THE EFFECT OF TRAINING AND MATURATION ON sRPE IN NCAA DI WOMEN SOCCER PLAYERS: A MULTI-SEASON EXPLORATION

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THE EFFECT OF TRAINING AND MATURATION ON sRPE IN NCAA DI WOMEN SOCCER PLAYERS: A MULTI-SEASON EXPLORATION

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Chapter 1

Introduction

The average NCAA DI women's soccer team carries 30 players. The composition of each team can vary largely from year to year. Recruitment phases, injuries, graduating seniors, and coaching staff changes all contribute to the overall age of the team. Teams can be considered young or inexperienced if they are composed mostly of freshmen or sophomores, whereas a team comprised of mainly juniors and seniors is considered mature and potentially "more elite". Age and maturation can play an important role in team performance and success. Veteran players may be more "experienced" or athletically developed, but younger players may possess more vigor due to less wear-and-tear or lack of exposure to training at this level. Trying to accommodate a team with varying levels of age, experience, and fitness may prove to be a difficult task for the coaching staff when it comes to training design. Because of physical inter-athlete differences and variation in training, players will respond to the training bouts differently (Bourdon et al., 2017; Impellizzeri, Rampinini, & Marcora, 2005). It is vital to monitor the amount of stress athletes experience and adjust the training load to ensure that each individual athlete is making physical improvements but is not on the cusp of injury (Bourdon et al., 2017; Drew & Finch, 2016; Impellizzeri, Marcora, & Coutts, 2019).

Training load is constructed of an internal and external component (Impellizzeri, Rampinini, Coutts, Sassi, & Marcora, 2004). Internal load is defined as the relative physiological and psychological stress experienced by the athlete during a training session, whereas external load is the physical work performed by the athlete during a given session and is influenced by the organization, intensity, and quantity of exercise (Impellizzeri et al., 2019; Impellizzeri et al., 2005; Viru & Viru, 2000). Therefore, it is the prescribed training plan, or external load, that determines the athlete’s internal response, but it is the internal load that leads to physiological adaptations over time (Impellizzeri et al., 2005). Training adaptations are vital to improving physiological mechanisms such as strength, speed, agility, endurance, and ultimately performance. However, when designing a training plan, it must be specific and applicable to the physiological goal. Training specificity is fundamental and widely accepted in training design. It states that training adaptations are highly associated to the type, intensity, frequency, and duration of exercise performed (Hawley, 2002; Viru & Viru, 2000). The training stimulus must be specific and large enough to induce physiological adaptation without leading to overtraining or injury. Moreover, prescribing the same type of exercise for the same duration at the same intensity has shown to either maintain or degrade the current fitness level (Hoff, Wisløff, Engen, Kemi, & Helgerud, 2002; Mujika & Padilla, 2000). Finding the “sweet spot” of training is critical to performance enhancement and injury avoidance (Bourdon et al., 2017). Coaches should strive to challenge this physiological “ceiling” within each athlete when creating a training program that offers improvement opportunities.

One way to do this is through individual training adaptations. They occur after chronic exposure to training or exercise and are affected by the athlete’s preexisting individual fitness level and the characteristics of the training (i.e. duration, intensity, or type) (Impellizzeri et al., 2005). This aspect of training makes the quantification of the individual internal load responses to a given external training load vital to enhancing physical fitness and performance. However, difficulty of monitoring and prescribing training load arises in team sports like soccer. The frequent use of group exercise and drills leads to a large variation in inter-player load making the prescription of training difficult in this setting (Halson, 2014; Impellizzeri et al., 2005; Los Arcos, Martínez-Santos, Yanci, Mendiguchia, & Méndez-Villanueva, 2015). Physiological differences in athletes as well as positional differences (i.e. forward vs. goalkeeper) make it difficult for group style training to accommodate all athletes appropriately. Due to the intricacies of training load and design, it is vital to monitor and quantify both internal and external training load during all training sessions. By doing so, strength and conditioning coaches and head coaches should be able to tailor training sessions to match the team's needs or even individual athlete needs. Training load can be used to create carefully crafted and scheduled training sessions so athletes do not experience overtraining or undertraining and the negative symptoms associated with them. Overtraining may lead to reduction in performance capacity, mood state disturbances, muscle soreness, illness, and injury; whereas, undertraining may lead to athlete plateau or loss of fitness (Foster, 1998; Lehmann, Foster, & Keul, 1993; Mujika & Padilla, 2000). Mitigating these adverse training side effects is pivotal to individual athlete improvement and overall team performance.

Many researchers and sport scientists have recognized the importance and value of load monitoring, leading to a substantial number of published studies on the topic within the past twenty years (Bourdon et al., 2017; Impellizzeri et al., 2019; Jones, Griffiths, & Mellalieu, 2017). A recent literature review revealed that 68 studies have been completed investigating the relationship between training load, injury, illness, and fatigue (Jones et al., 2017). The same review also showed that a variety of sports such as Australian football, rugby, soccer, and cricket have employed multiple methods for identifying and monitoring both types of training loads (Jones et al., 2017). The use and validity of internal and external load monitoring methods have been explored in several team sport settings (Alexiou & Coutts, 2008; Casamichana, Castellano, Calleja-Gonzalez, San Román, & Castagna, 2013; Scott, Lockie, Knight, Clark, & Janse de Jonge, 2013; Scott, Scott, & Kelly, 2016). Thus far, researchers have measured internal load in athletes using wellness surveys, heart rate derived metrics, blood lactate, biochemical and hormonal markers, and session rating of perceived exertion (sRPE) (Halson, 2014; Jones et al., 2017). However, because of accessibility and practical use, heart rate and sRPE based methods for calculating load are two of the most popular internal load monitoring techniques in team sports (Impellizzeri et al., 2005). External load monitoring techniques have also evolved and have become more commonplace among various sports. Due to the rapid advancement in technology and increase in availability, external load has most commonly been quantified using global positioning systems (GPS), gyroscopes, and accelerometers in team sports such as soccer, Australian football, rugby, and basketball (Bourdon et al., 2017; Halson, 2014; M. T. Scott et al., 2016). This microtechnology is used to gather external load metrics such as total distance covered, speed, power, accelerations, decelerations, and many other variables (Cardinale & Varley, 2017; Impellizzeri et al., 2019).

Even with multiple validated methods available for tracking training load, a common theme throughout the literature is the importance of gathering both internal and external load metrics (Gaudino et al., 2015; Halson, 2014; Impellizzeri et al., 2019; Impellizzeri et al., 2005; McLaren et al., 2018; Scott et al., 2013). Gathering both the “cause and effect” of training makes it possible to alter and improve training plans, curtail fatigue and injury, and get a better idea of how each athlete is adapting to the stress. With the copious amounts of training load data researchers are now able to collect and quantify, understanding how to interpret the data and make recommendations is becoming increasingly more important.

Although there is a basic understanding of training, gender differences need to be considered for individual performance success as well. Because of physical stature and genetic differences, males and females experience varying demands which require different training design and training loads. Much of the literature shows that female and male athletes perform differently based on physiological differences (Bradley, Dellal, Mohr, Castellano, & Wilkie, 2014). When comparing male and female soccer players across various aerobic and anaerobic fitness measures, most females perform at lower levels than males (Bradley et al., 2011; Bradley et al., 2014; Mujika, Santisteban, Impellizzeri, & Castagna, 2009; Rhodes & Mosher, 1992). This lower physical capacity then translates to performance differences in training and matches (Bradley et al., 2014; Krustrup, Mohr, Ellingsgaard, & Bangsbo, 2005). More specifically, Bradley and colleagues (2014) found at the highest competitive standard of European soccer, males cover more distance at higher speeds than females. Due to genetics and performance outcome differences, males and females cannot be trained at the same level or intensity. Male training load data and analysis cannot be directly applied to females because of these differences. Although, a plethora of literature exists exploring training and load monitoring in male soccer players (Campos-Vazquez, Toscano-Bendala, Mora-Ferrera, & Suarez-Arrones, 2017; Casamichana et al., 2013), additional foundational research in collegiate female players is needed before precise and specific training recommendations can be made (Anderson et al., 2016; Slater et al., 2018).

With widespread male training load data now available, studying training loads in collegiate female athletes over time in various divisions may be even more valuable. In a recent consensus statement (Bourdon et al., 2017), it was noted when implemented longitudinally, a combination of internal and external monitoring can provide insights on training-load adaptation for individual athletes and teams as a whole. The various metrics gathered, whether internal or external, allow training to be quantified and allow individual and team norms to be established. These numbers can then be used to compare current training to previous averages to ensure training is not overbearing, but still significant enough to lead to adaptations (Bourdon et al., 2017). Being able to track training adaptations over an athlete's entire playing career could potentially assist coaches with improving athlete and team performance, avoiding injury, and avoiding athlete plateau. Longitudinal data could allow coaches to get even more specific in their training design further evading mal-adaptations and amplifying the positive benefits of training. The more specific and tailored coaches can be with training prescription, the better each individual athlete will adapt to training. An optimal individualized training plan may lead to longer injury free athletic careers and maximal performance potential.

Purpose Statement

The sport performance research field is growing rapidly and is becoming fiercely competitive. Any advantage coaches can gain over other teams will be utilized. It is critical to continue to explore and monitor training load in various settings and populations; especially populations who are underrepresented in research such as female soccer athletes. Gaining a better understanding of the relationship between the training-load data and athlete adaptations is critical to assisting coaches and athletic personnel with the task of athlete improvement and injury avoidance. The purpose of this study is to investigate the effects prescribed training and maturational differences have on sRPE in NCAA Division I (DI) female soccer athletes. The goal of this study is to further explore how individual female soccer athletes respond differently to training over multiple seasons.

Chapter 2

Review of Literature

The importance of training load monitoring in sport has become increasingly more apparent as technology and knowledge of sport continue to evolve. Previous research (Bourdon et al., 2017; Impellizzeri et al., 2019) has investigated acute and season-long training load data, but longitudinal multi-season data has yet to be explored. Longitudinal training load monitoring in the population of NCAA DI women's soccer could become a standard in the next 5-10 years as the sport continues to grow in popularity. It is vital that coaches and sport scientists analyze and understand the meaning behind this rich data set. Further exploration is needed to accurately interpret and apply training load data. Monitoring load gives coaches the opportunity to safely improve athlete potential and performance while promoting longevity. It is important to examine this data from a more longitudinal approach to close the literature gap and educate coaches on effective training programs. Tracking how athletes respond to training over time is critical to assessing physiological changes. Rather than using traditional pre vs. post fitness tests (VO2 max, lactate threshold, etc.), tracking training adaptations from this approach is more time efficient and soccer specific making it optimal for comprehensive use. It is also vital to further understand how age, maturation, and experience level effects these monitoring values for load prescription.

