Georgia Southern University
Digital Commons@Georgia Southern

Electronic Theses and Dissertations

Graduate Studies, Jack N. Averitt College of

Summer 2019

# Player-Coach Perceptions of Internal Load, Exertion, and Recovery in Collegiate Male Soccer Players

Michelle L. Eisenman

PLAYER-COACH PERCEPTIONS OF INTERNAL LOAD, EXERTION, AND RECOVERY IN COLLEGIATE MALE SOCCER PLAYERS

by

MICHELLE EISENMAN

(Under the Direction of Greg Ryan)

ABSTRACT

Periodization of athlete training load to improve performance and maximize recovery, while reducing injuries and overtraining, is essential in team sports. Understanding internal load responses and monitoring athlete exertion and recovery can help coaches during a competitive season. Recovery Status (PRS) and Rating of Perceived Exertion (RPE) are two subjective scales used to help quantify training load and recovery. These scales are more useful if there is an agreement between coaches (C) and players (P) assessment of intensity and recovery. **PURPOSE:** To assess subjective measures (PRS and RPE scores) from P and C during a 13-week competitive soccer season. Furthermore, this study evaluated the relationship between P RPE and average practice heart rate (HR). **METHODS:** PRS scores prior to, and RPE scores after, practice were collected on 26 Division I male soccer P and 4 C. HR monitors were worn by P each practice and HR was averaged for the session. C were instructed to provide answers to PRS and RPE as to how P felt. Due to the categorical nature of the data, nonparametric Mann-Whitney U Tests were run comparing P to C data for each week (1-13). Spearman rank-order correlations were run comparing P RPE and average HR. **RESULTS:** There were statistically significant differences between P and C reported PRS ($U$ = 59175.5, $p$ = 0.03, $r$ = 0.07), but no differences for RPE ($U$ = 29153.5, $p$ = 0.52) across the 13-week season. When separated by week, only Week 6 was significant for PRS and RPE ($U$ = 305, $p$ < 0.01, $ES$ = 0.26; $U$ = 112, $p$ = 0.02, $ES$ = 0.22, respectively). A significant, strong, positive correlation ($r$ =0.53, $p$ <0.01) was found between seasonal HR and RPE among P. **CONCLUSION:** P and C mostly agreed on intensity of training and recovery throughout the season. HR and P reported RPE were significantly correlated indicating harder practices resulted in higher HR. The agreement between P and C indicate that these scales may be a successful and valid tool in helping to monitor training load during a competitive season.

INDEX WORDS: RPE, Heart rate, Football, Team sport, Training load monitoring

PLAYER-COACH PERCEPTIONS OF INTERNAL LOAD, EXERTION, AND RECOVERY IN COLLEGIATE MALE SOCCER PLAYERS

by

MICHELLE EISENMAN

B.S., Catawba College, 2016

M.S., Georgia Southern University, 2019

A Thesis Submitted to the Graduate Faculty of Georgia Southern University

in Partial Fulfillment of the Requirements for the Degree

MASTER OF SCIENCE

STATESBORO, GEORGIA

# PLAYER-COACH PERCEPTIONS OF INTERNAL LOAD, EXERTION, AND RECOVERY IN COLLEGIATE MALE SOCCER PLAYERS

by

MICHELLE EISENMAN

| | |
|---|---|
| Major Professor: | Greg A. Ryan |
| Committee: | Stephen J. Rossi |
| | Bridget F. Melton |

Electronic Version Approved:
July 2019

# ACKNOWLEDGMENTS

Foremost, I would like to thank my mentor and chair of my committee, Dr. Greg Ryan. Words cannot describe how grateful I am for guidance and unwavering support. Not only did you open the door to all these research opportunities, but you have been by my side every step of the way. Thank you for never giving up on me, even when it was clearly the easier option. I could not have accomplished as much as I have without your help along the way. You always knew what I needed to hear to keep me going, ranging from “breathe…” and “go home and sleep, you look exhausted,” to “the world doesn’t stop turning; get your stuff done.” Thank you for putting up with my sleep-deprived sassiness, keeping me on track, and sharing your wisdom with me throughout the years.

Additionally, I would like to thank Dr. Bridget Melton and Dr. Stephen Rossi for all the encouragement and insightful comments throughout this process. Thank you for all your hard work and dedication to my academic success. My committee members never faltered and were willing to be a part of this crazy journey. I sincerely appreciate all that Dr. Rossi, Dr. Melton, and Dr. Ryan have done for me.

My research would have been impossible without the aid, support, and willingness of Coach Murph and his coaching staff as well as and the 2018 Georgia Southern University Men’s Soccer team. Thank you all for your patience and cooperation throughout the past couple seasons. Working alongside this program has proven to be an amazing opportunity and opened my eyes to human performance research.

I would like to extend a special thank you to the lovely nightshift custodians that saw me in the office each night working on this project. I appreciate all the anecdotes and positive attitudes, as well as the amount of times I was checked on to see if I was still “burning the midnight oil.”

Finally, I would like to thank my family, friends, and colleagues for their support and constant encouragement. Thank you to Emily Langford, Mary Beth Yarbrough, and Sarah Lanham for your unconditional support and always being available for venting sessions, as well providing happy distractions along the way. There were days where I did not believe I would finish, but you all had faith I could do it. As for the people that said I cannot do it and would be better off on another track, thank you for that bizarre form of motivation.

# TABLE OF CONTENTS

# LIST OF TABLES

LIST OF FIGURES

Page

# CHAPTER 1

# INTRODUCTION

## Purpose of the Study

This study seeks to understand the relationship between player (P) and coach (C) perceptions of internal load variables throughout a 13-week competitive soccer season. The internal load variables include perceived recovery status (PRS) and ratings of perceived exertion (RPE). It is crucial P and C are in agreement of these variables to ensure the proper training load is imposed along with adequate recovery. Both are necessary to achieve desired adaptations and to prevent injuries and overtraining. Furthermore, this study explored the relationship between athlete RPE and average heart rate during training in an effort to validate player perception of training load to a quantifiable marker.

### *How This Study Is Original*

The present study involves Division-I collegiate athletes. The vast majority of the current research on this topic is on professional or elite athletes. However, collegiate athletes have a unique set of stressors that other athletes may not have, such as the academic stress, social pressure, and congested travel schedule. Additionally, very little research has compared coach and player perception of exertion and recovery, and even less has involved daily monitoring.

Training for sports requires a focus on both physiological and psychological load placed on the athletes to achieve success and maximize performance. During a competitive season, athletes undergo varying practice frequencies, durations, and training intensities. Accurately monitoring the stress the athlete experiences throughout the competitive season is an important consideration for coaching staff and sport scientists. One of the most common ways to measure the physiological and psychological stress is through calculating athlete training load. Training load takes into account both the volume and intensity of a training session or competition (Coutts, Gomez, Viveiros, & Aoki, 2010). Throughout the season, coaching staffs vary training structure to tax athletes physically and mentally, as well as to allow them to recover from previous training sessions or competition. Although the periodization of a competitive season tends to be scheduled before the season starts, coaches may need to adjust it as the season progresses based on athlete responses to the training. It is imperative that coaching and training staffs monitor the training load they are prescribing their athletes to achieve the desired adaptations while simultaneously reducing the risk of overtraining. Daily and weekly training loads are altered by adjusting various factors such as the duration, frequency, and intensity of training (Foster et al., 2001; Halson, 2014). Keeping the training load too high increases the risk of injury and the potential for overtraining, since oftentimes athletes do not have enough time between sessions or competitions to recover (Buchheit et al., 2013; Laurent et al., 2011). On the other hand, too low of a training load will not allow for proper adaptations to occur, and not maximize the time the coach has with the athlete. It is important for coaches to be aware of an athlete's, or team's, recovery status throughout the competitive season as it is a crucial component in skill development, refinement, and injury avoidance (Laurent et al., 2011).

Training load can be monitored both internally and externally using a myriad of variables and techniques (Impellizzeri, Rampinini, & Marcora, 2005). Internal training load refers to how the body responds to the external stimuli and includes level of fatigue, stress, soreness, and sleep quality (Oliveira et al., 2019). External factors include variables such as total distance, duration, number of sprints, power output, and speed, usually through the use of accelerometers and global positioning systems (Halson, 2014; Oliveira et al., 2019). In other words, internal training load represents the body's response to stress whereas external training load represents the physical work (Impellizzeri et al., 2005; McLaren et al., 2018).

One of the most common ways that physiological measures of internal training loads are evaluated is through heart rate (HR) monitors (Halson, 2014; Impellizzeri, Rampinini, Coutts, Sassi, & Marcora, 2004). These monitors can provide valuable information about the stress of a player or team to coaching and training staffs. More recently, psychological evaluation tools, such as ratings of perceived exertion (RPE), total quality recovery (TQR), perceived recovery status (PRS) scales, among others have been increasingly used. Subjective scales are oftentimes used in conjunction with HR monitors as an internal load monitoring tool to understand and evaluate players' perception of training load (Buchheit et al., 2013; Halson, 2014; Impellizzeri et al., 2004; Nazari et al., 2018). Despite slight variance in research on the reliability of internal training load measures, a meta-analysis completed by McLaren et al. (2018) demonstrated a consistent positive correlation between heart rate and perceived exertion.

