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The relationship between ratings of perceived exertion and heart rate in NCAA Division III male soccer players 2017

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The Relationship between Ratings of Perceived Exertion and Heart Rate in NCAA Division III Male Soccer Players

by

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ABSTRACT

Every sport has specific physical demands of the human body. The amount of physiological load that an athlete endures during a bout of exercise can be described as training load (TL). Accurate calculation of training loads within athletes is important when it comes to strength and power development, as well as injury prevention and monitoring fatigue. Common methods used to calculate training loads for athletes include rating of perceived exertion (RPE) based methods, heart rate (HR) based methods, rate of oxygen consumption (VO2) methods, and blood lactate methods. Specifically with NCAA male soccer athletes, HR based methods and RPE based methods are most prevalent. However, there has been conflicting research results when regarding the strength of the relationship between HR and RPE based methods to determine training loads with soccer athletes. The purpose of this study was to examine the relationship between Edwards' TRIMP and session RPE methods of determining training loads in NCAA Division III male soccer players during bouts of intermittent soccer specific exercise of moderate to long duration. Participants in this study were current members of an NCAA Division III men's varsity soccer team during the spring 2017 season (n=8, age=19.13 ± 0.835). Pre-existing HR and RPE data for each participant were taken from a scrimmage session played on April 23, 2017. Participants competed in a soccer specific scrimmage session lasting 60 minutes in duration (30 minute first half, 10 minute halftime, 30 minute second half). HR data for each participant were recorded for each participant throughout the entire soccer scrimmage using Polar Team 2 HR monitoring equipment. Each participant wore a Polar Team 2 HR chest monitor to record HR data for every second of activity. RPE data for each individual was collected 10 minutes post

soccer scrimmage using a Borg's CR-10 RPE scale. Edwards' Training Impulse values were calculated for each individual using HR data while session RPE training load values were calculated using individuals' CR-10 RPE scores. A Pearson's correlation was run to examine the relationship between Edwards' TRIMP and session RPE based training load methods. A significant, positive, moderately strong correlation was found between Edwards' TRIMP and session RPE based TL methods (r=0.719). The r^2 value of 0.517 suggested that about 52% of variance in TL values can be explained by the relationship between Edwards' TRIMP and session RPE TL methods. The results of this study suggest that session RPE is a fairly accurate measure of TL within soccer specific exercise of moderate to long duration, specifically within NCAA Division III soccer athletes.

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Chapter 1

Introduction

Participation in sport requires athletes to endure physically demanding bouts of exercise. As the popularity of competitive sport has grown, so has the science behind the physiological demands of the athlete. Specifically in the sport of soccer, different methods and guidelines have been developed to assess the physiological work load of the athlete during soccer specific exercise. Heart rate (HR), volume of oxygen consumption (VO2), and rating of perceived exertion (RPE) are generally accepted measures of workload. Heart rate is defined as the number of times that the human heart beats per unit of time, usually expressed in beats per minute (bpm) (Baechle & Earle, 2008). VO2 is the rate of oxygen consumed by the body. The relative rate of VO2 consumption in regards to body mass is usually expressed as milliliters of oxygen per unit of body mass per minute (mlO2/kg/min) (Baechle & Earle, 2008). Rating of perceived exertion (RPE) is a scale that is used to determine the intensity of a specific exercise (this is a measure of perceived exertions by the individual not a measure of intensity) (Borg, 1977). An example of the Borg CR-10 RPE scale is shown in appendix A (Borg, 1985). Exercise mode, exercise intensity, and environmental conditions can all affect HR, VO2, and RPE of an athlete during exercise (Alexiou & Coutts, 2008; Baechle, 2008; Drust, Reilly, & Cable, 2010; Eston & Williams, 1988; Lamb, Eston, & Corns, 1999).

Determining the relationship between HR and RPE within the realms of different sport-specific activity is needed to accurately monitor workload of an athlete . Also, there is still debate over the relative strength and relationship between HR and RPE between different modes and durations of exercise. Furthermore, there is even less evidence regarding

this relationship in a sport specific environment such as a soccer game that is played over a long duration of time.

Soccer is a team sport that involves intermittent bouts of high and low intensity aerobic exercise with few stoppages in play over two 45 min halves totaling 90 minutes. Recently in soccer, the implementation of RPE and HR measures have been utilized in order to gather physiological information on each athlete in order to determine specific workloads for training sessions and match play. However, with the strength of the relationship between RPE and HR still unclear in soccer specific exercise, the question becomes whether each measure is reliable for quantifying workload in soccer.

Statement of Problem

Properly determining and monitoring workloads is crucial for development and progression of athletes' training across virtually every sport and amongst many different levels of competition. Limited information of the relationships between the different methods used to monitor and quantify training loads leaves questions regarding the accuracy and validity of such training modalities currently being used.

Purpose of Study

The purpose of this study was to determine if there is a relationship between HR and RPE as a reliable indicator of workload during bouts of intermittent soccer specific exercise of moderate and long duration. Specifically, this relationship will be investigated within a population of NCAA Division III male soccer athletes.

Hypotheses

The following hypothesis were investigated in regards to the variables of session RPE (RPE based) and Edwards' Training Impulse (HR based) training load methods:

Research hypothesis: A significant positive correlation exists between session RPE and Edwards' Training Impulse training load values measured during intermittent bouts of soccer specific exercise of ninety minutes.

Null hypothesis: A significant correlation does not exist between session RPE and Edwards' Training Impulse training load values measured during intermittent bouts of soccer specific exercise of ninety minutes.