Training Load Monitoring Methods and Validity

External: Global positioning systems (GPS) have become one of the most common methods for measuring and tracking external load variables in field and court sports. As previously discussed, GPS equipped with gyroscopes and accelerometers can measure several valuable sport specific variables such as: total distance, accelerations and decelerations, high speed running distance, running velocity, and many others. Because of the value and increase in use, multiple studies have assessed the reliability and validity of GPS in various settings. Rampinini and colleagues (2015) investigated the accuracy of two portable GPS devices (SPI-Pro GPSports System, GPS-5 Hz and MinimaxX v4.0 Catapult Innovations, GPS-10 Hz) while eight sub-elite young male soccer players performed intermittent shuttle runs with the goal to mimic phases of an actual soccer match. Both devices were compared to a radar system (Stalker ATS, Radar Sales) sampling at 32 Hz, which was the criterion because of previously tested accuracy for running speed and metabolic power. The researchers found that when quantifying distance covered, distance covered at high speeds (HSR > $4.17\ m\cdot s^{-1}$), and metabolic power (calculated using energy cost and velocity) only the GPS sampling at the 10Hz frequency demonstrated satisfactory accuracy (Rampinini et al., 2015). Overall, it was concluded that the higher the sampling frequency of the GPS, the more accurate the system. Similarly, Varely et al. found that during straight-line running the same model and version 10Hz GPS device (MinimaxX v4.0 Catapult Innovations) was considered accurate when collecting acceleration, deceleration, and constant velocity when compared to a Laveg laser sampling at 50 Hz (2012). It is also important to note that GPS accuracy is negatively affected by a high rate of change in velocity making it difficult to quantify the magnitude and duration of accelerations (Varley et al., 2012). Researchers recommend interpreting this particular data with caution and explain that reporting the number (rather than magnitude) of accelerations/decelerations may be more appropriate (Bourdon et al., 2017; Varley et al., 2012). The use of GPS technology to quantify physical demands is becoming more commonplace in many different sports. Research shows that when sampling at 10Hz, the data collected should be considered reliable and valid. Having trustworthy external training load data points to analyze is critical in assessing the relationship between internal and external data load.

Internal: Internal training load has been measured through a myriad of methods. Heart rate, blood lactate, oxygen consumption, and session rating of perceived exertion (sRPE) are commonly used methods to measure internal load. However, in the team sport setting where time efficiency and practical use are crucial, heart rate and sRPE have become two of the most popular methods to measure internal load. The linear relationship between heart rate and the rate of oxygen consumption during steady-state exercise is what allows heart rate to represent internal load during exercise (Hopkins, 1991). With heart rate and oxygen consumption as the gold standard of internal load measurement, the validity of sRPE has been compared to these measures frequently in past research. For example, Herman et al. (2006) compared sRPE to oxygen consumption (VO_2) and heart rate during six randomly ordered 30-minute constant-load exercise bouts on a cycle ergometer or treadmill at three different intensities. The three intensities were designed to correspond to easy effort (~40 - 50% VO_2peak), moderate effort (~60 - 70% VO_2peak), and hard effort (~80 - 90% VO_2peak). Each subject completed each intensity session twice and sessions were separated by a minimum of two days rest. Results revealed significant non-linear relationships between sRPE and %VO_2peak ($R^2 = 0.76$), %HR_{peak} (R2 = 0.74) and %$HR_{reserve}$ (R2 = 0.71). Foster and colleagues (1998) concluded that the sRPE method for monitoring exercise training intensity is valid and reliable. This conclusion corresponds with previous literature and its finding.

In order to quantify training load with the validated sRPE method, the next step is monitoring it in an applied athletic setting. The use of sRPE derived training load in team sport settings has been investigated many times since Foster and colleagues (1995) developed and adapted the original method from the Borg scale (1987). Impellizzeri and colleagues (2004) investigated validity of the sRPE method for quantifying training intensity and load in a team of young male soccer players. The aim of the study was to employ the sRPE method to quantify internal training load during soccer specific training and compare it to three different HR-based methods. The first comparison method was Edward's training load (Edwards, 1993),calculated by measuring the product of the accumulated training duration (minutes) of five HR zones by a coefficient relative to each zone and summing the results. The second HR method used for validation was training impulse (TRIMP) (Banister et al., (1991), and it is calculated using the following equation: $TD \cdot HR_R \cdot 0.64e^{1.92xHR}{}_R$. Lastly, Lucia and colleagues (2003) proposed a method similar to Edward's method, where they collected and calculated data to assess the accuracy of the sRPE in soccer training. Impellizzeri and colleagues (2004) found that all individual correlations between the three HR-based training load methods and sRPE were statistically significant ($r = 0.50$ to $r = 0.85$, $p < 0.01$).

Alexiou and Coutts (2008) found similar results in a population of elite female soccer athletes. Again, HR based methods for quantifying internal load such as Banister's TRIMP and Edward's training load were used to compare sRPE during various soccer-based training bouts. However, Alexiou and Couts (2008) also chose to investigate another HR derived internal load, but this method corresponds to individualized lactate thresholds (another measure of exercise intensity specific to lactate being present in the blood). They further investigated the relationship between the four internal training load methods during specific training session types: conditioning, matches, speed, technical work, and resistance training. Statistical analyses revealed that sRPE was significantly correlated with Banister's TRIMP, lactate threshold-heartrate zone, and Edward's training load ($r = 0.84$, 0.83, & 0.85, all $p < .01$, respectively) during all soccer specific training types. Results also revealed that higher correlations were found during less intermittent and more aerobic-based training sessions. This may have implications for the accuracy of sRPE during resistance training and match play. It is important to note that sRPE may have a stronger relationship with external load during training rather than match play. Separate analysis may be required to account for this.

Relationship Between Internal and External Metrics

After exploring the validity of both internal and external load metrics, it is important to understand the relationship between the two types of load in an applied sport setting like soccer. Thus far, significant correlations have been found between specific internal and external load metrics in several sports including soccer (Casamichana et al., 2013; Scott et al., 2013). These relationships can give coaches and sport scientists a more comprehensive view of training load and the athletes' response to a given load. It is important to assess whether the athlete is responding optimally to the prescribed stress or not. To assess this relationship between internal and external load measures, Scott and colleagues (2013) gathered training load data using various methods in a population of fifteen professional male soccer players during in-season training sessions. Global positioning systems (GPS) were used to collect external load measures such as: average speed (m/min), total distance (m), low-speed activity distance (<14.4 km/h), high-speed running distance (>14.4 km/h), and very-high-speed running distance (>19.8 km/h). For this study, internal load was calculated using either HR derived methods (Banister's TRIMP and Edward's training load) or via Foster's sRPE method. Both internal and external load were gathered and/or calculated during 97 standard training sessions. The researchers found that external load measures of total distance, low-speed activity volume, and player load were all largely and significantly correlated (r= .71-.84; $p < .01$) with the HR-based and sRPE-based internal load methods (Scott et al., 2013). High-speed running distance (>14.4 km/h) and very high-speed running distance (>19.8 km/h) also saw significant (*p*< .01) correlations with internal load measures, but not as large as total distance, low-speed activity volume, and player load. Casamichana and colleagues (2013) found similar results to the other studies with analogous experimental methods but in a population of 28 semi-professional male soccer players. Moderate correlations were found between total distance and Edward's HR based internal load values (r=0.72, p < 0.01). Additionally, sRPE and total distance covered were also moderately correlated (r=0.74, p<0.01) (Casamichana et al., 2013).

In an additional training load study, Gaudino and colleagues (2015) closely examined other external load metrics collected via GPS and their impact on internal load measures. This study particularly sought to assess the influence that high speed running (>14.4 km/h), accelerations, and impacts (identified as maximum accelerometer values above 2 g in a 0.1-second period) have on internal load metrics of elite male soccer players. External training load was gathered with 10-Hz GPS integrated with an accelerometer and internal load was calculated via sRPE 20 minutes after every training session. Gaudino and colleagues (2015) found moderate correlations between RPE calculated training load (sRPE) and high-speed running distance, impacts, and accelerations (r = .11, r = .45, and r = .37, respectively). The findings from this study again point to the existing relationship between internal and external load values and the ability of external variables to impact internal responses measure using sRPE or heart rate.

Longitudinal/ Multi-Season Research

Presently, no multi-season training load analysis in DI women's soccer athletes has been completed. Female college soccer literature that does exist investigates match only play over multiple seasons (Sausaman, Sams, Mizuguchi, DeWeese, & Stone, 2019) or examines a lesser division of athletes (Gentles, Coniglio, Besemer, Morgan, & Mahnken, 2018). A longitudinal design in this population is unique and under researched. Understanding the reasons behind the number can assist in interpretation and application in actual team settings. Longitudinal data training would allow coaches and sport scientists to track changes in data and changes in external and internal load over time which may be indicative of training adaptations or mal-adaptations (Bourdon et al., 2017). Additionally, researchers have stated at least two or three years of training load data are needed before team norms can be established and science-based training recommendations can be made (Bourdon et al., 2017). It is vital to collect training load data for multiple reasons, but ultimately the purpose is to protect/ benefit the athletes by ensuring they are adequately adapting to training.

To date, entire-season training load studies have been used to investigate and delineate match demands among specific populations, positions, or starting-status (Anderson et al., 2016; Slater et al., 2018). These studies are beneficial for identifying training load differences among athletes on the same team and for establishing normal values which is also important for training design. For example, Slater et al. (2018) collected external load metrics vis GPS in a season-long study of 22 NCAA DI male college soccer players. Statistical analysis of match and positional demands showed the team ran significantly more during the first half (26.16 ± 3.58%) compared to the second half (24.83 ± 3.95%). No significant differences were found in distance covered (m) during games among the three positions, but differences in intensity at which the distance was covered varied slightly from position to position. Forwards and midfielders both demonstrated high proportions of high-speed activities when compared to defenders, but these differences were less marked during games that were won (Slater et al., 2018). Similarly, when exploring differences in game and training demands among starters (starting ≥60% of games), fringe players (starting 30–60% of games), and nonstarters (starting <30% of games) in a team of professional male soccer players over an entire season, Anderson et al. (2016) discovered that distance covered and total duration did not significantly differ between these groups. However, starters completed greater running distance (14.4–19.8 km/h), high-speed running distance (19.9–25.1 km/h), and sprinting (>25.2 km/h) (Anderson et al., 2016). These findings demonstrate the differences in physical or external demands in athletes within the same team further highlighting the importance of monitoring individualized training load to prepare each athlete for what they will face during competition.