Although it is beneficial to utilize both internal and external load quantifying techniques, the specific methods used will be dependent on resources available (financial and personnel). Methods that quantify external training load tend to be more expensive due to the wearable devices and their corresponding software. Internal measures, such as HR monitors and self-reported measures, are more cost-efficient while still reliable (Chen et al., 2002; Kellmann, 2010). Self-reported measures can be used alone or concomitantly with other methods. Some of the most common psychometric measures are RPE, TQR, PRS scales, and Recovery-Stress Questionnaires (RESTQ-Sport) (Chen, Fan, & Moe, 2002; Kellmann, 2010; Kentta & Hassmen, 1998; Laurent et al., 2011). As with all techniques, each of the self-monitoring tools has its advantages and disadvantages.

Extensive research has been executed to test the validity and reliability of the use of RPE scores (Chen et al., 2002; Kellmann, 2010). RPE is collected after an exercise or training session to individually rate its difficulty based on effort and exertion. There are multiple variations of RPE scales that can be utilized, including the CR-10 scale (ranges 0-10) and the original Borg RPE scale (ranges 6-20). The original Borg RPE scale correlates with exercise heart rates in healthy individuals. Both scales have verbal anchors attached to numbers to help participants understand what the numbers mean (Chen et al., 2002). RPE is a quick and easy instrument that can be used to quantify training load by estimating intensity.

There are multiple methods that can be used to quantify recovery status in athletes, since recovery is pertinent to improving performance and decreasing risk of injury, illness, and overtraining (Kellmann, 2010). By incorporating an instrument that quantifies the level of individual recovery, athletes and coaches alike can become more aware (Kentta & Hassmen, 1998). Increasing awareness can improve passive and active recovery. Similar to RPE, TQR utilizes a 6-20 point Likert-based scale, using analogous verbal anchors. However, the scales are inverse, which can be misleading to the individuals reporting scores. TQR was created to find the balance between overtraining and undertraining through psychophysiological means (Kentta & Hassmen, 1998). TQR is generally split into a subjective scale (TQRperceived) and objective scale (TQRactive) to incorporate qualitative and quantitative recovery factors. Splitting TQR into multiple scales allows for different types of questioning, but then requires calculating all the scores together to determine recovery status. Laurent et al. (2011) argue that utilizing TQR is better in theory than in practice, due to potential decreased compliance that often follows more challenging or tedious tasks.

RESTQ-Sport is another instrument for quantifying recovery among athletes by assessing physical and mental stress. It is a much longer method, which includes 77 items on a 0-6 Likert-type scale that the athlete answers. These questions are then broken down into categories based on general stress, sport-specific stress, general recovery, and sport-specific recovery (Kellmann, 2010). The number of questions, along with the breakdown can help athletes identify where their stress is and how to improve individual recovery. Although inclusive of a prodigious amount of factors, it is challenging to get athletes to respond fully and thoughtfully to each question (Halson, 2014). Additionally, due to the length of the questionnaire, there would be a limit on how often athletes fill it out, unlike other recovery reports that could be done daily.

PRS is a method that can be utilized daily to monitor athlete recovery (Laurent et al., 2011). It is a quick and reliable measure. The scale ranges from 0-10 with verbal anchors, making it simple to understand, and was modeled after the CR-10 RPE Scale (Laurent et al., 2011). It was modeled after that RPE scale because it is commonly used and understood. PRS was originally used for bout-to-bout/inter-set recovery but has since then been expanded for daily monitoring. Upon creation of the scale, Laurent et al. (2011) monitored its capability to accurately identify improved or declined performance based on perceived recovery. The scale worked best in cases where participants reported they were under-recovered. It was also founded that there was an increased consistency in more ‘extreme’ values with respect to individual performance. It has been shown to have a negative correlation with RPE and session-RPE (Laurent et al., 2011). As the intensity of a training session increases and athletes exert more effort, it is logical that the following day, they would feel less recovered. This scale can effectively monitor individual and team recovery status from each training session, which can give coaches a better idea on how to alter the following training sessions to achieve desired adaptations.

While it is possible to determine training load through exclusively physiological variables of internal or external measures, obtaining self-reported psychological measures of training load are important to create a more complete image of all of the stress the athlete is experiencing during training and competition. Differences among the athletes overall training load comes from individual internal characteristics, such as fatigue, stress, sleep, and nutrition. Two athletes may experience the same practice, thus the same external load, but the internal stress could have been completely different, due to fatigue or inadequate recovery from the previous training session (Halson, 2014).

There is not currently a gold-standard method for measuring training load (Halson, 2014; McLaren et al., 2018). Elite level athletes often have nearly every aspect of their performance monitored daily, both on and off the playing surface. The quantity and quality of data this type of monitoring provides is incredibly beneficial to coaching and training staffs in determining optimal training loads and player fatigue throughout the season (Buchheit et al., 2013). However, this method may not be feasible for each team due to the costs and expertise needed to collect and analyze the data. According to Buchheit et al. (2013), perceived wellness scores (i.e. fatigue, soreness, mood, stress levels, and sleep quality) and HR can accurately monitor training load and individual responses. Many professional and collegiate sport organizations have begun to monitor training load through HR devices, given their ease of administration, cost-effectiveness, and ability to wear the devices in competition following relatively recent rule changes (Impellizzeri et al., 2004). Additionally, incorporating HR to quantify individual internal training load along with obtaining player perceived exertion and recovery values, may provide valuable insight that has not been completely explored previously (Redkva, da Silva, Paes, & Dos-Santos, 2017).

Additionally, monitoring daily RPE scores is a common valid and reliable method to measure the athlete's perception of the training and is an indicator of overall psychophysiological load in team sports such as soccer (Chen et al., 2002; Gaudino et al., 2015). Evaluating RPE with various internal and external load variables, including HR and distance traveled, has demonstrated strong correlations in various sports (Borresen, & Lambert, 2008; Halson 2014). Coaching staffs put a great deal of time and effort into periodizing practice structure over the course of the competitive season, to maximize skill development and refinement while allowing for adequate recovery.

However, there are times where a coach's perception of the intensity of a training session is not matched by his or her players. Previous studies have investigated discrepancies between the training load planned by coaches and how the athletes actually perceive the load (Andrade Nogueira et al., 2014; Brink & Frencken, 2018; Wallace, Slattery, & Coutts, 2009). These studies reported discrepancies between player and coach perceptions often surrounding the intensity of the training sessions. Coaches and players tended to agree more often for the moderate-intensity sessions than for the low-intensity and high-intensity sessions (Andrade Nogueira et al., 2014; Redkva et al., 2017; Wallace et al., 2009). Players tended to report higher RPE values when compared to their coaches for both low-intensity and high-intensity training sessions. Other factors may also affect the level of agreement. It is proposed that the age and amount of experience the athlete has greatly influences the level of agreement with coaches on perceived exertion. Older and more experienced athletes have a higher correlation in values reported with their coaches. On the other hand, organizing the athletes of team sports by positions did not affect perceived exertion or load perceptions, regardless of the different demands at the various positions (Andrade Nogueira et al., 2014; Redkva et al., 2017). Understanding the internal responses the imposed training loads have on their athletes, and accurately monitoring exertion and recovery, can help coaches plan for future training sessions, and maximize subsequent performance.

While there has been some advancement in player-coach internal load comparisons among elite athletes, limited research is available on these comparisons in collegiate athletics. The purpose of this study was to compare player (P) to coach (C) perceptions of internal load variables of RPE and PRS during the course of a 13-week competitive season. Furthermore, this study explored the relationship between athlete RPE and average HR during training in an effort to validate player perception of training load to a quantifiable marker.

# CHAPTER 2

# METHODS

## *Experimental Approach to the Problem*

This study used an experimental design involving the seasonal analysis of a collegiate male soccer team to quantify and compare player RPE and PRS variations throughout the competitive season against their coaches. Secondary analysis was conducted to determine the agreement of player subjective measure of RPE to practice intensity. Intensity was quantified via average HR during each practice of the competitive season. Subjects wore a BioHarness that tracked HR and self-reported measures of RPE and PRS at each practice over a 13-week period during a competitive season from August to November. For the primary analysis, status (player or coach) was treated as the independent variable, with RPE and PRS treated as dependent variables. For the secondary analysis, correlations were run between player RPE and average HR during training for each practice.