Alternative hypothesis: A significant negative correlation exists between session RPE and Edwards' Training Impulse training load values measured during intermittent bouts of soccer specific exercise of ninety minutes.

A significantly strong correlation will exist between Edwards Training Impulse and session RPE training load values during intermittent bouts of soccer specific activity. The correlation between HR and RPE may be weaker in bouts of intermittent soccer specific exercise of longer duration compared to bouts of intermittent soccer specific exercise of shorter duration.

Group: 10 NCAA Division III men's soccer players

Population: An NCAA Division III men's soccer team

Treatment: The treatment consisted of one sixty minute soccer scrimmage (Two thirty minute halves separated by a ten minute halftime) where both heart rate and ratings of perceived exertion will be measured.

Delimitations

The study was delimited by the following factors:

1. CR-10 RPE

   a. CR-10 scale was the RPE scale chosen to obtain session RPE values for each participant

2. Minimum Fitness level of athletes

   a. 3 mile run in under 20 minutes spring season fitness test was completed

   b. Scrimmage session occurred after 4 weeks of spring season soccer training

3. Participants: Members of an NCAA DIII men's soccer team

Limitations

The following limitations should be considered when analyzing the results of the current study:

1. Exempt from strenuous exercise 24 hours prior to competition

   a. Participants were asked to abstain from any unnecessary strenuous exercise up to 24 hours prior to competition. Unnecessary strenuous exercise in this study was defined as any additional exercise of moderate to high intensity that is not a part of the normal daily activity required of the participant.

2. Group and Population size

   a. Only 17 players from an NCAA Division III men's soccer team were available for the Spring 2017 roster. Only 10 players from an NCAA Division III men's soccer team could participate in this study due to the limited team size as well as available, functioning heart rate equipment.

3. Exempt from caffeine intake 12 hours prior to competition

a. Participants were told to abstain from caffeine intake up to 12 hours prior to competition.

4. Fitness level variation

a. Offseason fitness responsibilities fall upon each individual and coaches/staff can not actively implement and enforce workouts due to NCAA rules and regulation

Assumptions

All subjects were assumed to have an acceptable cardiovascular fitness level due to participation in the previous four weeks of spring season training sessions as well as successfully completing a spring season fitness test, running 3 miles under 20 minutes prior to participation in this study. All subjects were assumed to have abstained from caffeine intake and unnecessary strenuous activity up to 24 hours prior to the competition period. All subjects were believed to be equally motivated to perform at their highest competition level possible in game-like scenarios.

Definition of Terms

Heart Rate The number of times that the heart contracts per unit of time (Baechle, 2008)

BPM Heart beats per minute (Baechle, 2008)

Stroke Volume The quantity of blood ejected by the heart per heart beat (Medical Definition of Stroke volume. (Baechle, 2008)

Rate of Perceived Exertion A subjective perceived feeling of effort during a specific exercise bout (Borg, 1977)

Session RPE A rating of perceived exertion that is multiplied by the total duration of time of the exercise (Baechle, 2008)

Training Load A term used to describe the total amount of physiological stress that the body experiences during a bout of exercise (Baechle, 2008)

Training Impulse A method used to quantify training load developed by Banister (1991). The TRIMP is calculated through the use of heart rate reserve and duration of exercise measures. (Baechle, 2008)

Edwards' TRIMP A method used to quantify training load developed by Edwards (1999). Edwards' TRIMP is calculated by multiplying time in seconds spent in 5 HR zones determined by percentages of one's max HR by corresponding HR zone coefficients. The Edwards' TRIMP value is the summation of all 5 values (Edwards, 1993)

Intermittent Exercise Exercise involving bouts of both high and low intensities (Baechle, 2008)

Heart Rate Variability A variation or change in heart rate under normal heart rate conditions (Billman, 2011)

VO2 The volume of oxygen consumed by the body per unit of time (Baechle, 2008)

Significance of Study

The significance of this study is to fill in the gaps missing in the literature involving the relationship between RPE and HR in regard to training loads of prolonged bouts of intermittent exercise in soccer players. The majority of research looking at this relationship involves exercise bouts of short duration or long bouts of continuous exercise. There is very little research exploring this relationship when exercise is intermittent over longer durations of time such as the type of exercise required in the sport of soccer. This sport specific research can also further support training load methods used to further the development and increase performance in soccer players.

Chapter 2

Review of Literature

In the field of exercise physiology, many different methods and guidelines have been developed in order to accurately determine the body's physiological work load during exercise. Physiological measures such as HR, VO2, and RPE have been generally accepted as accurate measures in monitoring and determining work load. These physiological characteristics share a similar correlation. HR, VO2, and RPE are all similarly affected by exercise mode, exercise intensity and environmental conditions. However, there is far less research on how the relationship between HR and RPE functions in certain sports specific conditions within each sport. Questions have developed regarding the accuracy of the correlation that exists between RPE and HR, as well as the accuracy of methods and scales used to rate perceived exertion for exercise modes of varying durations. Soccer is a sport with intermittent bouts of high and low intensity aerobic and anaerobic exercise, RPE and HR are often the measures used to monitor work load and metabolic output during training sessions and match play (Impellizeri et al., 2006; Alexiou & Coutts, 2008). Therefore, to provide information about the correlation between HR and RPE as the use of accurate measure of workload, this review has been organized into the following sections: NCAA Division III soccer season training, heart rate, rate of perceived exertion, and physiological relationship of RPE and HR in soccer.