Recent female soccer literature reveals trends in loads specific to individual teams during matches or practice. Gentles and others (2018) explored match and practice demands in a Division II (DII) women's soccer team over an entire season. External load was monitored using GPS units (Zephyr^{TM} BioHarnesses) and internal load was collected by using sRPE. Additionally, acceleration data from GPS was used to calculate Impulse Load: a measure of mechanical load that includes only locomotor related accelerations. Researchers found that during match play, mean impulse load was 20,120 ± 8609 N·s, average total distance was 5.48 ± 2.35 km, and average sRPE was 892.50 ± 358.50 AU. Mean Impulse Load, total distance, and sRPE during practice was 12,410 ± 4067 N·s, 2.95 ± 0.95 km, and 143.30 ± 123.50, respectively. These numbers are beneficial benchmarks for women's soccer, but all divisions must be explored to establish specific normative values. The sole multi-year women's soccer study assessed only external load metrics via GPS in matches in DI female soccer athletes and compared these values by position (Sausaman et al., 2019). They found as a team, total distance, high-speed distance, and sprint distance were 9,486 ± 300 m, 1014 ± 118 m, and 428 ± 70 m, respectively. Additionally, this study revealed that attackers (forwards) covered the greatest distance at all speeds compared to midfielders and defenders. This is vital and novel information for coaches and sports scientist to have in women's soccer, but the trends and normative values may vary by team and individual (Coyne, Haff, Coutts, Newton, & Nimphius, 2018). Further individualized research is needed to assist coaches with training design.

More extensive male, training load monitoring studies have been used to assess training outcomes such as physical fitness or injury/illness likelihood which is more similar to the goal of this study (Jaspers, Brink, Probst, Frencken, & Helsen, 2017). Using training load to track training adaptations or injury potential is another important aspect of longitudinal studies. For example, Owen and colleagues (2015) explored the potential relationship between training load/ intensity and injury incidence in professional male soccer players over two seasons. The researchers monitored training intensity using calculated heart rate zones from a maximal oxygen uptake treadmill test (VO_2max). Intensity was monitored through time spent in high-intensity (85–90%) and very high-intensity (≥90%) zones of maximal heart rate. Injury was defined as a "physical complaint sustained by the soccer player either in training or in competition, which prevented the injured player from participating in competition or normal training for at least one day" (p.1706). Results revealed individual training intensity and load were moderately correlated to total injury incidence ($r = 0.57$, $p = 0.005$). This study shows longitudinal training load data is beneficial for injury monitoring and prevention in this population.

Some researchers (Buchheit, 2008; Campos-Vazquez et al., 2017) have used fitness testing and training load monitoring in tandem to evaluate the effectiveness of training design. In a more acute study, Campos-Vaquez and colleagues (2017) investigated the relationship between internal load measures and changes in fitness performance during a single preseason (four weeks) of a professional male soccer team. To assess and track fitness, the 30-15 internment fitness test (Buchheit, 2008) was performed before and after the preseason. This test measures fitness by increasing the speed at which the athlete must run for 30 seconds followed by 15 seconds of rest. During the preseason, researchers gathered internal load from training sessions and inner-squad matches (scrimmages within the team) using the sRPE method and Edward's HR based training load (Campos-Vazquez et al., 2017). Researchers found that the players' intermittent fitness substantially increased (ES = 1.15 ± 0.25) from pre to post-test after the four-week preseason. Data analysis also revealed that sRPE calculated training load, practice volume, and sum of RPE during the preseason were positively and strongly correlated (r = 0.70–0.75) with changes in intermittent performance. Load calculated using sRPE during the preseason explained 50% of variance on intermittent fitness performance revealing a "dose-response" relationship. Tracking load over a longer time period may show greater changes in this relationship.

The Influence of Age and Experience on sRPE

It is also important to address other components that impact internal load and how the athlete responds to training physically and psychologically. Session rating perceived exertion is largely recognized for its relationship with physiological exertion during exercise or training, however, researchers have also investigated other factors such as psychological variables, age, and experience to further identify this multi-dimensional construct (Barroso, Cardoso, Carmo, & Tricoli, 2014; Gallo, Cormack, Gabbett, Williams, & Lorenzen, 2015). It is important to understand all factors that may play a role in the final internal load number that athletes select to represent the difficulty of training or games. To demonstrate potential differences between athletes' and coaches' perception of difficulty during training, Barroso and colleagues (2014) monitored 160 swimmers of different ages and nine different coaches using sRPE training load method. The researchers also wanted to assess the accuracy at which younger swimmers could quantify the difficulty of training compared to older more experienced swimmers. Results showed a weak correlation between athletes' and coaches' sRPE rating of difficulty ($r = .31$, $p < .001$) for 11- to 12-year-olds, however, the correlational strength increased for 13- to 14-year-olds ($r = .5$, $p < .001$), and was strongest for 15- to 16-year-olds ($r = .74$, $P < .001$). These results show a potential trend in athletes' ability to quantify training difficulty based on age and experience. Younger less experienced athletes may struggle to accurately quantify and express the internal load they are experiencing during training and competition. It is important for this to be further explored within teams who use sRPE to monitor training load in athletes.

To further investigate the effect that age and experience have on sRPE, Gallo and colleagues (2015) studied an entire squad of Australian league football players during a preseason training period. The researchers gathered internal load using the sRPE method previously discussed and external load using GPS technology over fourteen training sessions. For analysis, athletes were grouped based on playing experience from 0 to 1 years, 2 to 3 years, 4 to 5 years, or 6+ years. When controlling for external load variables (distance covered, average speed, high speed running distance, and player load) researchers found that the main effect on s-RPE training load was significant for years of experience ($F_{2,\ 265} = 4.62$, $p = 0.004$). Additionally, post hoc analysis of experience differences revealed that the 4- to 5-year group had a higher sRPE for training sessions than the 0 to 1-year and the 2- to 3-year groups ($p < 0.05$). These results emphasize the importance of further analyzing the effect that outside factors have on sRPE. When monitoring training load with aims of using it to prescribe training, it is critical coaches understand how not only current fitness level influences how athletes respond to external load, but how age and experience also play a role.

Research Question(s):

How will sRPE differ (if at all) from year one to year two in returning NCAA DI female soccer players (i.e. is sRPE sensitive enough to reveal improvements in physical fitness)? What differences, if any, will there be in sRPE load between classifications of players?

Hypotheses:

It is hypothesized that when external load (total distance covered) is controlled, sRPE from year two of data collection will be significantly ($p<0.05$) different from sRPE from year one in returning players. This is predicted because of the adaptive responses brought about by physiological training and aerobic exercise. This outcome may also point to the effect that experience with college level training may have on the quantification of load using sRPE.

Additionally, it is hypothesized there will be significant ($p<0.05$) differences in sRPE between classifications in both seasons due to lack of experience and exposure to higher levels of training in the younger classifications.

Significance:

This research is significant for several reasons. Studying a cohort of female soccer athletes will be beneficial for further understanding of individualized training loads. Also, such findings could be indicative of prescribed training adaptations in female athletes and/or associated with physical and psychological maturation. Results will assist in the assessment of the effectiveness of the current training program and could be used to establish team and athlete norms further assisting coaches with monitoring team training and avoiding injury. More importantly, this research may demonstrate the influence of how classification and playing experience of athletes may affect how they perceive the difficulty of training. Lastly, the longitudinal design is novel in this population.

Chapter 3

Method

Participants

For this study, a total of 39 DI female soccer players (N= 39) on the same team were recruited over two seasons. All athletes were between the ages of 18 and 22 years old (19.52 ± 1.25). Participants were classified according to position and academic year classification for further analysis. In the fall 2018 season, there were 6 freshman, 11 sophomores, 2 juniors, and 9 seniors. Seven of the athletes were defenders (D), six were forwards (F), twelve were midfielders (MF), and three were goalkeepers (GK). In the fall 2019 season, there were 11 freshman, 6 sophomores, 10 juniors, and 2 seniors. During this season, there were 7 defenders, 6 forwards, 13 midfielders, and 3 (GK). Seniors from the first season of data collection (Fall 2018) were excluded from being compared between the two years, but were included for analysis of sRPE between academic year classification. Exclusionary criteria included any injury or incidence that prevented the athlete from competing in at least 75% of practices and games. Athletes who reported using any performance enhancing or illegal drugs, regulated in accordance to NCAA standards, were not allowed to participate in the study.

Measures

Internal Load: Internal load was measured and quantified using Foster and colleague’s sRPE based method (1998; 2001; 1995). This method quantifies internal training load by multiplying the whole training session rating of perceived exertion (RPE) using the category ratio scale (CR10-scale) adapted from Borg et al. (1987) by the session duration. This product represents the magnitude of internal training in arbitrary units (AU) (Foster, 1998; Impellizzeri et al., 2004). sRPE was collected using the mobile application TeamBuildr (version 3.0.13;

TeamBuildr, Landover, MD) which allowed athletes to submit their scaled sRPE score (1-10) for each training session and game based on perceived difficulty. Duration (in minutes) of each training session and game was tracked using the GPS units which was the external load method chosen.

External Load: External load for each player was measured and quantified using a global positioning system (GPS) unit (OptimEye X4, Catapult Innovations, Melbourne, Australia) with a 10Hz sampling rate. This GPS unit and sampling rate have shown to be reliable and valid in past research (Bourdon et al., 2017; Rampinini et al., 2015; Varley et al., 2012). Each unit is also equipped with a gyroscope and accelerometer which allows other aspects of play to be captured and quantified. Total distance (m), intensity (m/min), and high-speed running distance (m) (distance traveled at > 5 ms^{-1}) were metrics collected via GPS. However, for the purpose of this study, total distance is the only external load metric of interest due to the high positive correlation with sRPE (Casamichana et al., 2013; Scott et al., 2013).

Procedures

General: Before the study began, the Kinesiology department was approached by the women's soccer team coaching staff at the University. The staff was interested in collecting and tracking training load and inquired about the tools that the department had to perform the service. After agreement from both parties, the Kinesiology department and the soccer team chose to begin a partnership starting with the 2018 fall season and continuing through the foreseeable future. Following the establishment of the relationship, the coaches signed a data agreement with the researchers outlining the potential use of data for current and future research projects.