## *Subjects*

Twenty-six Division-I collegiate male soccer players and four coaches (head coach has 25 years of coaching experience, and three assistants with 5.0 ± 2.4 yrs experience), which represented the entire population, participated in the study. Goalkeepers were excluded from data analysis, due to the nature of the BioHarness impeding their mobility during training, as well as the varying nature of their training, which impacts the variables collected. Data was excluded from analysis for individuals that did not participate in sessions due to injuries. Individuals needed to be enrolled as a full-time student and play for the university men's soccer team to participate. The university Institutional Review Board approved this study. All participants provided written consent after being informed of the study and its procedures.

## *Instrumentation*

The players' HR during each practice was recorded using a Zephyr 21 BioModule (Model BH3, Zephyr Technology Corporation, Annapolis, MD, USA). The BioModule, which functions as a transmitter and data logger, attaches to a chest receptacle on the compression shirt (BioHarness) and logs active practice time and HR. Prior to the start of the season, a profile (i.e., height, weight, age-predicted maximum HR) was created for each player. The BioModules were coded and matched to a player. The same units were used for each training session during the 13-week season to avoid variability within the system. Prior to the start of each practice, the BioModules were powered on for a minimum of 15 minutes, in accordance to manufacturer protocol. The BioModule was worn underneath the jersey, aligning with the xiphoid process, and secured to the BioHarness according to manufacturer recommendations. The HR data collected during practice were downloaded each day using the BioModule's software package (OmniSense Analysis, v. 3.9.7). Subjective scores were taken at the beginning and end of each session, using the PRS and RPE scales, respectively. Athletes and coaches alike were provided a visual of each scale at every session.

*Procedures*

For the purposes of the current study, all full-team practices over the course of the 13-week competitive season were considered for analysis. This refers to training sessions in which both the starting and non-contributing players trained together. All other forms of training were not included in the study. At the beginning of every practice, athletes arrived at the field and went to an investigator to provide a PRS score. Athletes were asked to step away from other players, to ensure that other players were not able to hear their answer, and were instructed not to share their responses with other members of the team or staff. Additionally, athletes were shown a copy of the PRS scale prior to providing an answer. The answer was then be recorded onto a computer, and the athlete received their assigned BioHarness. The same process was completed with each member of the coaching staff, following all the same parameters as the players. The start and end of practice was logged by an investigator and data recorded throughout practice. After each practice, a RPE score were provided by each athlete and coach following the same protocol as pre-practice. After providing an RPE score, players returned the BioHarness.

*Statistical Analysis*

All data were analyzed using SPSS (version 25.0; SPSS, Inc., Chicago, IL). Data was grouped and organized by week, and primary comparisons were made between P and C. The initial comparison was made to determine P to C agreement on both variables of interest, and additional analyses were conducted to determine agreement at each week of the 13-week competitive season. Mann-Whitney U tests were performed for RPE and PRS comparisons due to the categorical nature of the scales. Effect sizes were calculated using the formula $ES = Z \div (\sqrt{N})$, where Z is the Z-statistic from the Mann-Whitney test and N is the number of observations at each comparison. Secondary analysis was conducted using Spearman rank-order correlations to determine the relationship between player RPE and average HR during practice. Significance for all main effect results was set at an alpha of 0.05. The strength of the correlation coefficients were assessed using the Hopkins scale: ≤ 0.1 = trivial; 0.1 to 0.3 = weak; 0.3 to 0.5 = moderate; 0.5 to 0.7 = strong; 0.7 to 0.9 = very strong; > 0.9 = nearly perfect; 1 = perfect (Hopkins, Marshall, Batterham, & Hanin, 2009). Results are reported as mean ± standard deviation (SD) for continuous data, and median ± interquartile range (IQR) for categorical data.

# CHAPTER 3

# RESULTS

Data from 45 training sessions were collected and averaged throughout the 13-week competitive season from coaches (n = 4) and players (n = 26). Player demographic data are included in Table 1.

**Table 1**. Descriptive statistics of Division I male soccer players.

| | Mean ± SD |
|---|---|
| Age (yr) | 19.8 ± 1.4 |
| Height (cm) | 179.4 ± 6.5 |
| Weight (kg) | 73.4 ± 5.4 |

Note: yr = years; cm = centimeters; kg = kilograms

*P and C PRS and RPE Agreement*

Over the course of the 13-week competitive season, there were statistically significant differences between P and C with regard to PRS scores ($U$ = 59175.5, $p$ = 0.03, $r$ = 0.07), indicating that P and C disagreed on player recovery during the competitive season. However, reported RPE scores between P and C were not significantly different ($U$ = 29153.5, $p$ = 0.52) throughout the season, indicating an agreement on perceived intensity of practices during the course of the season. Further analysis revealed where during the course of the competitive season the differences in values were between weeks. Figure 1 presents the weekly differences between P and C reported PRS scores. Furthermore, the weekly differences in reported RPE scores between P and C are represented in Figure 2. During the 13-week season, only Week 6 showed statistically significant differences in P and C agreement of PRS and RPE scores, ($U$ = 305, $p < 0.01$, $ES$ = 0.26; $U$ = 112, $p$ = 0.02, $ES$ = 0.22, respectively). It is important to note that while statistically significant, the small effect size indicates that there may be limited practical difference during this week, which may explain how a difference in P and C RPE was found here, but not over the course of the whole season. Analysis suggests agreement between P and C on training exertion and recovery scores ($p > 0.05$) during the other 12 weeks of the competitive season (Table 2).

**Table 2.** Weekly Perceived Recovery Scores (PRS) and Ratings of Perceived Exertion (RPE) comparisons between players (P) and coaches (C) in Division I male soccer players.

| | | PRS | | | RPE | | |
|---|---|---|---|---|---|---|---|
| Week | | Median ± IQR | *p* | ES | Median ± IQR | *p* | ES |
| 1 | P | 5 ± 2 | 0.50 | -0.07 | 13 ± 6 | 0.69 | -0.04 |
| | C | 4 ± 1 | | | 13 ± 0 | | |
| 2 | P | 6 ± 2 | 0.98 | 0.00 | 13 ± 2.25 | 0.73 | -0.04 |
| | C | 6 ± 4 | | | 13.5 ± 0.5 | | |
| 3 | P | 6 ± 2 | 0.79 | -0.03 | 12 ± 4 | 0.55 | -0.06 |
| | C | 6 ± 3.5 | | | 12.5 ± 5.5 | | |
| 4 | P | 6 ± 3 | 0.33 | -0.11 | 13 ± 5 | 0.82 | -0.03 |
| | C | 5 ± 3 | | | 13 ± 0 | | |
| 5 | P | 7 ± 3.5 | 0.35 | -0.11 | 11 ± 2 | 0.52 | -0.08 |
| | C | 5.5 ± 4 | | | 12 ± 0 | | |
| 6 | P | 6 ± 1 | >0.01* | -0.26 | 13 ± 2 | 0.02* | -0.22 |
| | C | 5 ± 1 | | | 12 ± 1.5 | | |
| 7 | P | 6 ± 2 | 0.15 | -0.14 | 14 ± 3 | 0.38 | -0.09 |
| | C | 5 ± 2.5 | | | 14 ± 3 | | |
| 8 | P | 6 ± 2 | 0.71 | -0.05 | 10 ± 2 | 0.72 | -0.05 |
| | C | 6.5 ± 2.25 | | | 10 ± 2.75 | | |
| 9 | P | 6 ± 4.25 | 0.72 | -0.05 | 12 ± 7 | 0.89 | -0.02 |
| | C | 5.5 ± 3.25 | | | 12 ± 0 | | |
| 10 | P | 6 ± 2 | 0.37 | -0.09 | 11 ± 3 | 0.13 | -0.16 |
| | C | 6 ± 2.5 | | | 9 ± 2.25 | | |
| 11 | P | 6 ± 2 | 0.80 | -0.03 | 12 ± 2 | 0.57 | -0.07 |
| | C | 6 ± 2 | | | 12 ± 3 | | |
| 12 | P | 6 ± 2.5 | 0.17 | -0.14 | 11 ± 2.25 | 0.24 | -0.12 |
| | C | 7 ± 1 | | | 11 ± 2.75 | | |
| 13 | P | 7 ± 2 | 0.18 | -0.13 | 9 ± 3 | 0.97 | 0.00 |
| | C | 7 ± 2 | | | 8.5 ± 3.25 | | |