NCAA Division III Soccer Seasonal Training

The NCAA Division III men's soccer season is split up into a longer fall season and a shorter spring season with winter and summer being offseason. The fall season begins mid-August every year according to NCAA rules and regulations and may end as late as the first

week of December for the NCAA Division III National Championship Tournament. During an average week in the fall season, a team may compete in games on two days and have soccer specific practice usually lasting one to two hours each day for three or four other days in the week. During the shortened spring season, each team is allowed 15 practice sessions with an additional day of competition in which teams can scrimmage one another.

Monitoring training loads is extremely important when it comes to strength and skill development and progression, reducing fatigue, and limiting/reducing risk of injury. Specifically, within an NCAA Division III soccer season, the quantity of training sessions and competitions can lead to a high weekly training loads. Therefore, the careful and accurate monitoring of an athlete's training load across the season is crucial in the preparation of future progression or regression of training in order to optimize performance while decreasing injury potential and fatigue.

Training load models can fluctuate depending on coaching methods as well as the modes used to determine training loads and intensities. Generally accepted measures used to determine training loads in soccer athletes includes HR monitoring, VO2 testing, blood lactate measurements, and RPE (Alexiou & Coutts 2008; Matzenbacher et al., 2016; Impelizeri et al., 2006). Within NCAA Division III soccer, monitoring RPE can often be the most preferred method as there is little to no cost for equipment, and it is the least invasive. This leads to the question of whether RPE based training load methods within NCAA Division III soccer are as accurate as other methods using physiological metrics such as HR.

Heart Rate

Heart rate (HR) is the frequency at which the heart beats per duration of time. Most commonly, HR is described as the number of beats per minute (bpm). Stroke volume (SV) is

the volume of blood that is ejected from the heart in one beat and can be measured in milliliters per beat. The combination of both HR and SV make up what is known as cardiac output (Baechle, 2008). The equation for Cardiac output can be written as:

$$\text{Cardiac Output} = SV \times HR$$

Cardiac output is an important variable when it comes to the measurement of training loads, or how hard an athlete's body may be working during a period of exercise. The measurement of cardiac output has been utilized across many sports and many training modalities in order to accurately measure training loads. In soccer, several studies have used variations of cardiac output measures to determine training loads (Alexiou & Coutts, 2008; Drust et al., 2010; Matzenbacher et al. 2016). HR has been widely used to determine overall cardiac and physiological work given a specific exercise mode. HR is often monitored in athletes through the use of performance HR monitors. Based upon previous research, resting HR has been supported as a general marker for physical fatigue (Achten & Jeukendrup, 2003). Achten and Jeukendrup (2003) concluded that measuring HR as well as HR variability (HRV) can be useful in monitoring training intensities in different exercise modes, and can potentially play a role in the prevention and detection of overtraining. HRV can be defined as the variation or change in HR under normal HR conditions (Billman, 2011). HR and VO2 have been shown to share an almost linear relationship over many different modes of submaximal exercise, therefore HR monitoring has become an increasingly more popular and reliable method for quantifying training load during aerobic training sessions (Gilman, 1996). HRV has also been identified as a relatively good indicator of exercise training load. HRV can be easier to measure and calculate than some other more invasive methods to establish training load such as blood lactate and VO_2 measures. Research suggests that HRV methods,

similar to training impulse approaches, may be relatively reliable methods to establish cumulated training loads in an athlete population (Pichot et al., 2000).

Rating of Perceived Exertion

Rating of Perceived Exertion (RPE), is an objective measure used to describe the amount of exertion or intensity of a specific exercise bout (Borg, 1977). The Borg Scale, developed by Dr. Gunnar Borg, is an exertion scale that is widely used in exercise science and medicine. Smutok, Skrinar, and Pandolf (1980) found that through the use of two exercise sessions, healthy male subjects were able to "learn" the Borg 6-20 scale and effectively use it regulate their intensity of treadmill running (Smutok et al., 1980). However, there has been more recent research of the reliability and validity of RPE for the prescription of exercise intensity during bouts of specific types of exercises (Eston & Williams, 1988; Lamb et al., 1999). Pandolf (1983) suggested that if RPE is to be a basis for exercise prescription, then the exercise mode must be defined and specific because the perception of exertion and effort varies. This in turn influences the magnitude of RPE rating (Pandolf, 1983). Eston and Williams (1988) studied the reliability and validity of RPE in cycling. Reliability of heart rate measures as well as VO_2 measures was included in the study due to differing practical and clinical methods and applications (Eston & Williams, 1988). They observed that men and women at preselected RPE's produced similar relative exercise intensities based on percentages of VO_2 max. Correlations between RPE and HR were lower at all levels of the analysis than those for VO_2. Eston and Williams were able to conclude that RPE is a reliable reference to use in the regulation of high intensity exercise in healthy males and females (Eston & Williams, 1988).

Validity of the use of RPE has been associated with different modes of exercise such as running, walking, swimming, and rowing. However, statistically, a measurement tool cannot be deemed valid without also being reliable. Lamb et al. (1999) assessed the test-retest reliability (or repeatability) of the Borg 6-20 scale in incremental treadmill running. A more appropriate 95% limits of agreement statistical technique was used as a better means of assessing within-subjects factors compared to more traditional correlation coefficients (Lamb et al., 1999) Lamb et al. (what is the year) accepted that once introduced to the Borg 6-20 scale, subjects understanding of the scale and its application had been established. They found that upon different trials of incremental treadmill running, the test reliability of the Borg scale was somewhat inconsistent while measures of HR did not vary significantly across the trials (Lamb et al., 1999). These findings support an earlier study involving the reliability and comparison of RPE during variable and constant exercise protocols in older women (Wenos, Wallace, Surburg, & Morris, 1996). Wenos et al. (1996) measured RPE reliability correlations of 0.96, 0.97, and 0.72 at 30%, 50%, and 70% of maximum oxygen uptake during a discontinuous walking procedure. However, when separate constant load procedures were utilized using the same three percentages of maximum oxygen uptake, the RPE reliability correlations turned out to be much different (0.53, 0.94, and 0.67 not clear what this means respectively) (Wenos et al., 1996). A possible explanation for this phenomenon could be explained through research by Morgan in 1973. Morgan indicated that an individual's perception of perceived exertion of the same physiological load may differ at different times due to variability in that individual's psychological state (Morgan, 1973). The psychological state of an individual can cause differentiation in RPE values for the same physiological load. These findings cast doubt on the reliability of the Borg scale for