Protocol: Prior to subject recruitment and data collection, procedures were approved by the University Institutional Review Board (IRB). Participants were informed of all experimental procedures, risks, and benefits associated with the study. Approval from coaches was sought and acquired prior to contact with athletes. Written consent documents (Appendix A) were provided and signed before participation was permitted. It was made explicitly clear that participation in the study was completely voluntary and subjects had the option to stop participation at any time. A recruitment script was created and approved by the IRB prior to recruitment and introduction to the athletes.

GPS Procedures: All active players wore a global positioning system (GPS) unit (OptimEye X4, Catapult Innovations, Melbourne, Australia) with a 10Hz sampling rate at every training session and every game for the entirety of both the seasons. GPS units were taken out of the charging case and switched on by researchers before warm-up and individually placed between the player's shoulder blades in a vest like garment before each game and practice (Harley et al., 2010). Each activity started with the "warm-up" period (data collection began simultaneously when the players began their warm-up jog) and concluded at the end of game/ training session after all activity stopped. After completion of each game or practice, players removed the garments, researchers removed the units, powered off, and placed the unit back in the Catapult charging chase. Data was extracted using OpenField software (Catapult Innovations, Melbourne, Australia). From OpenField, the data was transferred and uploaded to the CatapultCloud where it was stored, analyzed, or exported. Both OpenField and CatapultCloud are password protected programs that only researchers have access to. Data was backed up on the CatapultCloud after each activity. After data was transferred and uploaded to the cloud, the GPS units stored the activity for up to 30 days, at which point the oldest activity was auto cleared by the device. Devices were fully charged before each activity by plugging the charging case into a standard outlet. Devices were fully charged when the LED light on the unit flashed green. Again, athletes were informed that wearing the unit was not mandatory and they had a choice not to wear them.

sRPE/ Questionnaire Procedures: The CR 1-10 sRPE scale (Appendix B) was explained to participants and they were given a visual representation of the scale explaining how difficulty coincides with a number on the scale. sRPE was collected after every game and every training session over two seasons. Based on past research, sRPE was be gathered 30 minutes after the end of the physical activity bout for accuracy and assessment of global difficulty (Foster et al., 2001). sRPE was collected via the TeamBuildr app on each of the athlete's smart phones. Verbal and electronic reminders were given to the athletes after each training session and game to ensure the questionnaire were filled out properly and on time. Honest answers were strongly encouraged and stressed throughout both seasons. Athletes were instructed not to share or discuss their ratings with each other. Athletes were instructed to input a "0" into TeamBuildr if they did not participate in training or matches. It was made clear that sRPE responses were not be shown to the coaching staff, therefore no one was punished or rewarded based on responses. If players did not respond to at least 75% of questionnaires (games and practice), athlete compliance was considered too low and the athlete was not included in data analysis.

Statistical Analysis

Demographic information was reviewed and compiled for each season by classification and position to provide more information about the makeup of each team. Means and standard deviations were calculated for descriptive variables (sRPE Load and total distance) for both years by classification and position. Prior to addressing the research questions, correlational analyses were run to verify a similar relationship between sRPE load (AU) and total distance (m) that was found by Lobato and colleagues (unpublished) in 2018 ($r=0.845$, $p <0.001$).

Prior to addressing either research question, the practice and game GPS data was averaged by athlete for each month (August, September, October, November) of the season. To address the first research question investigating differences in sRPE from year one to year two in the returning soccer athletes (excluding Fall 2018 seniors and Fall 2019 freshman) while controlling for total distance (m), a repeated measures ANCOVA was used. For research question 2, four separate MANCOVAs were used to investigate differences in sRPE between classification of players while controlling for total distance covered (m) in practices in 2018, games in 2018, practices in 2019, and games in 2019. Additional data organization and inclusion criteria are addressed in the results section.

Chapter 4

Results

The results from this study compared session rating of perceived exertion (sRPE) between returning DI female soccer athletes across two seasons. Additionally, sRPE comparisons were made by classification (FR, SO, JR, SR) of DI female soccer athletes across two consecutive seasons. This study was strictly observational and no interventions were introduced during either season. Results were derived from each practice and game session over two years. The sRPE product, measured in arbitrary units (AU), was calculated using the athlete's reported RPE score and session duration measured in minutes. Total distance (TD) in meters was recorded using individual GPS tracking devices worn by each athlete. The following research questions were asked: (1) How will sRPE differ from year one to year two in returning NCAA DI female soccer players? (2) What differences (if any) will there be in sRPE load between classifications of players? The first section provides the demographic information. The second section provides an exploratory description of the two seasons. The third section includes correlational analysis validating the relationship between sRPE and total distance in this population. The final two sections answer the two research questions regarding sRPE across two seasons.

Demographics

The participants in the study included a total of 39 DI female soccer athletes on the same team with ages ranging from 18-23 years old (19.52 ± 1.25). In 2018, the roster consisted of 28 athletes with 6 freshman, 11 sophomores, 2 juniors, and 9 seniors. The 2019 roster consisted of 29 athletes with 11 freshman, 6 sophomores, 10 juniors, and 2 seniors. Theses populations could not be controlled by the researchers, so an even distribution of classifications could not be achieved. After inclusion criteria was assessed, researchers had 20 athletes in 2018 and 23 athletes in 2019 for analysis. Even fewer athletes were available for game analysis with only 9 for the 2018 season and 7 for the 2019 season. Table 1 shows the classification and position breakdown for each season before exclusion of athletes. The small number of juniors in 2018 (N=2) led to the small number of seniors in 2019 (N=2) making classification representation unbalanced.

Table 1.
Participants by Classification and Position for both seasons.

Season		**2018**	**2019**
Total		28	30
Class.	**FR**	6	11
	SO	11	6
	JR	2	11
	SR	9	2
Position	**D**	7	6
	F	6	5
	MF	12	12
	GK	3	3

** FR = Freshman, SO = Sophomore, JR = Junior, SR = Senior*
** D = Defender, F = Forward, MF = Mid-fielder, GK = Goal Keeper*

All athletes who participated in each practice and game session wore a GPS tracking device so that duration and total distance could be recorded across the 2018 and 2019 seasons. This resulted in 2,708 total data points/sessions across all players for both seasons. This was too many data points to measure for the research questions. So, the sRPE data points for each of the four months were averaged by month (August, September, October, and November) for games and practices separately by each athlete. Total distance was also averaged for 2018 and 2019 for each athlete for games and practices separately. These time points will be used further for research questions 1 and 2.

For this study, researchers excluded any session that was less than 20 minutes in duration because sRPE would not be representative of a normal practice session (74.5 ± 16.3 mins) and would also suggest the athlete did not participate in the game (warm-up for game is 20+ minutes). For game analysis, players were excluded if they did not accumulate at least 100 AU for sRPE load because the average sRPE per game for a starter or significant sub was 845.2 ± 213.5 AU. An sRPE of less than 100 AU would be more than three standard deviations away from the average score. Table 2 displays average number of games and practice sessions for each season by month. Players did not have the same number of games and practice sessions because they either did not participate, were injured, or failed to complete the sRPE questionnaire according to protocol.

Table 2.
Average Game and Practice Session per Athlete by Month and Season

Season	**Session Type**	**Month**							
		Aug		**Sep**		**Oct**		**Nov**	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD
2018	**Games**	4.1	1.9	6.7	1.2	4.1	1.7	1.0	0.8
	Practices	14.8	3.0	10.1	1.5	7.3	2.3	5.6	2.9
2019	**Games**	2.7	1.6	5.0	2.2	4.7	2.4	1.9	1.5
	Practices	12.4	3.4	11.7	11.7	13.1	1.6	7.2	1.1

** SD= Standard Deviation*

Descriptive Analysis

Whole season mean and standard deviations of sRPE load (AU) and total distance covered (m) for each year by games and practices for each classification and position are displayed in Tables 3-6. This analysis was conducted after inclusion criteria was assessed. These tables also show how sample sizes became an issue for game analysis after several did not meet the inclusion criteria. This will be discussed as a significant limitation in the discussion.

Although statistical analyses were not run on these descriptive numbers, it is still important to point out specific trends in this population of female soccer athletes.

2018 Descriptive Analysis: Various trends and key points can be made using this descriptive data. Table 3 reflects the 2018 classification description data, while Table 4 reflects the 2018 position description data. Whole team averages revealed that regardless of classification, athletes ran approximately 3,656.7 ±681.4 m per practice and accumulated 389.2±76.0 AU of internal load in 2018. In games, athletes ran 8,069±1,604.8 m and accrued 794.9±198.1 AU of internal load. Upon further assessment of whole season descriptive variables by classification and position in 2018, additional trends began to emerge. Practice values revealed that freshman athletes ran the most during practice (3,940.6 ± 250.9 m) and correspondingly had the highest sRPE load (431.9± 78.0 AU). A similar trend was found in game analysis with freshman covering the most distance (8, 597.1 ± 903.5 m) at the highest sRPE load (878.7±144.8 AU). Positional descriptive analysis in 2018, seen in Table 4, highlighted that defenders covered the most distance in practice (3,933.4±388.4 m) and had the highest sRPE (428.1±76.8 AU) with midfielders close behind (3.922.1±667.7 m & 388.8±73.2).

Table 3.
Means and Standard Deviations of sRPE (AU) & Total Distance (m) by Classification for 2018 Team.

		Practice					**Game**			
Class	**N**	**sRPE**	***SD***	**Tot Dis**	***SD***	**N**	**sRPE**	***SD***	**Tot Dis**	***SD***
FR	5	431.9	*78.0*	3940.6	*250.9*	4	878.7	*144.8*	8597.1	*903.5*
SO	6	376.2	*62.6*	3468.4	*923.5*	1	553.5	*N/A*	5080.1	*N/A*
JR	2	421.2	*58.7*	3574.3	*36.8*	1	769.3	*N/A*	7407.2	*N/A*
SR	7	361.2	*69.7*	3605.6	*706.0*	3	770.0	*200.0*	8584.2	*1722.4*
Tot.	20	389.2	*76.0*	3656.7	*681.4*	9	794.9	*198.1*	8069.8	*1604.8*

** FR = Freshman, SO = Sophomore, JR = Junior, SR = Senior*

Table 4.

Means and Standard Deviations of sRPE (AU) & Total Distance (m) by Position for 2018 Team.