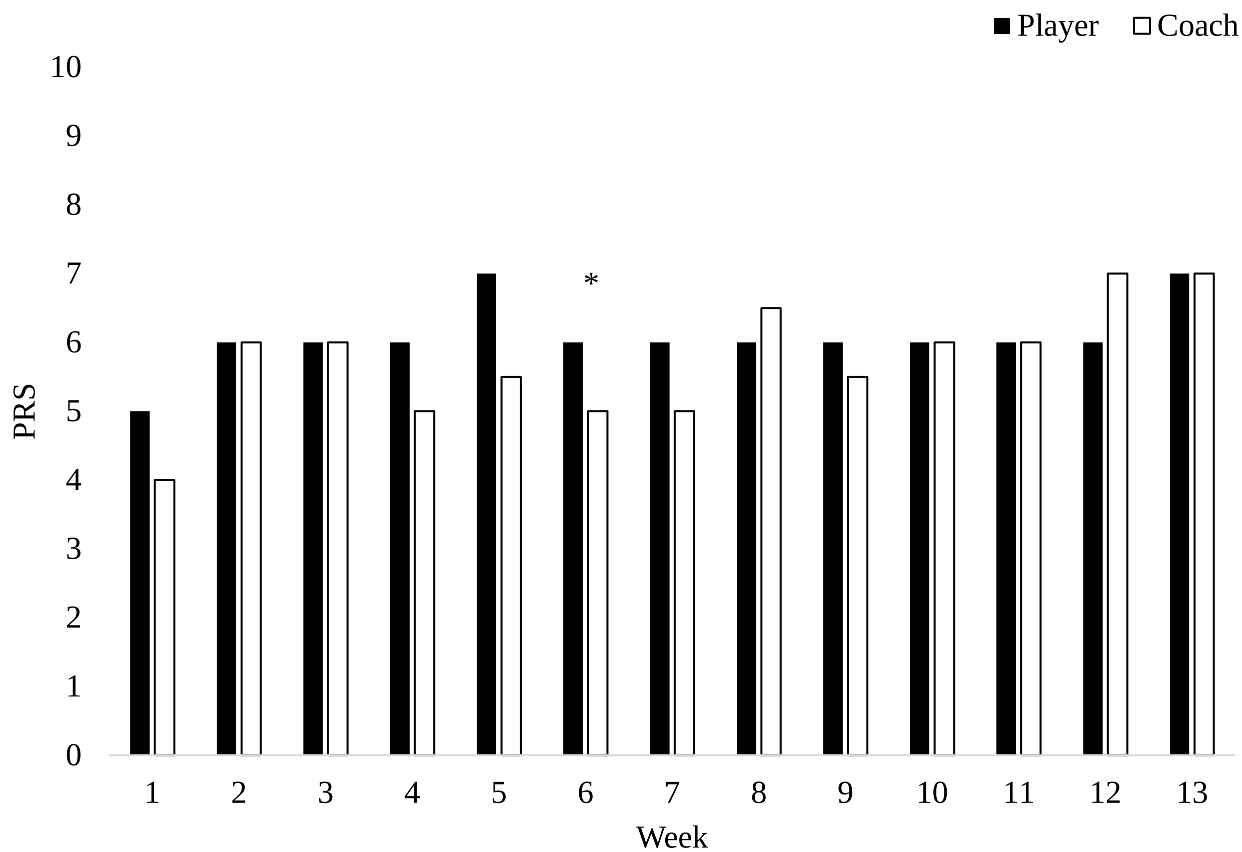


**Figure 1.** Player to Coach median rank of perceived recovery scores (PRS) during a 13-week competition season in Division I male soccer players. *Denotes significant difference at $p < 0.05$.

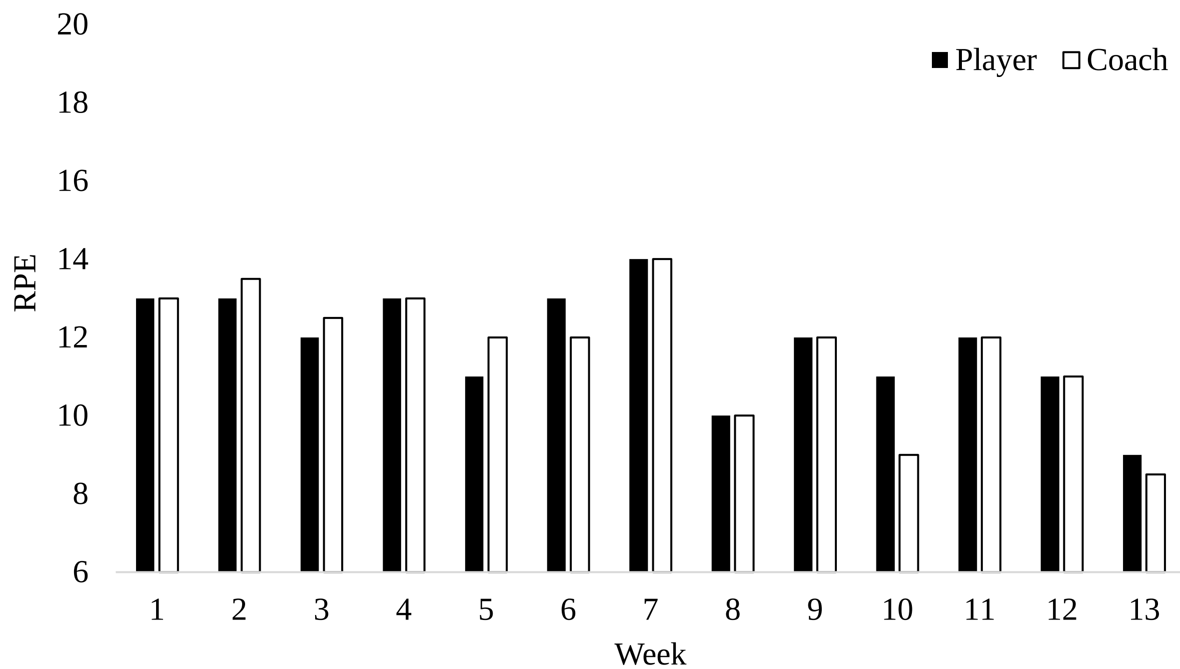


**Figure 2.** Player to Coach median rank of ratings of perceived exertion (RPE) during a 13-week competition season in Division I male soccer players. *Denotes significant difference at $p < 0.05$.

*HR and RPE Correlation*

Table 3 shows average practice HR at each RPE level provided by the athletes post-training. Table 4 provides average practice HR during each week of the 13-week competitive season. A significant, strong, positive correlation ($r_s = 0.53$, $p < 0.01$) was found between seasonal HR and RPE amongst players (Figure 3). Further analysis revealed significant correlations of average practice HR to player-reported RPE for 10 of the 13 weeks of the competitive season. Week 2 ($p = 0.72$), Week 6 ($p = 0.14$), and Week 8 ($p = 0.06$) did not show a significant relationship between HR and RPE during these weeks. Strength of significant correlations varied from weak to strong throughout the weeks during the competitive season. Table 5 provides individual correlation coefficient values and relationship between HR and RPE for each week.

**Table 3.** Average practice HR at each RPE value.

| RPE | HR (bpm) (Mean ± SD) | Min | Max |
|---|---|---|---|
| 6 | 96 ± 13 | 59 | 134 |
| 7 | 111 ± 21 | 74 | 164 |
| 8 | 110 ± 15 | 57 | 143 |
| 9 | 109 ± 16 | 65 | 155 |
| 10 | 116 ± 13 | 91 | 157 |
| 11 | 117 ± 14 | 64 | 153 |
| 12 | 120 ± 12 | 86 | 166 |
| 13 | 125 ± 12 | 101 | 152 |
| 14 | 126 ± 12 | 87 | 160 |
| 15 | 130 ± 11 | 107 | 162 |
| 16 | 130 ± 13 | 103 | 162 |
| 17 | 136 ± 14 | 109 | 168 |
| 18 | 135 ± 12 | 124 | 157 |
| 19 | 147 ± 9 | 136 | 154 |
| 20 | 139 ± 16 | 128 | 150 |

Note: HR = heart rate; RPE = rating of perceived exertion; bpm = beats per minute

**Table 4.** Weekly average practice HR.

| Week | HR (Mean ± SD) | Min | Max |
|---|---|---|---|
| 1 | 121 ± 14 | 89 | 168 |
| 2 | 126 ± 9 | 104 | 148 |
| 3 | 121 ± 19 | 82 | 166 |
| 4 | 120 ± 13 | 88 | 141 |
| 5 | 120 ± 17 | 74 | 152 |
| 6 | 127 ± 13 | 82 | 162 |
| 7 | 125 ± 18 | 77 | 162 |
| 8 | 119 ± 13 | 98 | 142 |
| 9 | 117 ± 24 | 59 | 157 |
| 10 | 115 ± 14 | 64 | 149 |
| 11 | 114 ± 14 | 78 | 153 |
| 12 | 110 ± 14 | 64 | 159 |
| 13 | 116 ± 15 | 76 | 157 |

Note: HR = heart rate

**Table 5.** Spearman correlations of weekly HR and RPE agreement in Division I male soccer players.

| | | HR | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Week | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
| | *r* | 0.58 | -0.04 | 0.73 | 0.42 | 0.46 | 0.14 | 0.57 | 0.28 | 0.65 | 0.33 | 0.53 | 0.61 | 0.29 |
| RPE | *p* | < 0.01* | 0.72 | < 0.01* | < 0.01* | < 0.01* | 0.14 | < 0.01* | 0.06 | < 0.01* | < 0.01* | < 0.01* | < 0.01* | < 0.01* |
| | *N* | 90 | 73 | 99 | 69 | 67 | 114 | 82 | 46 | 41 | 88 | 62 | 79 | 88 |

Note: HR = heart rate; RPE = rating of perceived exertion; *r* = correlation coefficient; *p* = p-value; *n* = sample; *denotes significance at ≤ 0.01.