estimating exercise effort during progressive and intermittent exercise. Inconsistency can be relevant in studies where RPE is used as a surrogate measure of HR to accurately quantify one's state of metabolic stress or oxygen uptake.

Session RPE is another measure of RPE. Session RPE is a modification to the Category Ratio (0-10) RPE method that involves giving a rating of perceived exertion about 10-30 minutes after an exercise session as opposed to a momentary rating collected during exercise. Herman, Foster, Maher, Mikat, and Porcari (2006) showed that there were limited objective data supporting the validity of the session RPE technique on the basis of HR and blood lactate. Session RPE has been used as an aid in determining inaccuracies in training programs for athletes, providing plausible explanation for overtraining. After 6 randomly ordered 30 minute bouts of exercise of constant load across 3 different exercise intensities, they found that there were significant non-linear relationships between session RPE and % VO_2 peak, % HR peak, and % HR reserve. There were also no significant differences in test-retest values (Herman et al., 2006). These results support the reliability and validity of session RPE on repeated measures of exercise bouts at constant loads. These results also support previous research supporting similar results between session RPE and heart rate measures. However, session RPE was not tested or analyzed under prolonged and exhaustive exercise conditions.

During prolonged exercise bouts, some suggest that the relationship between session RPE and heart rate becomes less accurate as indicators of training intensity (Chen, Fan, & Moe, 2002). This leads to questions about the accuracy of methods of measurement of exertion and training loads during prolonged exercise.

Training Load

TRIMP training load. The TRIMP approach (Training Impulse) developed by Morton, Fitz-Clarke, and Banister (1990) and Fitz-Clark, Morton, and Banister (1991) is a method that combines exercise intensity and duration into a single value used to represent both factors. A TRIMP is a measurement of physical effort that can be derived using maximal, resting, and average HR as well as training duration during the exercise session. However, there is limited research to support or deny the validity and reliability of the TRIMP approach in prolonged bouts of intermittent exercise. Describe or put formula

Banister's training impulse. Banister's training impulse developed by Banister in 1991 is a method used to calculate and individual's training load during a bout of exercise. This is done by multiplying the duration in minutes of an exercise bout, the mean HR during the exercise bout, and a constant, y (Banister, 1991). Banister's TRIMP equation can be seen below:

Banister's TRIMP = time (mins) x ΔHR x y

Several studies have compared the accuracy of Banister's training impulse method to other developed HR based training load methods for soccer specific exercise (Impellizeri et al., 2004; Alexiou & Coutts, 2008; Matzenbacher et al., 2016). These studies found a correlation between different HR based methods as well as to RPE based methods in soccer specific exercise.

Edwards' training impulse. Edwards' training impulse (TRIMP) is another training impulse method that is calculated using HR zones and corresponding coefficients. The time in seconds spent in each of five specific HR zones during an activity is multiplied by the coefficient corresponding to that zone in order to obtain a training load (Edwards, 1993).

Alexiou and Coutts (2008) and Matzenbacher et al. (2016) used Edwards' TRIMP as a method used to determine training load in soccer specific exercise. The Edwards' TRIMP is calculated using this equation:

Edwards' TRIMP = Summation of (Time (s) spent in HR zone x HR coefficient)

The HR coefficients used to compute Edwards' Trimp correspond to the HR zone and are shown in table 1.

Table 1

Heart rate ranges, HR zones, and Edwards' corresponding HR coefficients

HR Range as % of Max HR	HR Zone	HR Coefficient
50% < HR ≤ 60%	1	1
60% < HR ≤ 70	2	2
70% < HR ≤ 80%	3	3
80% < HR ≤ 90%	4	4
90% < HR ≤ 100%	5	5

Edwards' TRIMP was developed to more accurately calculate training impulse using HR as it incorporates the time spent in specific heart rate zones as opposed to just using mean heart rate (Edwards, 1993).

Physiological Relationship of RPE and HR in Soccer

Soccer is the most popular team sport in the world. Soccer is a physical activity that involves both aerobic and anaerobic demands. There are many different factors that play a role in the physiological stress that a soccer player must endure during training and match situations. Such factors may include technical/biomechanical, psychological, and physiological considerations. Even at high levels of competition, there are trends towards more systematic training and selection influencing the anthropometric profiles of players.

During a ninety minute match, an elite player may run on average a distance of ten kilometers at an average intensity close to 80-90% of their maximal HR (Stølen, Chamari, Castagna, & Wisløff, 2005). Within this endurance exercise there are many intermittent bouts and bursts of high intensity exercise that may include sprinting, kicking, jumping, lunging, changing direction, maintaining balance, and resisting the force of an opposing player. With such diversity of exercise movements within a single sport, it can be difficult to measure accurate training and exercise loads using techniques common in continuous and/or short duration exercise.