	Practice					Game				
Pos.	**N**	**sRPE**	***SD***	**Tot Dis**	***SD***	**N**	**sRPE**	***SD***	**Tot Dis**	***SD***
D	3	428.1	*76.8*	3933.4	*388.4*	2	935.3	*138.8*	8852.6	*448.2*
F	5	378.4	*82.5*	3848.8	*309.6*	3	711.8	*186.7*	7693.8	*945.6*
MF	8	388.8	*73.2*	3922.1	*667.6*	3	857.9	*200.0*	8920.5	*1722.4*
GK	2	357.0	*43.0*	2082.8	*843.8*	1	553.5	*N/A*	5080.1	*N/A*
Tot.	20	389.2	*76.0*	3656.7	*681.4*	9	794.9	*198.1*	8069.8	*1604.8*

***** *D = Defender, F = Forward, MF = Mid-fielder, GK = Goal Keeper*

2019 Descriptive Analysis: Various trends and key points can be made using this descriptive data as well. Table 5 reflects the 2019 classification description data, while Table 6 reflects the 2019 position description data. When compared to 2018 whole team season averages, the 2019 team ran less in practice (3,394.2±470.9 m) and correspondingly had a lower overall internal load (378.6±80.7 AU). However, team game averages showed that the 2019 team on average ran further (10,009.5±873.9 m) and had a higher internal load in games (908.3±215.4 AU). When delineated by classification, freshman still covered the most distance (3,558.6±471.5 m) in practice but had the third highest sRPE load (380.7±63.1 AU) while sophomores had the highest average load per practice (406.2±78.4 AU). Although every classification was not present for game analysis (juniors missing representative due to inclusion criteria), the sole senior ran the furthest (10,224.8 m) but had the lowest internal load per game (793.1 AU). For the 2019 team, defenders ran the most per practice (3,589.3±608.5 m), but goalkeepers had the highest sRPE load per practice (397.4±80.7 AU).

Table 5.
Means and Standard Deviations of sRPE (AU) & Total Distance (m) by Classification for 2019 Team

	Practice					Game				
Class	**N**	**sRPE**	***SD***	**Tot Dis**	***SD***	**N**	**sRPE**	***SD***	**Tot Dis**	***SD***
FR	9	380.7	*63.1*	3558.6	*471.5*	3	898.9	*203.8*	9940.3	*885.7*
SO	6	406.2	*78.4*	3433.0	*265.1*	3	955.9	*194.7*	9840.7	*714.7*
JR	6	343.1	*96.7*	3101.4	*562.0*	0	N/A	*N/A*	N/A	*N/A*
SR	2	392.8	*65.4*	3416.1	*86.0*	1	793.1	*N/A*	10224.8	*N/A*
Tot.	23	378.6	*80.7*	3394.2	*470.9*	7	908.3	*215.4*	10001.9	*873.9*

** FR = Freshman, SO = Sophomore, JR = Junior, SR = Senior*

Table 6.
Means and Standard Deviations of sRPE (AU) & Total Distance (m) by Position for 2019 Team

	Practice					Game				
Pos.	**N**	**sRPE**	***SD***	**Tot Dis**	***SD***	**N**	**sRPE**	***SD***	**Tot Dis**	***SD***
D	5	383.9	*52.1*	3589.3	*608.5*	1	1122.8	*N/A*	10485.5	*N/A*
F	4	394.5	*74.5*	3577	*165.7*	2	845.3	*167.6*	9207.5	*1065.5*
MF	11	365.3	*97.7*	3502	*305.1*	4	739.4	*218.2*	10271.9	*744.1*
GK	3	397.4	*52.2*	2429.7	*472.3*	0	N/A	*N/A*	N/A	*N/A*
Tot.	23	378.6	*80.7*	3394.2	*470.9*	7	908.3	*215.4*	10001.9	*873.9*

** D = Defender, F = Forward, MF = Mid-fielder, GK = Goal Keeper*

Correlation Validation

In 2018, researchers validated the relationship between sRPE load (AU) and total distance (m) (r=0.845, $p < 0.001$) based on the previous findings and previous literature (Alexiou & Coutts, 2008; Casamichana et al., 2013; Scott et al., 2013). For this study, a Pearson Product Moment correlation analysis confirmed a strong positive correlation between sRPE load (AU) and total distance (m) (r=0.802, $p < 0.001$) in 2019 just as it did in 2018. All sessions for all athletes from each respective season were used in these analyses. Figure 1 demonstrates the relationship between sRPE load (AU) and total distance covered (m) in 2018 for all players across all sessions (Lobato, 2018). Figure 2 displays the same relationship for the 2019 season.

Figure 1.

Relationship Between sRPE Load (AU) and Total Distance (m) 2018

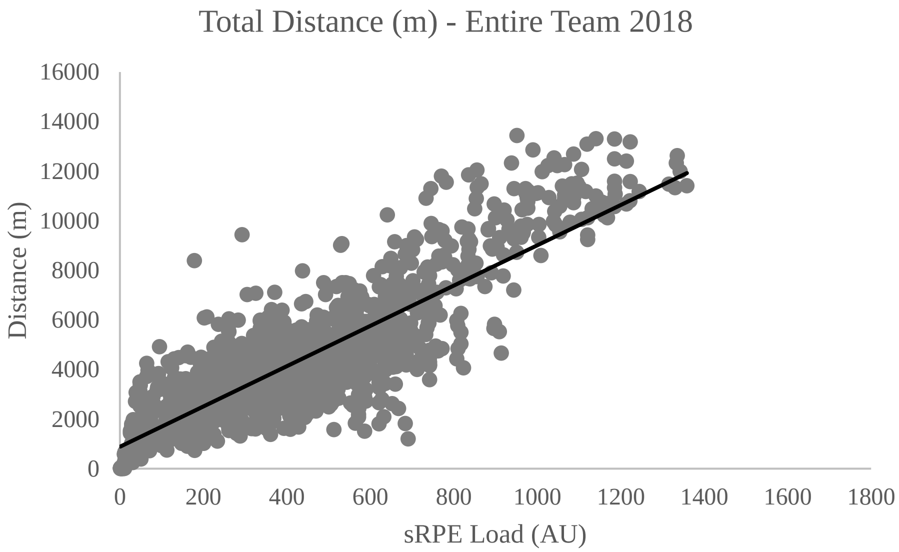
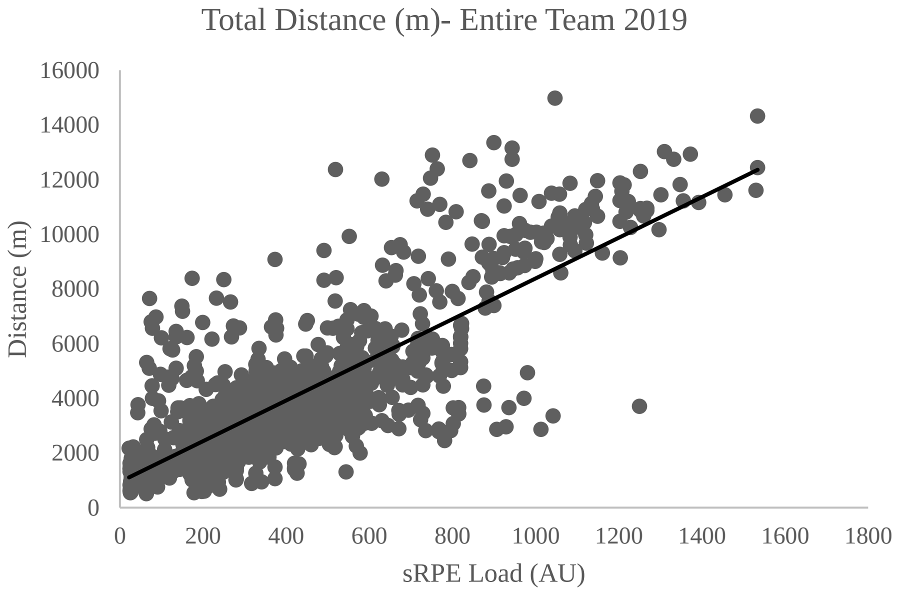


Figure 2.

Relationship Between sRPE Load (AU) and Total Distance (m) 2019



Research Question 1

The first research question assessed sRPE load change within returning athletes between the 2018 and 2019 seasons. Based on training literature, the researchers hypothesized that sRPE in 2018 would be significantly different from sRPE in 2019 ($p < 0.05$). sRPE was collected for games and practices for two consecutive seasons following the same protocol. Two separate analyses were assessed for sRPE comparisons: one for practice sessions and one for games. The practice analysis included 14 returning athletes (N=14). Seniors from 2018 (N=9) and freshman from 2019 (N=9) were excluded because they did not have data points across two seasons, so comparisons could not be made. Three of the fourteen athletes were also excluded from practice analyses and eight were excluded from game analyses because they did not practice or play for the minimum duration. This became problematic for comparing games across two seasons by classification because the numbers were too small. The independent variable in this analysis was experience level, which was determined by how long the athlete had been playing DI collegiate soccer in year 2019 (Sophomore = 2 years, Junior =3 years, and Senior =4 years). There were no transfer athletes on this team. The dependent variable sRPE load (AU) data points were averaged for each athlete in each training and competition month of the season: August, September. October, and November. The control variable was total distance covered in meters averaged across 2018 and 2019 for each athlete.

2018 to 2019 Practice Differences: A repeated measures ANCOVA revealed no significant differences in sRPE practice loads by month across two years, Wilks Lambda= 0.078, F(7,1)=1.697, p= 0.532., or when covarying for average distance covered, Wilks Lambda = .028, F(7,1) = 4.895, p=0.335, or by experience level, Wilks Lambda = 0.022, F(14,2)= 0.825, p=0.673. Therefore, the hypothesis for research question one was rejected. Table 7 reveals means and standard deviations of practice sRPE loads (AU) by experience level for returning athletes across both years. Although no significant differences were found, certain trends are noted. Players with two and four years of experience perceived 2019 to be slightly more difficult than 2018. September was relatively uniform across both years for all experience levels. Players with three years of experience were the only ones with a slight increase in sRPE from 2018 to 2019. All players saw a slight sRPE decrease in November.

Table 7.
Means and Standard Deviations of Practice sRPE (AU) by Experience Level and by Month in Returning Athletes

		Aug.				**Sep.**				**Oct.**				**Nov.**			
		2018		**2019**		**2018**		**2019**		**2018**		**2019**		**2018**		**2019**	
Exp.	**N**	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
2 Years	5	440.0	*94.9*	511.2	*16.7*	396.5	*82.3*	398.5	*74.5*	460.9	*112.7*	403.1	*50.2*	431.2	*43.4*	332.4	*31.2*
3 Years	4	401.1	*24.6*	353.9	*147.7*	346.5	*42.9*	358.3	*153.3*	382.5	*49.8*	391.5	*92.2*	316.6	*63.9*	290.3	*64.0*
4 Years	2	443.4	*23.8*	451.8	*23.3*	407.1	*48.9*	415.6	*65.0*	412.0	*150.7*	389.1	*78.4*	422.2	*18.8*	314.8	*55.9*
Tot.	11	426.5	*65.2*	443.2	*110.6*	380.3	*65.1*	387.0	*101.3*	423.5	*97.5*	396.3	*64.9*	387.9	*72.3*	313.9	*48.2*

2018 to 2019 Game Differences: A repeated measures ANCOVA was not run across games due to insufficient data. After athletes were excluded based on playing time criteria, the sample size to be compared equated to four athletes with two years college playing experience and only one athlete with four years college playing experience. Therefore, this part of the question was not answered. Power and effect sizes were negligible after athletes were excluded.

Research Question 2

The second research question investigated differences between sRPE among the classifications of players. The researchers hypothesized that there would be significant differences ($p < 0.05$) in sRPE by classification while controlling for distance in games and practices across both years. Returning athletes were used twice within their respective seasons (once in 2018 and once in 2019) because they were present on both teams. A multivariate analysis of covariance (MANCOVA) covarying for total distance covered (m) was utilized to address this question. Again, sRPE was averaged for each month (August, September, October, and November) for each athlete. Average distance covered for games and practices was calculated for each athlete by year separately (2018 and 2019). Four separate analyses were run to address this question: sRPE comparisons between classifications within 2018 team for practice, sRPE comparisons between classifications within 2018 team for games, sRPE comparisons between classifications within 2019 team for practice, and sRPE comparisons between classifications within 2019 team for games. Classification years were used as the independent variable in these analyses (Freshman, Sophomore, Junior, and Senior).

2018 Practice Analysis: A MANCOVA covarying for total distance covered (m) revealed no significant differences in 2018 practice sRPE by month and classification, Wilks' Lambda = 0.404, F(12,320) = 1.090, p=0.40. The hypothesis was rejected for this analysis. Table 8 reveals means and standard deviations of practice sRPE loads (AU) by month and classification for the 2018 team. Although not significant, the trend that freshman and juniors have the highest sRPE in each month in 2018 and these classifications continue to have the highest practice sRPE in 2019 is an important tracking variable.

Table 8.
Means and Standard Deviations of Practice sRPE (AU) by Classification and by Month in 2018 Athletes

		Aug.		**Sep.**		**Oct.**		**Nov.**	
Class.	**N**	Mean	SD	Mean	SD	Mean	SD	Mean	SD
FR	5	440.0	*94.9*	396.5	*82.3*	460.9	*112.7*	431.2	*43.4*
SO	6	375.6	*68.7*	346.1	*51.6*	390.4	*59.9*	305.4	*89.7*
JR	2	443.4	*23.8*	407.1	*48.9*	412.0	*150.7*	422.2	*18.8*
SR	7	394.1	*36.3*	379.0	*52.9*	383.6	*88.3*	309.0	*78.3*
Combined	20	405.0	*66.2*	376.3	*60.3*	407.8	*91.3*	349.8	*89.4*

2018 Game Analysis: Similar to question 1, athletes were excluded from game analysis if they did not meet criteria previously discussed, leaving a small sample size (N=9). A MANCOVA covarying for total distance covered (m) revealed no significant differences in 2018 game sRPE by month and by classification, Wilks Lambda = 0.001, F(12,2.9)= 2.924, p=0.208. The hypothesis for research question two for games in 2018 was also rejected. Table 9 displays means and standard deviations of game sRPE loads (AU) by month and classification for the 2018 team. Freshman and seniors seemed to have higher sRPE loads in August and September than sophomores and juniors. Seniors recorded higher sRPE numbers in October and Freshman recorded higher sRPE numbers in November.

Table 9.
Means and Standard Deviations of Game sRPE (AU) by Classification and by Month in 2018 Athletes

		Aug.		**Sep.**		**Oct.**		**Nov.**	
Class.	**N**	Mean	SD	Mean	SD	Mean	SD	Mean	SD
FR	4	698.7	*88.8*	904.1	*125.4*	909.7	*144.6*	1002.4	*214.4*
SO	2	449.9	*64.0*	665.0	*202.7*	886.4	*318.9*	863.4	*334.5*
JR	1	592.4	*N/A*	776.5	*N/A*	963.6	*N/A*	744.7	*N/A*
SR	2	720.6	*97.8*	855.8	*77.5*	1051.2	*28.7*	807.5	*185.7*
Combined	9	636.5	*131.6*	826.1	*147.8*	941.9	*158.1*	899.6	*215.1*

2019 Practice Analysis: A MANCOVA covarying for total distance covered (m) revealed no significant differences in 2019 practice sRPE by month and by classification, Wilks Lambda = 0.353, F(12,40)= 1.605, p=0.129. The hypothesis for research question two for practice in 2019 was rejected. Table 10 displays means and standard deviations of practice sRPE loads (AU) by month and classification for the 2019 team. The higher rating freshman and juniors from 2018 practice analysis became the higher rating sophomores and seniors in 2019. Overall, classifications were very similar in October and November.

Table 10.
Means and Standard Deviations of Practice sRPE (AU) by Classification and by Month in 2019 Athletes

		Aug.		**Sep.**		**Oct.**		**Nov.**	
Class.	**N**	Mean	SD	Mean	SD	Mean	SD	Mean	SD
FR	9	439.5	*55.3*	367.0	*42.1*	391.8	*56.2*	391.8	*56.2*
SO	6	505.5	*20.4*	389.4	*70.3*	407.5	*46.2*	407.5	*46.2*
JR	6	338.3	*120.3*	348.9	*126.3*	392.7	*74.3*	392.7	*74.3*
SR	2	451.8	*23.3*	415.6	*65.0*	389.1	*78.4*	389.1	*78.4*
Combined	23	431.4	*91.9*	372.4	*77.4*	395.9	*56.7*	395.9	*56.7*

2019 Game Analysis: Again, only participants that met all criteria for games in 2019 were included in this analysis (N=7). Unfortunately, after game inclusion criteria was assessed, no juniors were left for this analysis. A MANCOVA covarying for total distance covered (m) revealed no significant differences in 2019 game sRPE by month and by classification, Wilks Lambda = 0.72, F(6,2)= 0.911, p=0.608. The hypothesis for research question two for games in 2019 was rejected. Game means and standard deviations for 2019 sRPE loads (AU) by month and classification are reported in Table 11. Sophomores had the highest sRPE loads in all months but October where the sole senior had the highest sRPE load.

Table 11.
Means and Standard Deviations of Game sRPE (AU) by Classification and by Month in 2019 Athletes

		Aug.		**Sep.**		**Oct.**		**Nov.**	
Class.	**N**	Mean	SD	Mean	SD	Mean	SD	Mean	SD
FR	3	714.7	*194.9*	900.2	*244.9*	963.5	*194.7*	1017.5	*187.5*
SO	3	808.3	*146.4*	973.7	*197.6*	954.7	*321.1*	1087.3	*65.5*
SR	1	374.0	*N/A*	793.0	*N/A*	977.0	*N/A*	1028.0	*N/A*
Combined	7	706.2	*208.4*	916.4	*193.2*	961.7	*216.9*	1048.9	*120.2*

Chapter 5

Discussion

This study investigated the potential use of perceived exertion (sRPE) session rating for the purpose of identifying physiological adaptations to training and differences in responses to training in DI female collegiate soccer players. This descriptive study is the first of its kind to assess the behavior of load monitoring data across two consecutive seasons in collegiate female soccer athletes. The overall purpose of the study was to gain a better understanding of sRPE and its use in load monitoring and prescription within female soccer athletes. sRPE has been used previously by researchers to quantify match demands in soccer (Anderson et al., 2016; Bradley et al., 2014; Slater et al., 2018), assess differences in perceived difficulty by age between swimmers and coaches (Barroso et al., 2014), and to assess differences in perceived difficulty in Australian male football players by experience level (Gallo et al., 2015). With rapidly developing technology and increased importance placed on athlete health and longevity, understanding how to directly apply this load monitoring information for males and females should be a top priority for sports scientists and coaches. Therefore, this study explored specific trends in this data that may help coaches assess training effectiveness and potentially individualize training for athletes.

Demographics and Descriptive Statistics

The season long practice and game means of sRPE load and total distance revealed specific trends by season, classification, and position. Because this is one of the first load monitoring studies in DI female soccer players, these trends need to be further assessed within other teams. When compared to a season long load monitoring study in DII female soccer athletes, this DI team ran almost twice as much during matches but had similar team averages for sRPE (Gentles et al., 2018). However, in practice, total distance was much more similar, but this

DI team accumulated a higher average sRPE load per player during practice when compared to the DII team. It is apparent that internal and external load does vary by division, and should be taken into consideration when coaches are prescribing training to their athletes.

The descriptive values from this study were similar to those of previous studies with DI soccer athletes. Although Sausaman and colleagues' (2019) study only addressed external load metrics such as total distance and total distance covered at specific speeds in games, their findings were similar to those in this study. Though both teams covered similar total distances in games, Sausaman et al. (2019) found that forwards on that specific team covered the most distance. This contradicts the descriptive values in this study. In 2018, mid-fielders covered the most distance and in 2019, defenders covered the most distance. These differences could be present for many reasons, but the fact that discrepancies exists further highlights the need for coaches to make training decisions based on the current team they have. Understanding the need for team and individualized training moving forward will be vital to the future of load monitoring in males and females.

Correlation Analysis

The relationship between sRPE (AU) and total distance (m) was assessed previously in the same population in 2018 by Lobato and others in an unpublished thesis project. A similar strong, positive, and, significant relationship was found between sRPE load (AU) and total distance covered (m) in the 2019 season. These findings support not only what was found last year in the same population, but other research that has explored this relationship in male elite male soccer players (Casamichana et al., 2013; Gaudino et al., 2015; Scott et al., 2013). As the amount of distance covered in a game or in training increases, internal load, measured via sRPE, also increases. Conversely, as total distance covered in practice and games decrease, sRPE load experienced by the athlete also decreases. Further solidifying this relationship in collegiate female soccer players is vital because of potential load differences that do exist between males and females (Bradley et al., 2014). This finding enhances the validity of the use of sRPE to determine internal load and its relationship with external load in this specific population.

Question 1: sRPE in Returning Athletes

The first research question examined differences in sRPE across two different years in returning DI female soccer players. Despite the training and adaptation literature that does exist, the hypothesis of research question one was rejected; no significant differences were found. Training or physical stress, leading to physiological adaptations is a widely accepted concept in exercise physiology. The General Adaptation Syndrome (GAS), coined by Selye in 1950, asserts that the human body reacts to stress in three stages: Alarm, Resistance, and Exhaustion. This theory states that adaptations to challenging but familiar stimuli occur within the resistance stage (Selye, 1950). Based on this concept and the expounded information since, numerous studies have investigated specific physiological adaptations to imposed training (Hawley, 2002; Impellizzeri et al., 2019; Impellizzeri et al., 2005; Viru & Viru, 2000). Another common concept presented in exercise and sport literature is that adaptations are specific to the type of training that is elicited by coaches(Bourdon et al., 2017; Impellizzeri et al., 2005). These accepted concepts and theories led researchers to predict that there would be significant differences in internal load, measured via sRPE, due to physiological adaptations taking place from training over time. Specifically, when given the same external training load over time, it was perceived as "easier" by returning athletes. The findings from this study are contrary to what would be expected, but the metric of sRPE may not be sensitive enough to indicate internal physiological changes. Due to the "global" nature of the measure, multiple changes could be taking place they offset each other reveling no significant changes (Foster et al., 2001). Even though previous research has shown sRPE explains 50% of the variance in acute fitness improvements, researchers did not find significant main effects with this study (Campos-Vazquez et al., 2017). Unfortunately, due to small sample sizes, analysis of game sRPE within returning athletes could not be assessed. Although no significant differences were found, specific trends within this population will be explained in the "Direct Application and Trends" section.

Question 2: sRPE Between Classifications

The second research question assessed potential differences in sRPE load by classification for each season. To address this question practice and game loads were assessed separately. Training literature has asserted that individual training adaptations occur after chronic exposure to training or exercise and are affected by the athlete's preexisting individual fitness level and the characteristics of the training (Halson, 2014; Impellizzeri et al., 2005). Addtionally, previous research has found descrepancies in sRPE related to training experience and age (Barroso et al., 2014; Gallo et al., 2015). Based on this foundational knowledge of training, it was predicted internal load differences would be observed in both seasons between freshman, sophomores, juniors, and seniors. Differences related to lack of exposure to DI soccer training for the freshman and fatigue/overuse in the older athletes were expected to play a role in how athletes perceived training and games (Gallo et al., 2015; Impellizzeri et al., 2005; Mujika et al., 2009). However, this was not the case in this study. All hypotheses related to classificaton differences in games and training throughout both seasons were rejected in this study. Simliar to research question 1, although specific differences between classifications were not discovered, coaches should be aware of the trends this data produced.

Direct Application and Trends

Establishing team norms and trends within training load data is extremely important for avoiding injury and overtraining, while encouraging performance improvements (Bourdon et al., 2017; Impellizzeri et al., 2019). Recent research has established match and practice norms in a NCAA DII female soccer teams using various metrics (Gentles et al., 2018), but these findings may not be applicable to DI soccer females because of differences in game and performance demands. Though the findings from this study were not significant, the information may still be valuable for coaches in regards to how their players are perceiving games, training, and performance throughout the season. Anecdotally, this data revealed that August and October are perceived as the most difficult training months of practice across two seasons, while November is perceived as the least difficult. August is likely one of the most difficult months due to heat stress at this time of year and an increase in daily training loads imposed by two-a-days (Duffield, McCall, Coutts, & Peiffer, 2012). Conversely, October is likely to be one of the highest practice load months due to late season conference play and academic stresses from midterm examinations (Bangsbo, 2014). Because sRPE can be influenced by so many factors, it is vital to keep seasonal fluxuations in mind when prescribing training and encouraging recovery. Game sRPE trends were variable, but October and November were perceived as the most difficult. Again, this is most likely due to late season fatigue, difficulty of opponents, and increased importance of game outcomes (Bangsbo, 2014). The increased difficulty perceived by the athletes in November games is offset by lower practice loads; however, the high October game demands and training may produce concern for the coaching staff. Training in the month of October should be carefully considered to avoid overtraining and injury. Additionally, recovery strategies in this month should be prioritized.

Classification trends were also variable by season and session type, but after two seasons of load monitoring, freshman ran the furthest during practice. This could be due to the inherent challenges of being a freshman, such as trying to earn a starting role, lack formational or strategic knowledge, or “fresh legs”. Experience related differences in training and competition, with an emphasis on sub-elite players, has also been observed in other sports (Scanlan, Dascombe, & Reaburn, 2011). The data also indicated that “high responders” based on sRPE response to training 2018 (Freshman and Juniors), became high responders to training in 2019 (Sophomores and Seniors) (Mann, Lamberts, & Lambert, 2014). This highlights the need to base norms and thresholds on specific teams or classification, or ideally focused on the individual. This will be further discussed in the future direction section.

Limitations

Because of the nature of field research, many factors affected the lack of control researchers had in collecting the data. As noted in the results, several athletes did not meet inclusion criteria for game analysis which created imbalanced sample sizes across classifications. This significantly affected the power and effect sizes of the game analyses. Additionally, researchers could not control the playing or practice time of each player to ensure that each athlete was exposed to the same demands. However, external load was controlled to potentially counterbalance this limitation. Wins and losses could have also affected training design for subsequent practices which varied throughout both seasons. Style and intensity of play could be altered by the opponent the team was facing which was variable in both seasons as well. It is important to mention other factors that may be impacting the overall global sRPE measure such as: school stress, life stress, changes in nutrition sleep changes, time of year, soreness, fatigue menstruation and hormonal changes, and the time of day the training or game session took place.

Field research is essential for real life occurrences and to establish a baseline for DI female athletes, but it can also lead to potential implications in the outcome of this study.

Another potentially significant limitation would be the accuracy of the self-reported sRPE load. Although researchers tried to control and support honest and consistent responses, it cannot be determined that every athlete answered accurately as possible for every session. Although inter-athlete and intra-athlete reliability has been shown in research, accurate ratings may not always take place. Since researchers did not physically observe all players respond to all surveys for both seasons, accuracy cannot be certain. The athletes were advised not to share answers with one another and were told their answers do not affect playing time, but these things could have potentially impacted answers.

Future Directions

Further research is needed to establish general and team specific norms for women's collegiate soccer. As mentioned previously, norms and thresholds should be established based on teams and specific individuals on that team. Very recently other researchers have stressed the importance of individualizing training load information not only by sport and gender, but by individuals within that sport (Coyne et al., 2018). The next step in this type of research should be to normalize training load data using Z-scores to be able to make direct comparisons across the team and within individuals. This could greatly benefit coaches when prescribing training and could help notify the coaches when athletes are outside their normal ranges of load. To enhance the accuracy and reliability of this data, training loads should also be tracked over the athlete's entire career to account for physiological adaptations and changes in training or playing time. Future load monitoring research should aim to be longitudinal to make accurate assessments of the data. Accumulating internal and external load data over an athlete's entire career could also assist athletic trainers with return to play protocols if that athlete became injured. They would have individual game and practice norms for the athlete to progressively work towards full recovery. This could potentially be invaluable information for athletic trainers and the coaching staff starting immediately.

Future studies investigating the same type and amount of training load data should utilize mix model analyses to investigate main effects and to take advantage of all the data points collected. Conversely, researchers should also consider a random sample of data points at specific time points to narrow down changes and differences to one period of training or games. Researchers could also attempt to control for or measure other psychological factors at play throughout the season (school stress, life stress, mood, etc.) to determine if they are significantly affecting sRPE loads. Because of the subjective nature of sRPE, other objective internal and external load measures should be assessed in a similar format of this study to investigate potential differences in load across multiple years and by classification. This could help coaches identify and establish norms from multiple perspectives and help guide them to optimal training design and improved performance.

Summary

The findings from this study are important for soccer coaches, sport scientists, and athletic trainers. Sport performance research is growing rapidly, so it is critical to investigate training design and monitoring within specific teams and populations to ensure that athletes avoid injury but still have the opportunity to improve performance. Although no significant differences in internal load were found in returning athletes over two years or among different classifications of players, this study has provided valuable trends and training recommendations for this specific team which can help the coaches train their athletes more optimally. This study contradicts training load research previously conducted in other sports and populations (Barroso et al., 2014; Gallo et al., 2015; Impellizzeri et al., 2019; Scanlan et al., 2011), however, beneficial descriptive information was still discovered which can be directly applied to this team. Further analysis of this data is still needed.

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Appendix A

ATHLTE CONSENT FORM

Texas Christian University
Fort Worth, Texas

CONSENT TO PARTICIPATE IN RESEARCH

Title of Research: The Effect of Training and Maturation on sRPE in NCAA DI Women's Soccer Players: A Multi-Season Exploration

Study Investigators: Dr. Debbie Rhea, Brianna Barnhill, Dr. Stephanie Jevas, Daniel Arndts, Andreas Kreutzer

What is the purpose of the research? The primary objective of this study is to compare internal load, via session rating perceived exertion, over the course of two consecutive NCAA DI Women's soccer seasons.

How many people will participate in this study? Thirty female soccer athletes who are currently on the TCU women's DI NCAA soccer team will be recruited for this study. Only those that are currently on the active roster will be enrolled in the study.

What is my involvement for participating in this study?
If you qualify and agree to participate, a research administrator will explain the risks associated with this study, which are listed below. You will have the opportunity to sign this informed consent. We will then collect basic information and medical history (age, height, weight, medical history, sport history). As part of the study, you will complete the following procedures throughout the entire season: daily wellness questionnaires, session rating of perceived exertion (sRPE) questionnaires, and agree to be monitored during training and matches with GPS and HR technology.

Wellness Questionnaire-
The wellness questionnaire is to be answered daily. It will be made available on your individual Teambuildr profile that you have made using your mobile device. The questionnaire will encompass 4 questions about your: sleep quantity, overall stress, muscle soreness, and energy level.

Session Rating of Perceived Exertion-
Your individual rating of perceived exertion will be collected within 15 minuets of your training. This questionnaire will be administered after each training session, game, and practice. Like the wellness questionnaire, the sRPE questionnaire will also be administered using your individual Teambuildr profile on your mobile device.

External Load and Heart Rate Monitoring-
This data will be collected at every training session and every match this season. Sport Science or athletic training personnel will be responsible for providing you with your individual vest, GPS Catapult unit, and Polar heart rate monitor. This process only requires you to put on and take off your assigned Catapult vest.

How long am I expected to be in this study for and how much of my time is required? You will participate in the screening and consent which will take approximately 30 minutes. The daily wellness questionnaire will take approximately 5 minutes to complete and will be done each day you have a soccer obligation. Your perceived rating of exertion will take only moments to complete and will be collected after each training session. External load monitoring will only require you to put on and take off your assigned vest at the beginning and end of every match and training session which will only take a couple minutes.

What are the risks of participating in this study and how will they be minimized? Risks outside of those standard to participation in the sport of soccer include those associated the assigned questionnaires. You may experience emotional discomfort during completion of the questionnaires. Each questionnaire will be thoroughly explained to you and you can ask questions at any time to reduce this risk of discomfort. You may stop filling out the questionnaire at any, however, refusal to fill out the questionnaire in their entirety will disqualify you from further participation in this study. There are no known risks associated with collecting the external load data. Collecting equipment, such as GPS vests and HR straps, may become uncomfortable during training or matches, but can be readjusted or resized when brought to the attention of study personnel.

What are the benefits for participating in this study? There is no direct benefit to the participants in this study. However, the results will help identify trends in sRPE over two consecutive season which can be potentially used to evaluate the effectiveness of training prescription and assist in avoiding overtraining.

Will I be compensated for participating in this study? There will be no compensation for participating in the study.

What is an alternate procedure(s) that I can choose instead of participating in this study?
There is no alternate procedure. You may simply choose to not participate in the study.

How will my confidentiality be protected? When enrolled in the study you will be assigned an identification number that is not associated with any of your personal information. This number will be used for all data collection. The code with identifying information will be stored on a TCU issued password-protected computer. In addition, all data will be stored in a locked file cabinet and password-protected computer for at least 3 years. Electronic data will be stored without identifiers on a password-protected computer. Only those investigators involved in data collection will have access to data. Names or any other identifying information will not be made known. Health information will be kept private and only those investigators identified on this form will have access to data. Data will be stored in a locked file cabinet for at least 3 years. Electronic data will be stored without identifiers on a password-protected computer.

Is my participation voluntary? Participation in this study is completely voluntary and you may withdraw at any time. Participation in this study will not result in any special treatment in either training or matches, nor will non-participation result in any punishment.

Can I stop taking part in this research? Yes, you may withdraw from the study at any time without penalty. If you wish to withdraw, you may communicate that information with any of the persons listed on this document or you may contact the PI: Dr. Debbie Rhea at 817-257-5263 or via email at d.rhea@tcu.edu.

What are the procedures for withdrawal?
You may contact Dr. Debbie Rhea at 817-257-5263 or by email at d.rhea@tcu.edu.

Will I be given a copy of the consent document to keep? Yes, you will be provided with a copy of the consent document.

Who should I contact if I have questions regarding the study? You may contact Dr. Debbie Rhea at 817-257-5263 or by email at d.rhea@tcu.edu.

Who should I contact if I have concerns regarding my rights as a study participant?

Dr. Dru Riddle, Chair, TCU Institutional Review Board, (817) 257-6811, d.riddle@tcu.edu; or Ms. Lorrie Branson, JD, TCU Research Integrity Officer, (817) 257-4266, l.branson@tcu.edu

Your signature below indicates that you have read or been read the information provided above, you have received answers to all of your questions and have been told who to call if you have any more questions, you have freely decided to participate in this research, and you understand that you are not giving up any of your legal rights.

Participant Name (please print): ____

Participant Signature: __________________________________ **Date:**_______________

Investigator Name (please print):__________________________________**Date:**_______________

Investigator Signature: __________________________________ **Date:**_______________

PROTECTED HEALTH INFORMATION AUTHORIZATION FORM

Researchers from the study "The Effect of Training and Maturation on sRPE in NCAA DI Women's Soccer Players: A Multi-Season Exploration " would like **your permission** to **use your health information** which will be gathered as a part of this study.

The following **health information** will be **gathered** from you:

Medical history
Height & Weight

The **names of the TCU researchers** who will gather this information from you are (insert the names of all TCU researchers starting with the lead researcher):

Debbie Rhea, Ed.D.	Brianna Barnhill, MS Student
Andreas Kreutzer, MS	Daniel Arndts, MS Student
Stephanie Jevas, PhD	

Your **health information may be shared** with others who are working with the TCU researchers on this study, institutes that are paying for this study or involved in any other way, or as required by law. The names of these other researchers (include name, affiliation, and role in the study) or institutions (name and role in the study) are listed below.

Eric Freese, PhD – Gatorade Sport Science Institute

The TCU researchers and other researchers who work with TCU will **protect** your **health information** in the following ways:

- Your health information will be kept **private**
- Your **name or any other identifying information will not** be made known
- Your health information may be shown in research papers or meetings **without any information about you** that will link it to you.
- Your health information will be given a **special code** for security
- Your health information will be **grouped together with other people's** health information to form an average
- Your health information will be **locked in a cabinet** and kept safe.

You can contact Dr. Debbie Rhea at d.rhea@tcu.edu or 817-257-5263 with any questions that you have about the study.

You will be **given a copy** of this form to keep.
If you have any **questions or concerns** about **your rights** as a study participant, you can contact:

Dr. Dru Riddle, Chair, TCU Institutional Review Board, (817) 257-6811, d.riddle@tcu.edu; or Ms. Lorrie Branson, JD, TCU Research Integrity Officer, (817) 257-4266, l.branson@tcu.edu.

By signing your name below, **you are saying** that you **understand what is being said in this form**, you have **received answers** to all your questions, you have **freely agreed to sign** this form, you have been told **who to contact** if you have questions regarding **your rights** as a participant, and you have **allowed TCU to gather, use, and share your health information** as described in the form.

Participant's Name (please print): ____

Participant's Signature: ____________________________ **Date:** ___________

Investigator's Signature: ____________________________ **Date:** ___________

<u>Legal Representative of Research Participant (if applicable):</u>

Legal Representative's Name (please print): ________________________________

Relationship to research participant: ___________________________

I certify that I have the legal authority as a ________________________________ (e.g., parent, legal guardian, person with legal power of attorney, etc.) to make this authorization on behalf of the research participant named above.

Signature of the Legal Representative: ____________________ **Date:** ___________

Investigator's Signature: ____________________________ **Date:** ___________

Appendix B

Foster’s Modified CR 10 sRPE Scale

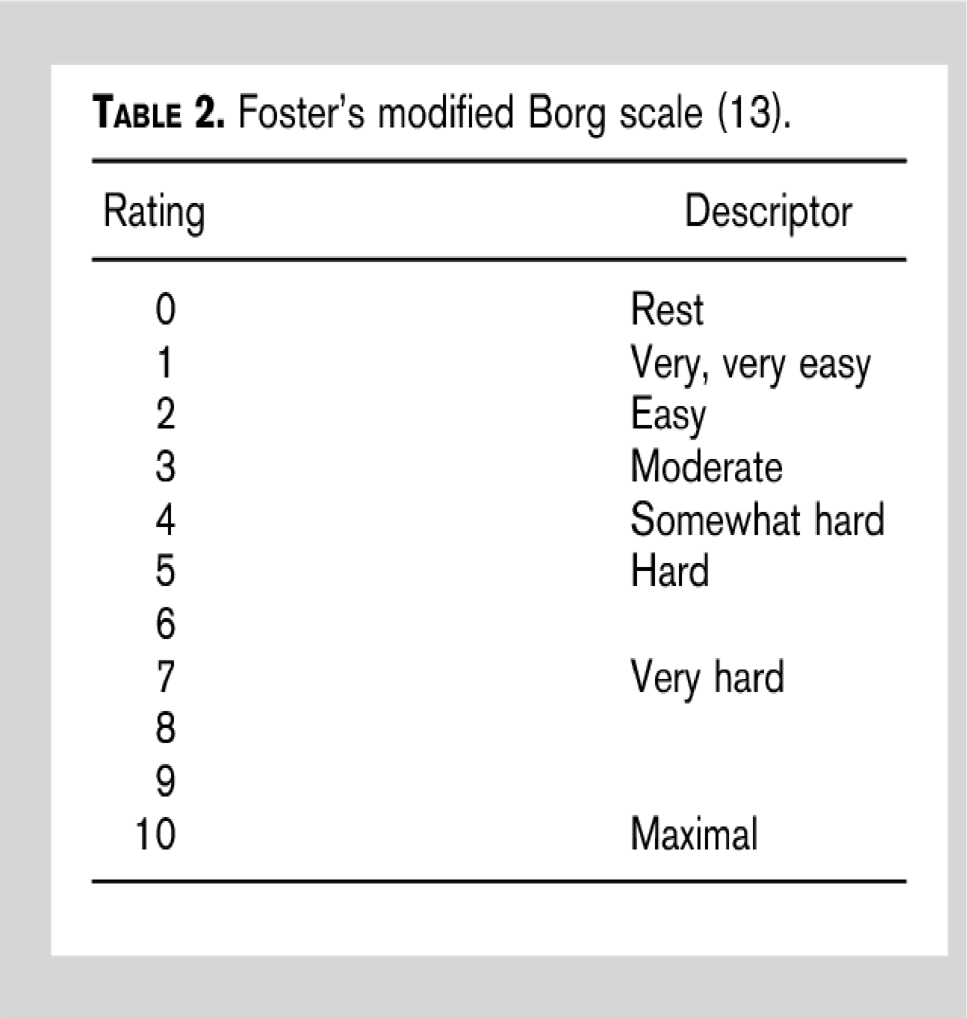

TABLE 2. Foster's modified Borg scale (13).

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

ABSTRACT

THE EFFECT OF TRAINING AND MATURATION ON sRPE IN NCAA DI WOMEN SOCCER PLAYERS: A MULTI-SEASON EXPLORATION

By Brianna Nicole Barnhill M.S., 2020
Department of Kinesiology
Texas Christian University

Thesis Advisor: Dr. Debbie Rhea, Associate Dean of Harris College

The purpose of this study was to investigate the effect that prescribed training and age have on an internal load which is how individuals physiologically respond to training. This was measured using Session Rating of Perceived Exertion (sRPE) in NCAA Division I female soccer athletes (N=39). No significant differences in internal load were found in returning athletes over two years or among different classifications of players, but this study has provided valuable trends and training recommendations for this specific team which can help the coaches train their athletes more optimally. It is critical to investigate training design and monitoring within specific teams and populations to ensure athletes avoid injury but still have the opportunity to improve performance. Load monitoring is a growing field that needs more longitudinal collegiate female soccer literature to educate coaches and sport scientists.