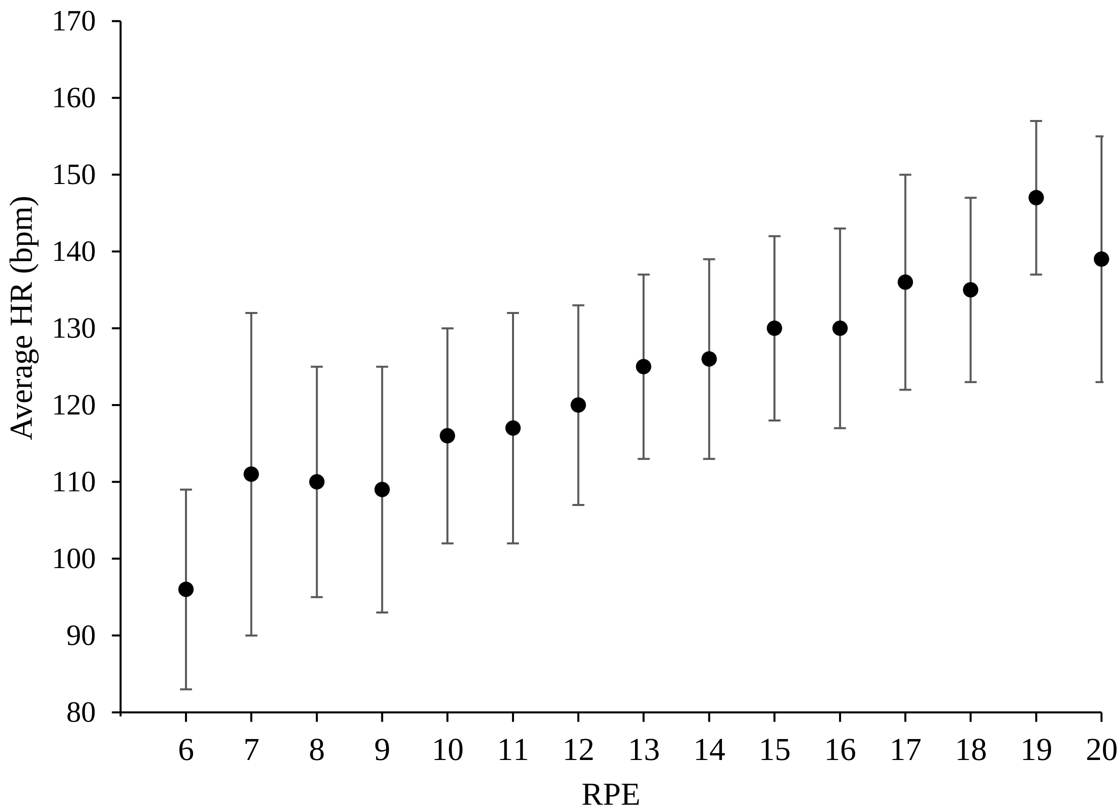


**Figure 3.** Mean and standard deviation of practice heart rate (HR) compare to reported ratings of perceived exertion (RPE) scores in Division I male soccer players. Note: significant, strong, positive correlation ($r = 0.53$, $p < 0.01$).

# CHAPTER 4

# DISCUSSION

The primary purpose of this study was to compare collegiate soccer P and C self-reported internal load measures for recovery (PRS) and exertion (RPE) throughout the course of a 13-week competitive season. Minimal research has been done comparing C and P perceptions of internal load, and even less is focused on the collegiate population. RPE was not significantly different over the course of the competitive season. Therefore, P and C tended to agree on the relative intensity of practices. However, there was a significant difference in reported PRS scores. Overall, P indicated they were slightly more recovered than C thought they were. However, only one week out of the entire 13-week competitive season showed statistically significant results for either scale. Week 6 showed significant differences for both PRS and RPE values. P reported being more recovered than C perceived. As C believed P to be less recovered in week 6, they intended practice sessions to be a low-intensity to assist with recovery. However, P rated the practices as requiring more exertion than what the coaches thought. This could be due to potential increased duration of practice, volume and type of drills, or intensity level over a shorter duration. Week 6 marked the middle of the competitive season and the athletes might have had added stressors on them, such as an increase in schoolwork, that could have added to the stress of practice. Although statistically significant, the practical difference between P and C may not mean much due to the small effect size, indicating that the actual difference between comparisons were not vastly different. The results reported for the primary analysis corresponded with the literature comparing C and P perceptions of training load. P and C tend agree with the exertion in moderate-intensity session, but some disagreement still exists on higher and lower intensities (Andrade et al., 2014; Brink & Frencken, 2018; Doeven et al., 2017; Redkva et al., 2017; Wallace et al., 2009). Due to the fact that the average HR recorded during weekly training did not exceed moderate intensity (110-127bpm), this could help explain why P and C agreed on RPE as much as they did.

Additionally, the secondary purpose of this study was to evaluate the relationship between the athletes' self-reported RPE scores with the average practice HR. There was a strong, significant, positive correlation (*r* = 0.53, *p* < 0.01) for HR and RPE across the competitive season. As the practices got harder, average session HR increased as well (Table and Figure 3). Broken down by weeks, there were significant correlations for each week in the competitive season except for weeks 2, 6, and 8 (*r* = 0.04, *p* = 0.72; *r* = 0.14, *p* = 0.14; *r* = 0.28, *p* = 0.06, respectively). The weeks that showed significant correlations ranged in strength from weak to very strong (Hopkins, 2000). The results of this study suggest that the Borg RPE scale when used in conjunction with heart rate is a valid method to monitor internal training load (Little & Williams, 2007). However, due to the varying degree of agreement between player reported RPE and HR response, caution should be used when relying on self-reported RPE as a monitoring tool for exertion in this population.

Although the overall correlation between HR and RPE throughout the competitive season was considered strong (*r* = 0.53), the strength of significant correlations broken down week by week ranged from weak to very strong (*r* = 0.29 to *r* = 0.73). These values are in accordance to previous studies and are on the lower end for strength of correlation. A meta-analysis reported the weighted mean of the appropriate studies to have a correlation of *r* = 0.62 (Chen et al., 2002). Studies completed by Buchheit et al. (2013) and Little and Williams (2007) moderate- to strong correlations between HR and RPE (*r* = 0.45-0.58 and *r* = 0.60, respectively). Similar to Impellizzeri et al. (2004), the correlation range we reported was slightly lower than that of other projects (*r* = 0.50-0.85). Other studies had a stronger correlation than what we found in our research, which may be attributed to the added difficulty of the intermittent training often found in soccer (Foster et al., 1998; Martin & Andersen, 2000; Vahia, Kelly, Knapman, & Williams, 2019; Wallace & Slattery, 2009; Zinoubi, Zbidi, Vandewalle, Chamari, & Driss, 2018).

As with every study, there were limitations faced. It is possible that there was generally a high level of agreement between P and C perception of exertion based on the number of easy and hard training sessions in comparison to moderate-intensity sessions, as proposed by Andrade et al. (2014). In the future, we suggest investigators to have C identify the intensity of training sessions to look into that. We did not separate P by position for this analysis, but previous studies of team sports have demonstrated no significant differences in scores reported by position (Andrade et al., 2014; Redkva et al., 2017).

Monitoring a larger population would be another good addition, especially if investigators were able to include male and female sports, different competitive levels, and a variety of sports. Another limitation of this study was that we did not separate athletes based on playing status (starters, contributors, and noncontributors). It is possible that the playing status could make a difference in the results based on having to recover from games. Additionally, athletes that played the full match or a majority of the match tended to have a recovery session whereas the remaining athletes participated in a moderate- to high-intensity session. We did not take into account the type of practice session (recovery vs. normal) for each athlete. Lastly, it is difficult to know how much the athletes thought about their responses and if they were always honest with the reported scores. It is possible that they may give the answer they think their coaches want to hear instead of how they actually perceive their level of recovery and exertion of training. This is especially true if the athletes think it could affect their playing status. The self-reported scales are only reliable if the participants understand the scales fully and follow the procedures associated with them.

# CONCLUSION

In conclusion, it appears that P and C agreement on intensity of training and subsequent recovery following training exist in this population, with a minimum exception. The results of this study indicate that the coaching staff shared a general understanding of the training load players were being subjected to, and potentially made changes to the practice schedule throughout the competitive season in an attempt to manage this stress. Additionally, P self-reported RPE values were significantly correlated with HR, though the strength of agreement between weeks was varied. This could indicate that, while players generally reported higher intensities following training that elicited higher HRs, there are other factors at play that kept players from more closely matching RPE with HR response.

REFERENCES

Andrade Nogueira, F. C. d., Nogueira, R. A., Coimbra, D. R., Miloski, B., Freitas, V. H., & Filho, M. B. (2014). Internal training load: Perception of volleyball coaches and athletes. *Revista Brasileira de Cineantropometria & Desempenho Humano, 16*(6), 638-647.

Borresen, J., & Lambert, M. I. (2009). The quantification of training load, the training response and the effect on performance. *Sports Medicine, 39*(9), 779-795.Brink, M. S., & Frencken, W. G. P. (2018). Formative feedback for the coach reduces mismatch between coach and players' perceptions of exertion. *Science and Medicine in Football, 2*(4), 255-260.

Bourdon, P. C., Cardinale, M., Murray, A., Gastin, P., Kellmann, M., Varley, M. C.,…Cable, N. T. (2017). Monitoring athlete training loads: Consensus statement. *International Journal of Sports Physiology and Performance, 12*(2), S161-170.

Brink, M. S., & Frencken, W. G. (2018). Formative feedback for the coach reduces mismatch between coach and players' perceptions of exertion. *Science and Medicine in Football, 2*(4), 255-260.

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

Chen, M. J., Fan, X., & Moe, S. T. (2002). Criterion-related validity of the Borg ratings of perceived exertion scale in healthy individuals: a meta-analysis. *Journal of Sport Sciences, 20*(11), 873-899.

Coutts, A. J., Gomes, R. V., Viveiros, L. E., & Aoki, M. S. (2010). Monitoring training loads in elite tennis. *Revista Brasileira de Cineantropometria e Desempenho Humano, 12*(3), 217-220.

Doeven, S. H., Brink, M. S., Frencken, W. G. P., & Lemmink, K. A. P. M. (2017). Impaired player-coach perceptions of exertion and recovery during match congestion. *International Journal of Sports Physiology and Performance, 12*(9), 1151-1156.

Edwards, S. (1993). High performance training and racing. In *The Heart Rate Monitor Book,*. Edwards, S. (Ed.). Sacramento, CA: Feet Fleet Press, pp. 113-123.

Foster, C., Florhaug, J. A., Franklin, J., Gottschall, L., Hrovatin, L. A., Parker, S.,…Dodge, C. (2001). A new approach to monitoring exercise training. *Journal of Strength & Conditioning Research, 15*(1), 109-115.

Gaudino, P., Iaia, F. M., Strudwick, A. J., Hawkins, R. D., Alberti, G., Atkinson, G., & Gregson, W. (2015). Factors influencing perception of effort (session-RPE) during elite soccer training. *International Journal of Sports Physiology and Performance, 10*(7), 860-864.

Halson, S. L. (2014). Monitoring training load to understand fatigue in athletes. *Sports Medicine, 44*(2), S139-147.

Hopkins W.G., Marshall, S.W., Batterham, A.M., & Hanin, J. (2009). Progressive statistics for studies in sports medicine and exercise science. *Medicine & Science in Sports & Exercise 41*(1), 3-13.

Impellizzeri, F. M., Rampinini, E., Coutts, A. J., Sassi, A., & Marcora, S. M. (2004). Use of RPE-based training load in soccer. *Medicine & Science in Sports & Exercise, 36*(6), 1042-1047.

Impellizzeri, F. M., Rampinini, E., & Marcora, S. M. (2005). Physiological assessment of aerobic training in soccer. *Journal of Sport Sciences, 23*(6), 583-592.

Kallus, K. W. (2016). Stress and recovery: An overview. In K. W. Kallus & M. Kellmann (Eds.), *The Recovery-Stress Questionnaires: User Manual* (pp. 27-48). Frankfurt am Main: Pearson Assessment & Information GmbH.

Kellmann, M. (2010). Preventing overtraining in athletes in high-intensity sports and stress/recovery monitoring. *Scandinavian Journal of Medicine & Science in Sports, 20*(2), S92-102.

Kenttä, G., & Hassmén, P. (1998). Overtraining and recovery. A conceptual model. *Sports Medicine, 26*(1), 1-16.

Laurent, C. M., Green, J. M., Bishop, P. A., Sjökvist, J., Schumacker, R. E., Richardson, M. T.,…Curtner-Smith, M. (2011). A practical approach to monitoring recovery: Development of a perceived recovery status scale. *Journal of Strength and Conditioning Research, 25*(3), 620-628.

Little, T., & Williams, A. G. (2007). Measures of exercise intensity during soccer training drills with professional soccer players. *Journal of Strength and Conditioning Research, 21*(2), 367-371.

Martin, D. T., & Andersen, M. B. (2000). Heart rate-perceived exertion relationship during training and taper. *Journal of Sports Medicine and Physical Fitness, 40*(3), 201-208.

McLaren, S. J., Macpherson, T. W., Coutts, A. J., Hurst, C., Spears, I. R., & Weston, M. (2018). The relationships between internal and external measures of training load and intensity in team sports: A meta-analysis. *Sports Medicine, 48*(3), 641-658.

Moalla, W., Fessi, M. S., Farhat, F., Nouira, S., Wong, D. P., & Dupont, G. (2016). Relationship between daily training load and psychometric status of professional soccer players. *Research in Sports Medicine*, *24*(4), 387-394.

Nazari, G., Bobos, P., MacDermid, J. C., Sinden, K. E., Richardson, J., & Tang, A. (2018). Psychometric properties of the Zephyr bioharness device: a systematic review. *BMC Sports Science, Medicine, & Rehabilitation, 10*(6), 1-8.

Oliveira, R., Brito, J. P., Martins, A., Mendes, B., Marinho, D. A., Ferraz, R.,…Marques, M. C. (2019). In-season internal and external training load quantification of an elite European soccer team. *PLoS One, 14*(4), 1-18.

Redkva, P. E., Gregorio da Silva, S., Paes, M. R., & Dos-Santos, J. W. (2017). The relationship between coach and player training load perceptions in professional soccer. *Perceptual and Motor Skills, 124*(1), 264-276.

Vahia, D., Kelly, A., Knapman, H, & Williams, C. A. (2019). Variation in the correlation between heart rate and session rating of perceived exertion-based estimations of internal training load in youth soccer players. *Pediatric Exercise Science*, *31*(1), 91-98.

Wallace, L. K., Slattery, K. M., & Coutts, A. J. (2009). The ecological validity and application of the session-RPE method for quantifying training loads in swimming. *Journal of Strength and Conditioning Research*, *23*(1), 33-38

Zinoubi, B., Zbidi, S., Vandewalle, H., Chamari, K., & Driss, T. (2018). Relationships between rating of perceived exertion, heart rate and blood lactate during continuous and alternated-intensity cycling exercises. *Biology of Sport, 35*(1), 29-37.

APPENDIX A

LITERATURE REVIEW

## INTRODUCTION

Due to the popularity of sports worldwide, regardless of the competitive level, there is an ever-growing interest in improving human performance. Performance improvements are rather difficult to predict accurately due to the various factors that are involved, training and non-training related (Bourdon et al., 2017). In order to improve performance, there needs to be a method of quantifying it. Although there are countless tests to quantify various aspects of performance (i.e. laboratory and field tests), testing tends to take place outside of training sessions and matches. Performing measures outside of training sessions or matches might not correlate directly to the sport, add to the athletes' current level of fatigue, or be based on the athlete's motivation/willingness to participate, all of which can give inaccurate results (Halson, 2014). Monitoring aspects of training via training load is one way to quantify session performance. Training load refers to the physiological stress (internal load) and external stimulus (external load) placed on an athlete (Impellizzeri, Rampinini, Coutts, Sassi, & Marcora, 2004). Training load can be altered by adjusting the frequency, duration, or intensity of training (Halson, 2014). Altering the training load can allow for proper recovery while simultaneously providing proper stimulus for desired adaptations. Athletes could be at an increased risk of injury, non-functional overreaching or even overtraining if the load is not monitored and adjusted properly.

Depending on the sport, along with the various positions within the sport, certain physical and mental demands are required. Athletes and coaches alike should monitor both the physiological and psychological load to maximize performance. Awareness of the load experienced by the athletes can help coaches plan training sessions accordingly. The training load prescribed by the coaches' changes each session throughout the competitive season based on the duration and intensity of each (Coutts, Gomez, Viveiros, & Aoki, 2010; Halson, 2014). Variations in training load, even minor ones, have shown to impact physiological and wellness variables in elite athletes (Buchheit et al., 2013). Not only can the awareness and control assist in the prevention of overtraining, it can also properly prepare the athletes for each competition. This variation in training load ultimately allows athletes to recover, which is necessary for adaptation and improvement. Coaches tend to prescribe much lower training loads the day before a competition, compared to being a few days out (Coutts et al., 2014). Lower training load prior to competition is crucial for recovery.

As technology continues to improve, more and more methods are being introduced to help quantify. However, these forms of technology can be rather expensive or require additional personnel to analyze the data collected. Luckily, there are methods available for quantifying training load that will not break the bank. With the increased availability of these methods, many teams are adopting them. One method includes evaluating the perceived exertion the athletes feel after a session. Numerous studies have shown teams incorporating this technique into their routine.

## INTERNAL AND EXTERNAL LOAD

Training load can be broken down and monitored into external and internal loads (Impellizzeri et al., 2005). External load refers to the stimuli coaches can see, such as distance, number of sprints, weight lifted, and duration of practice. External measures can be monitored using accelerometers or global positioning systems (GPS) (Oliveira et al., 2019). Even though GPS tracking can monitor the velocities, distances, and durations of various tasks, its reliability in certain sports, such as soccer, may be reduced. These units do not quantify the load involved in quick change of directions, agility, heading or kicking a ball, along with other sport-specific actions (Halson, 2014). Other factors can impact the training load that cannot be measured by the typical external load methods, such as the weather, dehydration, and fatigue (Borresen & Lambert, 2009; Impellizzeri et al., 2004).

Most coaches already monitor training load based on external parameters such as the duration of practice, number of sprints, and recovery time between drills (Andrade et al., 2014; Wallace, Slattery, & Coutts, 2009). However, it is important to look at the internal load as well. In team sports where coaches prescribe similar external load (all athletes perform each drill), monitoring internal load is increasingly important, thus indicating the differences in players fatigue or response to the program (Halson, 2014;

Impellizzeri et al., 2004). It has been suggested that internal load and physiological stress has a greater impact on the athlete's ability to adapt (Andrade et al., 2014; Coutts et al., 2014; Impellizzeri et al., 2004; Wallace, Slattery, & Coutts, 2009). The individualized approach is encouraged for all sports, as it demonstrates to the coach if the intended load corresponds with what was experienced (Halson, 2014). If the perceived load does not match the intended load, athletes will either not respond to the program or can increase risk of illness, injury, and overtraining. Internal measures help indicate levels of stress, fatigue, sleep quality, and general muscle soreness (Oliveira et al., 2019). Evaluating internal load may give a better look at the fatigue level an athlete is experiencing (Halson, 2014). Although the use of heart rate monitors is a common way to measure internal load, subjective scales are increasingly popular (Buchheit et al., 2013).

## SUBJECTIVE SCALES

### *Rating of Perceived Exertion (RPE)*

One of the most common methods used to monitor internal training load is through Borg's ratings of perceived exertion (RPE). RPE alongside a physiological measure, such as heart rate, has been shown to strongly correlate with exercise intensity (Chen et al., 2002; Impellizzeri et al., 2004). Although RPE alone can reflect the intensity of a session, differences in scores given by the athletes could indicate variations in psychological stress or residual physiological stress. As such, it is possible RPE could be used to detect excessive fatigue leading to overtraining (Impellizzeri et al., 2004). Borg's RPE was initially validated using heart rate and intended to correspond directly with the heart rate changes occurring during exercise of healthy individuals.

Currently, there are four variations of the RPE scale that are used; the original scale (15-point) and CR-10 scale being the most common (Impellizzeri et al., 2004). It is possible that a specific scale may be more or less accurate depending on the population that utilizes it. Choosing the proper scale is important based on the exercise type, protocol used, and individual fitness level (Chen et al., 2002).

According to a meta-analysis performed checking the validity of various criterion variables against RPE, the 15-point scale correlates the strongest with healthy, fit, young men (Chen et al., 2002).

Research indicates that several steps need to be followed to get the most accurate response from individuals while using RPE. It is important that the athletes and coaches understand what the numbers represent, which can increase the accuracy (Impellizzeri et al., 2004). The number is intended to describe the intensity of the entire training session or match, not merely the last drill completed (Coutts et al., 2010). Furthermore, athletes should wait 30 minutes after cessation of training to report their scores (Impellizzeri et al., 2004). Another suggestion is that individuals are away from others when reporting their scores to avoid being influenced by someone else's answer.

Oftentimes, RPE in the CR-10 scale form is used in conjunction with the duration of practice to quantify session-RPE (s-RPE) without using heart rate monitors (Foster et al., 2001; Halson, 2014; Impellizzeri et al., 2004; Impellizzeri et al., 2005). This method has been used specifically to monitor the internal training load of soccer players, basketball players, and endurance athletes in combination with heart rate (Edwards, 1993; Foster et al., 2001; Impellizzeri et al., 2004).

### ***Total Quality Recovery (TQR)***

While monitoring the training process is important, monitoring recovery is too. Ideally, athletes need to find a balance between training and recovery to optimize performance while simultaneously decreasing the risk of injury and overtraining (Kentta & Hassmen, 1998). One method of monitoring recovery is through the use of the total quality recovery (TQR) scale. TQR was modeled after the original RPE scale, using the 6-20 scale with verbal anchors tied to certain numbers. However, TQR is split into two subscales: TQR perceived (TQRper) and TQR action (TQRact). TQRper represents more of a subjective score including an overall rating of physiological stress (Kentta & Hassmen, 1998). TQRact is a more in-depth scale that is objective. Athletes will rate their proactive recovery interventions across four categories: nutrition and hydration; sleep and rest; relaxation and emotional support; stretching and active rest (Kentta & Hassmen, 1998).

Although initially intended for elite senior athletes, the utilization of TQR has expanded to numerous other groups to avoid staleness (Kentta & Hassmen, 1998). Monitoring recovery helps athletes increase their own self-awareness of their bodies. With this self-awareness, athletes can proactively recover. It is suggested that the TQR ratings are equal to or greater than the RPE score given to ensure proper recovery (Kentta & Hassmen, 1998). Another way to analyze TQR scores is by comparing TQRper to TQRact. If TQRper is noticeably lower than TQRact, the athlete may not be recovering well enough (Kentta & Hassmen, 1998).

***Recovery-Stress Questionnaire (RESTQ-Sport)***

Variations of questionnaires can be utilized to monitor an athlete's recovery status. One questionnaire that is commonly used with athletes is the RESTQ-Sport. This measure takes into account accumulated stress through all aspects of life, not just from training (Kentta & Hassmen, 1998). RESTQ-Sport is an adaptation off the original RESTQ to indicate more sport-specific aspects of recovery and stress (Kallus, 2016). Additionally, the responses can differentiate between mood-states and traits. The questionnaire is broken down into general stress scales, general recovery scales, sport-specific stress scales, and sport-specific recovery scales and contains 77 items (Kellmann, 2010). Stress and recovery are explicitly separated because the relationship between the two does not tend to be linear (Kallus, 2016). Ideally, athletes will have high scores in the recovery sections and low scores in the stress sections. RESTQ-Sport has been used in a variety of sports, in individual and team settings. If an athlete's recovery-stress states do not parallel the training schedule, he/she might need to be removed from the stimulus in order to recover (Kellmann, 2010). Although this method encompasses numerous aspects that relate to performance, it may not be ideal for athletes due to the length of the questionnaire. Length of the questionnaire, frequency of retest, and time taken to complete it are three important factors sport scientists need to take into account to determine if the athletes will thoughtfully complete it (Halson, 2014).

***Perceived Recovery Status (PRS)***

Another method to monitor athlete recovery is through the PRS scale. It is an inexpensive and reliable method that allowed for quick responses from the athletes at any point in time. It is only one question/scale, making it easier for athletes to comply to it. The scale was modeled after the CR-10 scale for exertion, and ranges from 0-10 (Laurent et al., 2011). Initially, Laurent et al. (2011) created the scale to be used between sets and small bouts of recovery. At the end of the resting period of a set, investigators would question the participant on how recovered he/she felt, as it correlated to performance. Higher scores relate to improved performance and lower relate to decrements in performance. The scale is most accurate with predicting performance when the participants perceived their recovery to be at more ‘extreme’ values (Laurent et al., 2011). It also accurately predicts performance in cases where participants report an under-recovered score. Although not initially intended to be used only between full practice sessions, it has since expanded to encompass that. As long as athletes understand what the scale represents and gives honest answers, PRS scores can give coaches a better insight on the recovery status of the athletes and can adjust training if necessary.

**MONITORING**

There currently is not a definitive variable that is the most effective for understanding training load, yet multiple variables have shown correlation (Halson, 2014). RPE is a valid and practical measure use to estimate training load in team sports (Impellizzeri et al., 2005). Additionally, monitoring training load and recovery status through the use of various scales increases the athlete’s awareness of his/her body (Kentta & Hassmen, 1998). Increasing self-awareness can hopefully improve how he/she responds to a training session and the corresponding recovery modalities. Monitoring heart and wellness scores compared to training load demonstrated a negative correlation, suggesting their sensitivity to changes in training load (Buchheit et al., 2013).

Coaches can prescribe a certain training load for the session, but athletes may not agree with the intended load based on their perceived exertion. Several studies have begun to look at the comparison of the perceived internal load/exertion viewed by the athletes and coaches (Andrade et al., 2014; Brink & Frencken, 2018; Doeven et al., 2017; Wallace, Slattery, & Coutts, 2009). Ideally, the athletes and coaches will be in agreement. If the intended load is perceived differently by the athletes, there could be a negative impact on performance or lead to injuries or overtraining (Brink & Frencken, 2018; Wallace, Slattery, & Coutts, 2009).

Overall, there tends to be some sort of disassociation or discrepancy in what training load coaches intend to prescribe with that is perceived by the athletes (Foster et al., 2001). Brink and Frencken (2018) attempted to see how giving coaches feedback on the perception of exertion between coach and athletes affected future sessions. They showed that giving the coaches feedback on the data improved the agreement between coach and player. The improvement occurred most drastically in the hard sessions.

A common theme among the studies that compared coach and athlete perceptions of internal training load was that there not significant differences, especially for the moderate-level practices (Foster et al., 2001; Wallace, Slattery, & Coutts, 2009). Athletes also tended to say easier practices were harder than coaches intended, and hard practices were less intense than intended (Foster et al., 2001; Impellizzeri et al., 2004; Wallace, Slattery, & Coutts, 2009). Similar results were found by Andrade Nogueira et al. (2014) in that there were no significant differences between players and coach perceptions of exertion. However, when intensity is brought to question, the researchers found discrepancies occurring for the high and low intensity practices.

Brink & Frencken (2018) suggested that a study incorporate a recovery portion in with the perceived exertion to improve feedback. Improved feedback would help the coaches determine how to plan training sessions to encourage recovery as needed. The use of s-RPE to determine training load for an individual session allowed the coaches to evaluate athletes during various components of their training session, which allowed them to better understand the load imposed (Wallace, Slattery, & Coutts, 2009). Many studies used s-RPE instead of a HR measure or distance travelled for describing training load (Wallace, Slattery, & Coutts, 2009).

## GAPS IN RESEARCH

Although plenty of studies have researched the effects of the various methods for quantifying training load its validation, there are still plenty of gaps in the literature. Many of the studies completed are pertaining to professional athletes (Andrade Nogueira et al., 2014; Brink & Frencken, 2018; Buchheit et al., 2013; Coutts et al., 2010; Doeven et al., 2017; Gaudino et al., 2015; Impellizzeri et al., 2004; Redkva et al., 2017). Data on collegiate athletes is currently lacking. Furthermore, much of the data collected is reported to be from pre-season (Andrade Nogueira et al., 2014; Buchheit et al., 2013). The entire competitive season may be more useful to track training load and recovery. Additionally, very few studies have investigated discrepancies between the perception of training load between the players and the coaches (Andrade Nogueira et al., 2014; Brink & Frencken, 2018; Wallace, Slattery, & Coutts, 2009). Of the studies that did compare discrepancies in perceived scores between coach and player, many did not incorporate a physiological measure in it.

Andrade Nogueira et al. (2014) suggested the incorporation of physiological variables in addition to RPE to investigate if athletes understand the RPE scale and are using it correctly. There are inconsistent results with surrounding the validity of the correlation between RPE and physiological measurements such as HR (Chen et al., 2002). We plan to retest this to determine if there is a strong correlation between RPE and HR in the collegiate male soccer player population.

## FUTURE RESEARCH

Additional research could be done on collegiate athletes due to the lack of data currently surrounding that population in terms of player-coach perceptions. Collegiate athletes are unique in comparison to the professional or elite athletes that were studied previously. They have additional stress that other groups do not need to consider. Some stress these student-athletes may have include keeping up their schoolwork/grades, social stress, balancing school and sport, and potentially congested game schedules causing them to travel often and miss classes. It would also be interesting to compare the various positions or playing status. Furthermore, research could be done on various levels of competition and age groups to determine if age and experience play a role in the agreement among athletes and coaches. Another way to expand the research is to add external load monitoring into it. Improving both coach and player awareness of exertion and recovery can lead to improved performance through proper periodization.

LITERATURE REVIEW REFERENCES

Andrade Nogueira, F. C. d., Nogueira, R. A., Coimbra, D. R., Miloski, B., Freitas, V. H., & Filho, M. B. (2014). Internal training load: Perception of volleyball coaches and athletes. *Revista Brasileira de Cineantropometria & Desempenho Humano, 16*(6), 638-647.

Borresen, J., & Lambert, M. I. (2009). The quantification of training load, the training response and the effect on performance. *Sports Medicine, 39*(9), 779-795.Brink, M. S., & Frencken, W. G. P. (2018). Formative feedback for the coach reduces mismatch between coach and players' perceptions of exertion. *Science and Medicine in Football, 2*(4), 255-260.

Bourdon, P. C., Cardinale, M., Murray, A., Gastin, P., Kellmann, M., Varley, M. C.,…Cable, N. T. (2017). Monitoring athlete training loads: Consensus statement. *International Journal of Sports Physiology and Performance, 12*(2), S161-170.

Brink, M. S., & Frencken, W. G. (2018). Formative feedback for the coach reduces mismatch between coach and players' perceptions of exertion. *Science and Medicine in Football, 2*(4), 255-260.

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

Chen, M. J., Fan, X., & Moe, S. T. (2002). Criterion-related validity of the Borg ratings of perceived exertion scale in healthy individuals: a meta-analysis. *Journal of Sport Sciences, 20*(11), 873-899.

Coutts, A. J., Gomes, R. V., Viveiros, L. E., & Aoki, M. S. (2010). Monitoring training loads in elite tennis. *Revista Brasileira de Cineantropometria e Desempenho Humano, 12*(3), 217-220.

Doeven, S. H., Brink, M. S., Frencken, W. G. P., & Lemmink, K. A. P. M. (2017). Impaired player-coach perceptions of exertion and recovery during match congestion. *International Journal of Sports Physiology and Performance, 12*(9), 1151-1156.

Edwards, S. (1993). High performance training and racing. In *The Heart Rate Monitor Book,*. Edwards, S. (Ed.). Sacramento, CA: Feet Fleet Press, pp. 113-123.

Foster, C., Florhaug, J. A., Franklin, J., Gottschall, L., Hrovatin, L. A., Parker, S.,…Dodge, C. (2001). A new approach to monitoring exercise training. *Journal of Strength & Conditioning Research, 15*(1), 109-115.

Gaudino, P., Iaia, F. M., Strudwick, A. J., Hawkins, R. D., Alberti, G., Atkinson, G., & Gregson, W. (2015). Factors influencing perception of effort (session-RPE) during elite soccer training. *International Journal of Sports Physiology and Performance, 10*(7), 860-864.

Halson, S. L. (2014). Monitoring training load to understand fatigue in athletes. *Sports Medicine, 44*(2), S139-147.

Impellizzeri, F. M., Rampinini, E., Coutts, A. J., Sassi, A., & Marcora, S. M. (2004). Use of RPE-based training load in soccer. *Medicine & Science in Sports & Exercise, 36*(6), 1042-1047.

Impellizzeri, F. M., Rampinini, E., & Marcora, S. M. (2005). Physiological assessment of aerobic training in soccer. *Journal of Sport Sciences, 23*(6), 583-592.

Kallus, K. W. (2016). Stress and recovery: An overview. In K. W. Kallus & M. Kellmann (Eds.), *The Recovery-Stress Questionnaires: User Manual* (pp. 27-48). Frankfurt am Main: Pearson Assessment & Information GmbH.

Kellmann, M. (2010). Preventing overtraining in athletes in high-intensity sports and stress/recovery monitoring. *Scandinavian Journal of Medicine & Science in Sports, 20*(2), S92-102.

Kenttä, G., & Hassmén, P. (1998). Overtraining and recovery. A conceptual model. *Sports Medicine, 26*(1), 1-16.

Laurent, C. M., Green, J. M., Bishop, P. A., Sjökvist, J., Schumacker, R. E., Richardson, M. T.,…Curtner-Smith, M. (2011). A practical approach to monitoring recovery: Development of a perceived recovery status scale. *Journal of Strength and Conditioning Research, 25*(3), 620-628.

Oliveira, R., Brito, J. P., Martins, A., Mendes, B., Marinho, D. A., Ferraz, R.,…Marques, M. C. (2019). In-season internal and external training load quantification of an elite European soccer team. *PLoS One, 14*(4), 1-18.

Redkva, P. E., Gregorio da Silva, S., Paes, M. R., & Dos-Santos, J. W. (2017). The relationship between coach and player training load perceptions in professional soccer. *Perceptual and Motor Skills, 124*(1), 264-276.

Wallace, L. K., Slattery, K. M., & Coutts, A. J. (2009). The ecological validity and application of the session-RPE method for quantifying training loads in swimming. *Journal of Strength and Conditioning Research, 23*(1), 33-38.