Soccer specific studies have investigated different methods to more accurately determine workloads within the sport. Some research has suggested that the mean intensity of the physical demands of a soccer game can be around 87% of maximal HR (Ascensão, Rebelo, & Oliveira (2008). HR measures gathered through the use of HR monitoring techniques are a valid way to determine overall training load and intensity (Hoff, Wisløff, Engen, Kemi, & Helgerud, 2001). Work by Hoff et al. (2001) aimed to determine whether small sided soccer games as well as soccer specific dribbling drills could be used as a training mechanism for aerobic endurance. Six male soccer players from a professional team volunteered to participate in the study. The subjects' VO2 max values were determined using an incremental treadmill test. HR max values and blood lactate values were also recorded for each individual. The subjects then participated in a soccer dribbling circuit as well as a small sided soccer scrimmage. HR was recorded throughout using Polar^{TM} HR monitors. Volume of oxygen consumption (VO2), ventlilation (VE), respiratory exchange ratio (R), and breathing frequency (fb) were measured using a portable metabolic test system. VO2 and HR measures correlated at several intensities (Hoff et al., 2010) Hoff et al. also concluded that

soccer specific intermittent exercises such as dribbling at pace and small sided games (5 vs. 5) can elicit exercise intensities necessary for aerobic training.

Drust et al. (2010) aimed to produce a laboratory based treadmill exercise that represented work rates of soccer players during match play. Seven male university soccer players participated in forty-five minutes of a soccer-specific intermittent exercise protocol that was completed on a treadmill (Drust et al., 2010). The seven subjects also participated in a continuous steady-rate exercise protocol for forty five minutes at the same average speed. The physiological responses to the laboratory-based soccer-specific protocol that were observed were compared to values that had previously been observed for soccer match-play. The physiological responses were similar to previously observed values for soccer match-play with oxygen consumption about 68% max and HR average of 168 ± 10 bpm. There were no significant differences observed in oxygen consumption and HR between the two conditions, however RPE ratings during soccer specific intermittent exercise was 15 ± 2 compared to 13 ± 1 for steady state exercise (Drust et al., 2010). These results support the suggestion that the relationship between RPE and HR may become weaker as exercise becomes more intermittent.

Impellizeri et al. (2006) compared the effects of small-sided soccer specific aerobic interval training versus generic aerobic interval training on physical fitness in soccer athletes. Interval training consisted of four bouts of four minutes of high intensity exercise with three minutes of rest between bouts (Impellizeri et al., 2006). Measures of maximum oxygen uptake, lactate threshold, running economy, a soccer-specific endurance test (Ekblom's circuit), and indices of physical performance during soccer matches such as total distance and time spent standing, walking, and at low- and high-intensity running speed were all taken

throughout training sessions. Training load, which was quantified using HR and RPE methods, was recorded during all training sessions as well. HR and RPE based methods of determining training loads were found to be similar between the two groups (Impellizeri et al., 2006). However, this study only looked into the relationship between HR and RPE to monitor training loads within the mode of short duration soccer specific training.

Matzenbacher et al. (2016) investigated the relationship between session RPE and two training impulse methods (Edwards' TRIMP and Banister's TRIMP) to determine training loads in futsal players. Futsal is an indoor sport with many of the same rules as soccer, but played with fewer players and smaller goals on a harder, gym floor surface. The physiological demands of futsal, involving intermittent bouts of exercise can be similar to those found in soccer (Matzenbacher et al., 2016). The training loads of nine futsal players were calculated using session RPE as well as Edwards' TRIMP and Banister's TRIMP methods for 57 practice sessions (Matzenbacher et al., 2016). The CR-10 rating of perceived exertion scale was used to determine session RPE training load values. Matzenbacher et al. found that correlations between session RPE based methods and Banister's TRIMP as well as between session RPE based methods and Edwards' TRIMP. The correlations between the internal loads based on the session RPE compared to the two TRIMPs were characterized as strong ($r = 0.58$; $r = 0.48$) to very strong ($r = 0.79$; $r = 0.78$), respectively (Matzenbacher et al., 2016). However, the significance of results in relationship to soccer in terms of competition can be argued as the duration, distance covered, and overall training loads are higher in a single game of soccer compared to a single game of futsal.

Alexiou et al. (2008) compared methods used to quantify training loads in women's soccer players. They compared the session RPE method for quantifying internal training load

(TL) with various HR-based training load quantification methods across a variety of training modes with women soccer players. Session RPE, HR, and duration were recorded for 735 individual training sessions and matches over a period of sixteen weeks (Alexiou & Couts, 2008). They found that correlations between session RPE training loads and the three HR based methods separated by training type were all significant. The strongest correlations between session RPE and HR based methods for training loads were observed during technical (r = 0.68 to 0.82), conditioning (r = 0.60 to 0.79) and speed sessions (r = 0.61 to 0.79). Since higher correlations were found in less intermittent, primarily aerobic based training sessions, it can be suggested that HR-based training loads relate better to session RPE training loads in less intermittent training situations (Alexiou & Couts, 2008). These results support previous findings showing that the Session-RPE training loads compare relatively well with HR-based techniques for quantifying internal training load in a variety of soccer training modes. However, it should also be noted that as intermittent activity increases, the correlation between session RPE and HR methods of establishing training load generally decreases.

In conclusion, previous research has suggested that a significant correlation exists between HR and session RPE based methods of determining training loads. Some research has shown that this relationship remains significant within the mode of soccer specific exercise (Alexiou & Couts, 2008; Matzenbacher et al., 2016; Impellizeri et al., 2006). However, some studies suggest that the strength of this correlation between the two types of training load methods may decrease in strength as duration and intensity increases (Alexiou & Coutts, 2008; Drust et al., 2010). This portrays a potential problem when it comes to the accuracy of monitoring and determining training load with the belief that the two methods can be used

interchangeably. In practical scenarios, many professional and NCAA Division I soccer programs use HR monitoring systems and the use of HR based training impulse methods in order to determine and monitor accurate training loads for their athletes throughout the season. However, within NCAA Division III soccer programs RPE based training load methods tend to be the most common. This difference is a result primarily from the size of the programs and their budgets. NCAA Division I schools tend to have more money to spend on technology like HR monitoring systems, while the cost of HR monitoring systems is beyond the budgets of most NCAA Division III programs. Therefore, this investigation was aimed towards determining whether RPE based training load methods can still be as reliable in determining true training load as HR based training load methods within soccer specific exercise.

Chapter 3

Research Manuscript

Workload during exercise training is important when developing the optimal program for athletes, especially in soccer, a sport that elicits workloads of intermittent bouts of both aerobic and anaerobic exercise. There are many different methods used to determine the workload of different exercise modes in soccer. Session rate of preserved exertion (RPE) and heart rate (HR) have been utilized to develop training load of different soccer specific exercises. However as exercise becomes more intermittent and longer in duration, the correlation between session RPE and HR based methods used to determine workload become more ambiguous (Alexiou & Coutts, 2008). There has been far less research regarding this correlation within sport specific exercise. Impellizeri et al. (2004), showed that among a population of young soccer players, there was a relatively strong correlation between session RPE based training loads and HR based training loads with correlation coefficients ranging between 0.50 and 0.85 (Impellizeri et al., 2004). These correlations were statistically significant but the 0.35 range in correlation coefficients is fairly wide between session RPE and HR based training load measures. The research conducted in this study is a unique investigation of this correlational relationship in soccer specific exercise in an environment that is the more similar to the exercise and intensity that is commonly found in an actual soccer match. The purpose of this research study was to determine the strength of the relationship between HR and RPE based training load methods in soccer specific exercise of moderate to long duration.

Methods

Participants. Ten members of an NCAA DIII men's varsity soccer team who had already participated in four weeks of spring season training were recruited to participate in this study. All participants were volunteers and were given a detailed explanation of study based procedures and potential risks. All participants passed the men's soccer team spring 2017 fitness test of a 3 mile run in under 20 minutes. Each participant signed an informed consent form (Appendix B). The ten participants were fitted with Polar Team 2 HR system monitors (Appendix D) prior to the start of the testing period. Two of the ten participants had heart rate monitors that failed to function properly throughout the scrimmage session. Therefore, only data from eight of participants were included and analyzed.

Soccer specific exercise. All participants took part in a team soccer scrimmage during the spring 2017 season. The scrimmage was played against two different NCAA soccer teams (NCAA Division 2 team first half, NCAA Division 1 team second half). Each team consisted of eleven players. The soccer scrimmage consisted of 60 minutes of soccer specific exercise (One thirty minute first half, a ten minute halftime period, and then a thirty minute second half period) The scrimmage was played under NCAA Soccer rules and parameters. Ten field position players (Four defenders, four midfielders, and two forwards) from an NCAA Division III varsity men's varsity soccer team were fitted with the polar team 2 HR monitors and CR-10 RPE data was obtained from each participant 10 minutes post soccer scrimmage.

Heart rate monitoring. Prior to the start of the first 30 minute scrimmage half, each participant was fitted with a Polar Team 2 chest HR monitor. These monitors tracked the HR of each individual every second throughout the entire scrimmage (30 minute first half, 10

minute halftime, and 30 minute second half). The HR of each individual was recorded and stored within Polar Team 2 monitors. Individual maximum HR was estimated using the general formula of 220-age (Baechle, 2008). The HR zones shown in table 1 were calculated for each participant by multiplying the calculated max HR by each percentile range. This gave a specific HR range that would represent each HR zone. Time within each HR zone (in seconds) was determined for each individual by analysis of the data collected within the Polar HR monitor. The total time that each individual spent in each HR zone during the scrimmage, excluding the 10 minute halftime period, was multiplied by corresponding HR zone coefficients shown in table 1. The five values were then summed and the result was the Edwards' TRIMP training load for the scrimmage.

Session RPE monitoring. Session RPE values were recorded for each individual at the end of the second thirty minute half. The session RPE values were calculated using the CR-10 RPE scale value chosen by each individual multiplied by the duration of the exercise for that player. An example of the CR-10 RPE scale can be found in appendix C. Session RPE training load values for each individual were calculated. The equation used to determine session RPE training loads is:

Session RPE = Borg CR10 rating of perceived exertion (1-10) x exercise duration (s)

Statistical analysis. A Pearson correlational analysis of Edwards' TRIMP values and session RPE values for each participant was completed using SPSS version 23 software. The Pearson correlation coefficient (*r*) obtained from the correlational analysis is a measure of the linear correlation between the two variables, session RPE training load values and Edwards' TRIMP values. From the Pearson correlational analysis, the *r* value was analyzed for statistical significance and compared to other values obtained in some of the previous studies

involving soccer training loads. Descriptive statistics of the participants' height, weight, and age were also calculated through data obtained from pre-existing medical records.

Results

The Pearson correlation coefficient between session RPE and Edwards' TRIMP was statistically significant ($r = 0.719$, $p < .05$). A Pearson correlation coefficient of 0.719 can be characterized as a strong correlation. About 52% of the variance could be explained by the relationship between session RPE and Edwards' TRIMP, with an $r^2 = 0.517$. The correlations between session RPE and Edwards' TRIMP methods are presented in Table 2. Figure 1 in appendix E shows a scatterplot of Edwards' TRIMP vs. session RPE by position. Descriptive statistics of the participants' height, weight, and age are shown in table 3.

Table 2
Pearson Correlation Coefficients Between Training Load Variables

Variable	RPE	Time	Session RPE	Edwards' Trimp
RPE	-	-	-	-
Time	0.748*	-	-	-
Session RPE	0.955**	0.909**	-	-
Edwards' TRIMP	0.765*	0.566	0.719*	-
Average HR	0.060	-0.442	-0.162	0.473

*$p < 0.05$; **$p < 0.01$

Note: Relationships between Time & RPE, Edwards' Trimp & RPE, and Edwards' Trimp & Session RPE were all significant ($p<0.05$). Relationships between Session RPE & RPE as well as Session RPE & Time were significant ($p<0.01$)

Table 3

Mean Age, Mass, and Height of the Participants

	Mean ± SD	Range
Age (years)	19.13 ± 0.84	
Mass (kg)	75.98 ± 10.57	
Height (cm)	181.3 ± 7.9	

Discussion

This study is one of very few investigating the relationship between Edwards' TRIMP and session RPE based TL within collegiate soccer players. The study is the first to our knowledge that investigates the relationship between session RPE and Edwards' TRIMP within NCAA Division III men's soccer athletes. In agreement with the results of previous research, a strong correlational relationship between Edwards' TRIMP and session RPE TLs was observed ($r = 0.719$, $p < 0.05$) (Alexiou & Coutts, 2008; Matzenbacher et al., 2016; Impellizeri et al., 2006). The strength of this relationship found within soccer specific match type play is consistent with results found in previous research (Alexiou & Coutts, 2008; Matzenbacher et al. 2016; Impellizeri et al., 2006).

Previous studies have shown support for the validity of session RPE TL methods in quantifying internal TL in soccer specific exercise bouts (Alexiou & Coutts, 2008). Alexious and colleagues found a significant correlation between session RPE and the three HR methods of determining TL tested (Banister's TL, Lucia's TRIMP and Edwards' TRIMP) ($r = 0.84$, 0.83, and 0.85, all $p < .01$, respectively). However, the correlations between Banister's TL and session RPE as well as Edwards' TRIMP and session RPE for match type play show lower correlation values ($r = 0.49$, 0.65, all $p < 0.001$), respectively. The correlation strength between Edwards' TRIMP and session RPE TL methods within match type play in this study was found to be slightly higher ($r = 0.719$, $p < 0.05$). With soccer

specific exercise, specifically match type play being both aerobic and anaerobic, HR as well as session RPE based methods of determining TL have both been commonly practiced methods. In agreement with previous research, the results of the present study suggest that session RPE based TL methods is a reliable approach to determining TL in soccer specific exercise (Alexiou & Coutts, 2008; Matzenbacher et al. 2016). Table 4 shows a comparison of studies investigating the relationship between Edwards TRIMP and session RPE in soccer.

Table 4
A Comparison of Studies regarding the Session RPE & Edwards TRIMP relationship

Study	Measure	Population	n	Condition	Correlation
Impelizerri et al., 2004	Relationship between Session RPE and Edwards TRIMP	Male soccer players	19	Match-play & training	r=0.54-0.78
Alexiou & Coutts, 2008	Relationship between Session RPE and Edwards TRIMP	Elite womens soccer players	15	Match-play & training	r=0.65
Matzenbacher et al., 2016	Relationship between Session RPE and Edwards TRIMP	Male futsal players	9	Match play & training	r= 0.78
Guider, 2017	Relationship between Session RPE and Edwards TRIMP	NCAA Division 3 male soccer players	8	Match-play	r= 0.719

Table 4 shows comparable characteristics between studies relating to the relationship between Session RPE and Edwards TRIMP

Limitations

The sample size of only eight participants can be considered a limitation in this study. Only seventeen members of an NCAA Division III men's soccer team were available to participate for the Spring 2017 season. Of the seventeen, only the ten starting field players played significant time to be deemed moderate to long duration (≥40minutes). Of the ten field position players used, two of them had heart rate monitors that failed to accurately collect and maintain heart rate data in the second half. The data for these two participants were not used. Data from eight of the field position players was utilized in this study.

Another limitation to this research could be the duration of the soccer specific training session. The duration of the soccer scrimmage used for this was limited to sixty minutes, compared to the usual ninety minute duration of a real soccer game. The duration of sixty minutes was agreed upon by team coaches and could not be controlled by the researcher.

Further limitations could include failure of participants to abstain from caffeine intake within 12 hours of competition as well as failure to abstain from unnecessary strenuous exercise within 24 hours of competition. Caffeine can effect both blood pressure as well as heart rate measures (Robertson, et al. 1978). Unnecessary strenuous exercise could have also played a role in RPE measures if participants were coming into the scrimmage session pre-fatigued.

Practical Application

The session RPE based method of determining training load is a very simple and cost effective method that can be utilized by athletes, coaches, and exercise physiologists. Its ease of use makes it a very versatile tool that can be used across different soccer specific training

modalities. Specifically, within NCAA Division III soccer programs, the cost effectiveness and ease of use makes session RPE a very practical method to monitor and progress TLs within athletes. It is evident that long term monitoring of individual TLs throughout a season combined with proper progression and regression when necessary is important when it comes to improving performance. Future research investigating the relationship between session RPE and HR based TL methods should be pursued in order to better understand this relationship in regards to developing and monitoring TLs involving intermittent bouts of soccer specific exercise of moderate to long duration over the course of an entire season.

Reference List

Achten, J., & Jeukendrup, A. E. (2003). Heart Rate Monitoring. *Sports Medicine*, *33*(7), 517-538.

Alexiou, H., & Coutts, A. (2008). A comparison of methods used for quantifying internal training load in women soccer players. *International Journal of Sports Physiology and Performance*, *3*, 320-330. Retrieved from https://opus.lib.uts.edu.au/handle/10453/12561

Akubat, I., Patel, E., Barrett, S., & Abt, G. (2012). Methods of monitoring the training and match load and their relationship to changes in fitness in professional youth soccer players. *Journal of Sports Sciences*, *30*(14), 1473–1480.

Ascensão, A., Rebelo, A., & Oliveira, E. (2008) Biochemical impact of a soccer match—analysis of oxidative stress and muscle damage markers throughout recovery. *Clinical Biochemistry*, *41* (10–11), 841–851.

Baechle, T. R., Earle, R. W. (Eds.). (2008). *Essentials of strength training and conditioning*. (3rd ed.). Champaign, IL: Human Kinetics.

Banister, E. W. (1991). Modelling athletic performance. In H. J. Green, J. D. McDougal, & H. Wenger (Eds.), *Physiological testing of elite athletes* (403 –424). Champaign, IL: Human Kinetics.

Billman, G. E. (2011). Heart Rate Variability – A Historical Perspective. *Frontiers in Physiology*, *2*, 86. http://doi.org/10.3389/fphys.2011.00086

Borg, G.A.V., (1977). *Physical Work and Effort*. Oxford: Pergamon Press.

Borg, G.A.V. (1985). *An introduction to Borg's RPE scale*. Ithaca, NY: Mouvement Publications.

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 Sports Sciences*, 20, 873–899.

Drust, B., Reilly, T., & Cable, N. T. (2010). Physiological responses to laboratory-based soccer-specific intermittent and continuous exercise. *Journal of Sports Sciences*. Retrieved from http://www.tandfonline.com/doi/abs/10.1080/026404100750017814

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

Eston, R. G., & Williams, J. G. (1988). Reliability of ratings of perceived effort regulation of exercise intensity. *British Journal of Sports Medicine*, *22*(4), 153–155.

Fitz-Clarke J.R., Morton, R.H., Banister, E.W. (1991). Optimizing athletic performance by influence curves. *Journal of Applied Physiology*, *71*, 1151-8.

Gilman, M. B. (1996). The use of heart rate to monitor the intensity of endurance training. *Sports Medicine*, *21*, 73 –79.

Herman, L., Foster, C., Maher, M., Mikat, R., & Porcari, J. (2006). Validity and reliability of the session RPE method for monitoring exercise training intensity. *South African Journal of Sports Medicine*, 18, 14-17. Retrieved from http://www.ajol.info/index.php/sasma/article/view/31891

Hoff, J., Wisløff, U., Engen, L.C., Kemi, O.J., & Helgerud, J. (2002) Soccer specific aerobic endurance training. *British Journal of Sports Medicine*, *36*(3), 218-221.

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., Marcora, S. M., Castagna, C., Reilly, T., Sassi, A., Iaia, F. M., & Rampinini, E. (2006). Physiological and performance effects of generic versus specific aerobic training in soccer players. *International Journal of Sports Medicine*, *27*(6), 483–92.

Lamb, K. L., Eston, R. G., & Corns, D. (1999). Reliability of ratings of perceived exertion during progressive treadmill exercise. *British Journal of Sports Medicine*, *33*(5), 336–339. doi:10.1136/bjsm.33.5.336

Matzenbacher, F., Pasquarelli, B.N., Rabelo, F.N., Dourado, A.C., Durigan, J.Z., Gonçalves, H.R., Stanganelli, L.C.R. (2016). The use of the rating of perceived exertion to monitor and control the training load in futsal. *Journal of Exercise Physiology, 19*(4), 42-52.

Morgan, W. P., 1973. Psychological factors influencing perceived exertion. *Medicine and Science in Sports*, 5, 97-103.

Morton R.H., Fitz-Clarke J.R., Banister E.W. (1990). Modeling human performance in running. *Journal of Applied Physiology*. *69*, 1171-1177.

Pandolf, K. B., (1983) Advances in the study and application of perceived exertion. In R. Terjung (Ed.), *Exercise and Sports Science Reviews* (118-158). New York, NY: Pergamon Press.

Pichot, V., Roche, F., Gaspoz, J.M., Enjolraz, F., Antoniadis, A., Minini, P., Costes, F., Busso, T., Lacour, J.R., Barthelemy, J.C. (2000). Relation between heart rate variability and training load in middle-distance runners. *Medicine & Science in Sports & Exercise*, *32*(10), 1729-1736.

Robertson, D., Frölich, J.C., Carr, K.R., Watson, T.J., Hollifield, J.W., Shand, D.G., Oates, J.A. (1978). Effects of caffeine on plasma renin activity, catecholamines and blood pressure. *New England Journal of Medicine*, *298*, 181-186.

Smutok, M. A., Skrinar, G. S. and Pandolf, K. B., (1980) Exercise intensity: subjective regulation by perceived exertion. *Archives of Physiology, Medicine and Rehabilitation 61*, 569-574.

Stølen, T., Chamari, K., Castagna, C., & Wisløff, U. (2005). Physiology of soccer: an update. *Sports Medicine (Auckland, N.Z.)*, *35*(6), 501–36. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/15974635.

Wenos D.L., Wallace J.P., Surburg P.R., & Morris, H.H. (1996). