Scannapieco, F.A., Bergey, E.J., Reddy, M.S., & Levine, M.J., *Characterization of salivary alpha amylase binding to streptococcus sanguis.* Infection and immunity, 1989. 57(9): p. 2853 2863.

121. Takai, N., Yamaguchi, M., Aragaki, T., Eto, K., Uchihashi, K., & Nishikawa, Y., *Effect of psychological stress on the salivary cortisol and amylase levels in healthy young adults.* Archives of Oral Biology, 2004. 49(12): p. 963-968.

122. Bosch, J.A., Ring, C., de Geus, E.F., Veerman, E.C., & Amerongen, A.V., *Innate secretory immunity in response to laboratory stressors that evoke distinct patterns of cardiac autonomicactivity.* Psychosomatic Medicine, 2003. 65(2): p. 245-258.

123. Chatterton Jr., R.R., Vogelsong, K.M., Lu, Y., Ellman, A.B., & Hudgens, G.A., *Salivary α-amylase as a measure of endogenous adrenergic activity.* Clinical Physiology and Functional Imaging, 1996. 16: p. 433-448.

124. Nater, U.M., La Marca, R., Florin, L., Moses, A., Langhans, W., Koller, M.M., & Ehlert, U., *Stress induced changes in human salivary alpha-amylase activity-associations with adrenergic activity.* Psychoneuroendocrinology, 2006. 31: p. 49-58.

125. Nater, U.M., Rohleder, N., Scholtz, W., Ehlert, U., & Kirschbaum, C., *Determinants of the diurnal course of salivary alpha-amylase.* Psychoneuroendocrinology, 2007. 32(4): p. 392-401.

126. Rohleder, N., Nater, U.M., Wolf, J.M., Ehlert, U., & Kirschbaum, C., *Psychosocial sterss-induced activation of salivary alpha-amylase: an indicator of sympathetic activation.* Annals of the New York Academy of Sciences 2004. 1032: p. 258-263.

127. Chatterton, R.T., Vogelsong, K.M., Lu, Y.C., & Hudgens, G.A., *Hormonal responses to psycholgoical stress in men preparing for skydiving.* Journal of Clinical Endocrinology and Metabolism, 1997. 82: p. 2503-2509.

128. Walsh, N., & Gleeson, M., *The effects of high-intensity intermittent exercise on salivary IgA, total protein, and a-amylase.* Journal of Sports Sciences, 199. 17: p. 129-134.

129. Li., T.L., & Gleeson, M., *The effect of a single and repeated bouts of prolonged cycling and circadian variation on salivary flow rate, immunoglobulin A and alpha-amylase responses.* Journal of Sports Sciences, 2004. 22: p. 1015-1024.

130. Vineetha, R., Pai, K., Vengal, M., Gopalakrishna, K., & Narayanakurup, D., *Usefulness of salivary alpha amylase as a biomarker of chronic stress and stress related oral mucosal changes a pilot study.* Journal of Clinical and Experimental Dentistry, 2014. 6(2): p. e132-e137.

131. Wolf, J.M., Nicholls, E., & Chen, E., *Chronic stress, salivary cortisol, and a-amylase in children with asthma and healthy children.* Biological Psychology, 2008. 78: p. 20-28.

132. Takai, N., Yamaguchi, M., Aragaki, T., Eto, K., Uchihashi, K., & Nishikawa, Y., *Gender-specific differences in salivary biomarker responses to acute psychological stress.* Annals of the New York Academy of Sciences, 2007. 1098: p. 510-515.

133. Taylor, I.M., Turner, J.E., Gleeson, M., & Hough, J., *Negative psychological experiences and saliva secretory immunoglobulin A in field hockey players.* Journal of Applied Sport Psychology, 2015. 27: p. 67-78.

134. Gleeson, M., McDonald, W.A., Pyne, D.B., Cripps, A.W., Francis, J.L., & Fricker, P.A., Clancy, R.L., *Salivary IgA levles and infection risk in elite swimmers.* Medicine and Science in Sport and Exercise, 1999. 31(1): p. 67-73.

135. Gleeson, M., Pyne, D.B., Austin, J.P., Lynn Francis, J., Clancy, R.L., McDonald, W.A., & Fricker, P.A., *Epstein-Barr virus reactivation and upper-respiratory illness in elite swimmers.* Medicine and Science in Sport and Exercise, 2002. 34(3): p. 411-417.

136. Brandtzaeg, P., *Role of secretory antibodies in the defence against infections.* International Journal of Medical Microbiology, 2003. 293(1): p. 3-15.

137. Bishop, N., & Gleeson, M., *Acute and chronic effects of exercise on marker of mucosal immunity* Frontiers in Bioscience 2009. 14: p. 4444-4456.

138. Fahlamn, M.M., Engels, H.J., Morgan, A.L., & Kolokouri, I., *Mucosal IgA response to repeated wingate tests in females.* International Journal of Sports Medicine, 2001. 22(2): p. 127 131.

139. Neville, V., Gleeson, M., & Folland, J.P., *Salivary IgA as a risk factor for upper respiratory infections in elite professional athletes* Medicine and Science in Sport and Exercise, 2008. 40(7): p. 1228-1236.

140. Trochimiak, T., Hubner-Wozniak, E., & Tomaszewski, P., *The resting salivary antimicrobial proteins and cortisol concentration in wrestlers during 12-week training.* Biomedical Human Kinetics, 2015. 7: p. 1-8.

141. Willemsen, G., Carroll, D., Ring, C., & Drayson, M., *Cellular and mucosal immune reactions to mental and cold stress: Associations with gender and cardiovascular reactivity.* Psychophysiology 2002. 39: p. 222-228.

142. Morgado, J.P., Monteiro, C.P., Matias, C.M., Alves, F., Pessoa, P., Reis, J., Martins, F., Seixas, T., & Laires, M.J., *Sex-based effects on immune changes induced by a maximal incrementa exercsie test in well-trained swimmers.* Journal of Sports Science and Medicine 2014. 13(3): p. 708-714.

143. Jemmott, J.B. & K. Magloire, *Academic stress, social support, and secretory immunoglobulin A.* Journal of Personality and Social Psychology, 1988. 55(5): p. 803-810.

144. Bosch, J.A., Ring, C., de Geus, E.F., Veerman, E.C., & Amerongen, A.V., *Stress and secretory immunity.* International Review of Neurobiology 2002. 52: p. 213-253.

145. Carpenter, G.H., Proctor, G.B., Anderson, L.C., Zhang, X.S., & Garrett, J.R., *Immunoglobulin A secretion into saliva during dual sympathetic and parasympathetic nerve stimulation of rat submandibular glands.* Experimental Physiology, 2000. 85(3): p. 281-286.

146. Beauchemin, J., *College student-athlete wellness: and integrative outreach model.* College Student Journal, 2014. 48(2): p. 268-280.

147. Henschen, K., *Mental practice - skill oriented.* 2005.

148. Kellmann, M., *Enhancing recovery: Preventing underperformance in athletes*, Ed., Editor. 2000, Human Kinetics: Champaign, IL.

149. Fischer, S., Nater, U.M., & Laferton, J.A.C., *Negative Stress Beliefs Predict Somatic Symptoms in Students Under Academic Stress.* International Journal of Behavioural Medicine 2016. 23: p. 746-751.

150. Leme, L.O., R., de Paula Ramos, S., Nakumura, F., Milanez, V., & Leicht, A., *The influence of a weekend with passive rest on the psychological and autonomic recovery in professional male handball players.* Kinesiology, 2015. 47(1): p. 108-114.

151. Moreira, A., Arsati, F., Lima-Arsati, Y.B.O., Simones, A.C., & De Araujo, V.C., *Monitoring stress tolerance and occurrances of upper respiratory illness in basketball players by means of psychometric tools and salivary biomarkers* Stress and Health: Journal of the InternationalSociety for the Investigation of Stress, 2011. 27(3): p. e166-e172.

152. Milanez, V.F., Ramos, S.P., Okuno, N.M., Boullosa, D.A., & Nakamura, F.Y., *Evidence of a non linear dose-resonse relationship between training load and stress markers in elite female futsol players.* Journal of Sports Science and Medicine, 2014. 13(1): p. 22-29.

153. Garrosa, E., Moreno-Jimenez, B., Benadero, M.E.M., & Rodriquez-Carvajal, R., *Individual differences in energy-tension cycle and self-regulation of mood* Psicologia em Estudo, 2008. 13(1): p. 3-11.

154. Thayer, R.E., *Problem perception, optimism, and related states as a function of time of day (diurnal rhythm) and moderate exercise: Two arousal systems in interaction.* Motivation & Emotion, 1987. 11(1): p. 19-36.

155. Yoon, T., Keller, M.L., De-Lap, B.B.S., Harkins, A., Lepers, R., & Hunter, S.K., *Sex differences in response to cognitive stress during a fatiguing contraction.* Journal of Applied Physiology, 2009. 107(5): p. 1486-1496.

156. Caruso, C.M.G., D.L., Dzewaltowski, D.A., & McElroy, M.A., *Psychological and physiological changes in cometitive state anxiety during a noncompetition and competitive success and failure.* Journal of Sport and Exercise Physiology, 1990. 12: p. 6-20.

157. Rushall, B.R., *A tool for measuring stress tolerance in elite athletes.* Journal of Applied Sport Psychology, 1990. 2: p. 51-66.

158. Thayer, R.E., *Activation-deactivation adjective check list: current overview & structural analysis* Psychological Reports 1986. 58: p. 607-614.

159. Lautenback, F., Laborde, S., Klampfl, M., & Achtzehn, S., *A link between cortisol and performance; an exploritory case study of a tennis match.* International Journal of Psychology, 2015. 98(167-173).

160. Benham, G., *The shape of stress: the use of frequent sampling measure temporal variation in S IgA levles during acute stress.* Stress and Health, 2007. 26: p. 295-301.

161. Petrov, L.A., Bozhilov, G., Alexandrova, A.V., Mugandani, S.C., & Djarova, T.G., *Salivary alpha amylase, heart rate and heart-rate variability in response to an experimental model of competitive stress in vollyball players.* African Journal for Physical, Health Education, Recreation and Dance, 2014. 20(2.1): p. 308-322.

162. Petrie, T.A., Stoever, S., & Cogan, K.D., *Psychosocial antecedents for female student-athlete's academic performances* Journal of Sport and Exercise Psycology, 1995. 17(2): p. S85.

163. Antshel, K.M., VanderDrift, L.E., & Pauline, J.S., *The role of athletic identity in the relationship between difficulty thinking or concentrating and academic service use in NCAA student athletes.* Jornal of Clinical Sport Psychology, 2016. 10: p. 309-323.

164. Alexandre, D., Diniz da Silva, C., Hill-Haas, S., Wong, D.P., Natali, A.J., De Lima, J.R., Bara, F.M., Marins, J., Silami, G.E., & Karim, C., *Heart rate monitoring in soccer: Interest and limits during competitive match play and training, practical applicaiton.* Journal of Strength and Conditioning Research, 2012. 26(10): p. 2890-2906.

165. Barbosa, C.D., Gomes, C.L., Fleury, M., L.A., Ribeiro, H.A.S., Bouzas, M.J.C., Dias Soares, D., & Silamni, G.E. , *Energy demand and heart rate evaluation at different phases during a match along an official soccer competition.* Brazilian Journal of Kineanthropometry & Human Performance, 2012. 14(4): p. 419-427.

166. Jones, J.G., Swain, A., & Cale, A., *Antecedents of multidimensional competitive state anxiety and self-confidence in elite intercollegiate middle-distance runers.* The Sport Psychologist, 1990. 4: p. 107-118.

167. Allen, M.S., Jones, M., McCarthy, P.J., Sheehan-Mansfield, S., & Sheffield, D., *Emotions correlate with perceived mental effort and concentration disruption in adult sport performers.* European Journal of Sport Science, 2013. 13(6): p. 697-706.

168. Eysenck, M.W., & Calvo, M.G., *Anxiety and performance: the processing efficiency theory.* Cognition and Emotion, 1991. 6(6): p. 409-434.

169. Wyatt, J.K., Cecco, A.R., Czeisler, C.A., & Dijk, D., *Circadian temperature and melatonin rhythms, sleep, and neurobehavioral function in humans living on a 20-h day.* American Journal of Physiology 1999. 277(4): p. R1152-R1163.

170. Reilly, T., Atkinson, G., Edwards, B., Waterhouse, J., Farrelly, K., & Fairhurst, E., *Diurnal variation in temperature, mental and physical performance, and tasks specifically related to footbal (soccer).* Chronobiology International, 2007. 24(3): p. 507-519.

171. Novas, A., Rowbottom, D., & Jenkins, D., *Total daily energy expenditure and incidence of upper respiratory tract infection in symptoms in young females.* International Journal of Sports Medicine, 2002. 23(7): p. 465-470.

172. Malm, C., *Susceptibility to infections in elite athletes: the S-curve.* Scandinavian Journal of Medicine, Science, and Sports, 2006. 16: p. 4-6.

173. Ademovic, A., *Differences in the quality and intensity of playing in elite soccer palyers of different position in the game.* Homo Sporticus, 2016. 18(1): p. 26-31.

174. Andersson, H.A., Randers, M.B., Heinter-Moller, A., Krustrup, P., & Mohr, M., *Elite female soccer players perform more high-intensity running when playing in international games compared with domestic league games.* Journal of Strength and Conditioning Research, 2010. 24(4): p. 912-919.

175. LaManca, F.J., Sisto, S., DeLuca, J., Johnson, S., Lang, G., Pareja, J., Cook, S., & Natelson, B., *Influence of exhaustive treadmill exercise on cognitive functioning in chronic fatigue syndrome.*The American Journal of Medicine, 1998. 105(3): p. 59S-65S.

176. Marcora, S.M., Staiano, W., & Manning, V., *Mental fatigue impairs phyisical performance in humans.* Journal of Applied Physiology, 1985. 106(3): p. 857-864.

177. McMorris, T., & Graydon, J., *The effect of exercise on cognitive performance in soccer-specific tests.* Journal of Sports Sciences, 1997. 15(5): p. 459-468.

178. Bishop, D., *The effects of travel on team performance in the Australian national netball competition* Journal of Science and Medicine in Sport, 2004. 7(1): p. 118-122.

APPENDIX A.
INSTITUTIONAL REVIEW BOARD APPROVAL FORM

ACTION ON PROTOCOL APPROVAL REQUEST

Institutional Review Board
Dr. Dennis Landin, Chair
130 David Boyd Hall
Baton Rouge, LA 70803
P: 225.578.8692
F: 225.578.5983
irb@lsu.edu | lsu.edu/irb

TO: Neil Johannsen
Kinesiology

FROM: Dennis Landin
Chair, Institutional Review Board

DATE: February 9, 2017

RE: IRB# 3764

TITLE: Physiological and psychological well-being responses during the spring season in female soccer players

New Protocol/Modification/Continuation: New Protocol

Review type: Full ____ Expedited _X_ **Review date:** 12/2/2016

Risk Factor: Minimal ___X___ Uncertain ______ Greater Than Minimal_______

Approved_____X_____ **Disapproved**__________

Approval Date: 2/9/2017 **Approval Expiration Date:** 2/8/2018

Re-review frequency: (annual unless otherwise stated)

Number of subjects approved: 15

LSU Proposal Number (if applicable):

Protocol Matches Scope of Work in Grant proposal: (if applicable)

By: Dennis Landin, Chairman DLandin

PRINCIPAL INVESTIGATOR: PLEASE READ THE FOLLOWING –
Continuing approval is CONDITIONAL on:

1. Adherence to the approved protocol, familiarity with, and adherence to the ethical standards of the Belmont Report, and LSU's Assurance of Compliance with DHHS regulations for the protection of human subjects*
2. Prior approval of a change in protocol, including revision of the consent documents or an increase in the number of subjects over that approved.
3. Obtaining renewed approval (or submittal of a termination report), prior to the approval expiration date, upon request by the IRB office (irrespective of when the project actually begins); notification of project termination.
4. Retention of documentation of informed consent and study records for at least 3 years after the study ends.
5. Continuing attention to the physical and psychological well-being and informed consent of the individual participants, including notification of new information that might affect consent.
6. A prompt report to the IRB of any adverse event affecting a participant potentially arising from the study.
7. Notification of the IRB of a serious compliance failure.
8. **SPECIAL NOTE: When emailing more than one recipient, make sure you use bcc.**

**All investigators and support staff have access to copies of the Belmont Report, LSU's Assurance with DHHS, DHHS (45 CFR 46) and FDA regulations governing use of human subjects, and other relevant documents in print in this office or on our World Wide Web site at http://www.lsu.edu/irb*

ACTION ON PROTOCOL APPROVAL REQUEST

Dr. Dennis Landin, Chair
130 David Boyd Hall
Baton Rouge, LA 70803
P: 225.578.8692
F: 225.578.5983
irb@lsu.edu
lsu.edu/research

TO: Neil Johannsen
Kinesiology

FROM: Dennis Landin
Chair, Institutional Review Board

DATE: March 2, 2017

RE: IRB# 3764

TITLE: Physiological and psychological well-being responses during the spring season in female soccer players

New Protocol/Modification/Continuation: Modification

Brief Modification Description: Timing of the salivary samples and data collection sheet players will complete.

Review type: Full ____ Expedited X **Review date:** 3/2/2017

Risk Factor: Minimal X Uncertain ______ Greater Than Minimal ______

Approved X **Disapproved** ______

Approval Date: 3/2/2017 **Approval Expiration Date:** 2/8/2018

Re-review frequency: (annual unless otherwise stated)

Number of subjects approved: 15

LSU Proposal Number (if applicable):

Protocol Matches Scope of Work in Grant proposal: (if applicable)

By: Dennis Landin, Chairman D Landin

PRINCIPAL INVESTIGATOR: PLEASE READ THE FOLLOWING –
Continuing approval is CONDITIONAL on:

1. Adherence to the approved protocol, familiarity with, and adherence to the ethical standards of the Belmont Report, and LSU's Assurance of Compliance with DHHS regulations for the protection of human subjects*
2. Prior approval of a change in protocol, including revision of the consent documents or an increase in the number of subjects over that approved.
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APPENDIX B.
ACTIVATION-DEACTIVATION ADJECTIVE CHECKLIST

AD-ACL, 1989

Self-Assessment Inventory

INSTRUCTIONS: Following are some adjectives that describe people■s feelings. Please, read each of the adjectives and then indicate how you are feeling *at this particular moment*, by circling the appropriate response. There are no right or wrong answers, so do not spend too much time on any one item. Check to make sure you have responded to all the items.

	Definitely feel	Feel slightly	Cannot decide	Definitely do not feel
1. Active	++	+	?	no
2. Placid	++	+	?	no
3. Sleepy	++	+	?	no
4. Jittery	++	+	?	no
5. Energetic	++	+	?	no
6. Intense	++	+	?	no
7. Calm	++	+	?	no
8. Tired	++	+	?	no
9. Vigorous	++	+	?	no
10. At rest	++	+	?	no
11. Drowsy	++	+	?	no
12. Fearful	++	+	?	no
13. Lively	++	+	?	no
14. Still	++	+	?	no
15. Wide-awake	++	+	?	no
16. Clutched-up	++	+	?	no
17. Quiet	++	+	?	no
18. Full-of-pep	++	+	?	no
19. Tense	++	+	?	no
20. Wakeful	++	+	?	no

Thayer (1989)

APPENDIX C.
DAILY ANALYSIS OF LIFE DEMANDS IN ATHLETES QUESTIONNAIRE

Centers for Orthopaedics
Experience in Motion

UNE
UNIVERSITY OF NEW ENGLAND

OA/UNE Human Performance Lab

DALDA Questionnaire
Monitors state of well being and mood state

(a = worse than normal, b = normal, c = better than normal)

Part A

1.	a	b	c	Diet
2.	a	b	c	Home Life
3.	a	b	c	School/college/work
4.	a	b	c	Friends
5.	a	b	c	Sports Training
6.	a	b	c	Climate
7.	a	b	c	Sleep
8.	a	b	c	Recreation
9.	a	b	c	Health

Part B

1.	a	b	c	Muscle Pains
2.	a	b	c	Techniques
3.	a	b	c	Tiredness
4.	a	b	c	Need for rest
5.	a	b	c	Supplementary Work
6.	a	b	c	Boredom
7.	a	b	c	Recovery Time
8.	a	b	c	Irritability
9.	a	b	c	Weight
10.	a	b	c	Throat
11.	a	b	c	Internal
12.	a	b	c	Unexplained aches
13.	a	b	c	Technique Strength
14.	a	b	c	Enough Sleep
15.	a	b	c	Between Session Recovery
16.	a	b	c	General Weakness
17.	a	b	c	Interest
18.	a	b	c	Arguments
19.	a	b	c	Skin Rashes
20.	a	b	c	Congestion
21.	a	b	c	Training Effort
22.	a	b	c	Temper
23.	a	b	c	Swelling
24.	a	b	c	Likability
25.	a	b	c	Runny Nose

Number of "a" Scores: _______

Increase in "a" scores suggests
overreaching or overtraining.

OA/UNE Human Performance Lab
15 Lund Road, Saco, Maine 04072 • 207-710-5509 • Fax: 207-282-8185

APPENDIX D.
WISCONSIN UPPER RESPIRATORY SURVEY-21

Wisconsin Upper Respiratory Symptom Survey – 21 --- *Daily Symptom Report*

Day:	*Date:*	*Time:*	*ID:*

Please fill in one circle for each of the following items:

	Not sick	Very mildly		Mildly		Moderately		Severely
	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**
How sick do you feel today?	O	O	O	O	O	O	O	O

Please rate the **average severity** of your cold symptoms **over the last 24 hours** for each symptom:

	Do not have this symptom	Very mild		Mild		Moderate		Severe
	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Runny nose	O	O	O	O	O	O	O	O
Plugged nose	O	O	O	O	O	O	O	O
Sneezing	O	O	O	O	O	O	O	O
Sore throat	O	O	O	O	O	O	O	O
Scratchy throat	O	O	O	O	O	O	O	O
Cough	O	O	O	O	O	O	O	O
Hoarseness	O	O	O	O	O	O	O	O
Head congestion	O	O	O	O	O	O	O	O
Chest congestion	O	O	O	O	O	O	O	O
Feeling tired	O	O	O	O	O	O	O	O

Over the last 24 hours, how much has your cold interfered with your ability to:

	Not at all	Very mildly		Mildly		Moderately		Severely
	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Think clearly	O	O	O	O	O	O	O	O
Sleep well	O	O	O	O	O	O	O	O
Breathe easily	O	O	O	O	O	O	O	O
Walk, climb stairs, exercise	O	O	O	O	O	O	O	O
Accomplish daily activities	O	O	O	O	O	O	O	O
Work outside the home	O	O	O	O	O	O	O	O
Work inside the home	O	O	O	O	O	O	O	O
Interact with others	O	O	O	O	O	O	O	O
Live your personal life	O	O	O	O	O	O	O	O

Compared to yesterday, I feel that my cold is…

Very much better	Somewhat better	A little better	The same	A little worse	Somewhat worse	Very much worse
O	O	O	O	O	O	O

APPENDIX E.
PITTSBURGH SLEEP QUALITY INDEX

Name________________________________ Date__________

Sleep Quality Assessment (PSQI)

What is PSQI, and what is it measuring?

The Pittsburgh Sleep Quality Index (PSQI) is an effective instrument used to measure the quality and patterns of sleep in adults. It differentiates "poor" from "good" sleep quality by measuring seven areas (components): subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleeping medications, and daytime dysfunction over the last month.

INSTRUCTIONS:

The following questions relate to your usual sleep habits during the past month only. Your answers should indicate the most accurate reply for the majority of days and nights in the past month. Please answer all questions.

During the past month,

1. When have you usually gone to bed? __________
2. How long (in minutes) has it taken you to fall asleep each night? __________
3. What time have you usually gotten up in the morning? __________
4. A. How many hours of actual sleep did you get at night? __________
   B. How many hours were you in bed? __________

5. During the past month, how often have you had trouble sleeping because you	Not during the past month (0)	Less than once a week (1)	Once or twice a week (2)	Three or more times a week (3)
A. Cannot get to sleep within 30 minutes				
B. Wake up in the middle of the night or early morning				
C. Have to get up to use the bathroom				
D. Cannot breathe comfortably				
E. Cough or snore loudly				
F. Feel too cold				
G. Feel too hot				
H. Have bad dreams				
I. Have pain				
J. Other reason (s), please describe, including how often you have had trouble sleeping because of this reason (s):				
6. During the past month, how often have you taken medicine (prescribed or "over the counter") to help you sleep?				
7. During the past month, how often have you had trouble staying awake while driving, eating meals, or engaging in social activity?				
8. During the past month, how much of a problem has it been for you to keep up enthusiasm to get things done?				
9. During the past month, how would you rate your sleep quality overall?	Very good (0)	Fairly good (1)	Fairly bad (2)	Very bad (3)

Scoring

Component 1	#9 Score	C1 ______
Component 2	#2 Score (<15min (0), 16-30min (1), 31-60 min (2), >60min (3)) + #5a Score (if sum is equal 0=0; 1-2=1; 3-4=2; 5-6=3)	C2 ______
Component 3	#4 Score (>7(0), 6-7 (1), 5-6 (2), <5 (3)	C3 ______
Component 4	(total # of hours asleep) / (total # of hours in bed) x 100 >85%=0, 75%-84%=!, 65%-74%=2, <65%=3	C4 ______
Component 5	# sum of scores 5b to 5j (0=0; 1-9=1; 10-18=2; 19-27=3)	C5 ______
Component 6	#6 Score	C6 ______
Component 7	#7 Score + #8 score (0=0; 1-2=1; 3-4=2; 5-6=3)	C7 ______

Add the seven component scores together __________ *Global PSQI* __________

A total score of "5" or greater is indicative of poor sleep quality.
If you scored "5" or more it is suggested that you discuss your sleep habits with a healthcare provider

VITA

Adam Lowe began his education in his home state of New York. He completed his bachelor's in exercise science at the State University of New York College at Cortland in Cortland, New York and continued his education at Louisiana State University where he studied athletic performance. His work will continue in the future, pursuing a career in optimizing sport performance.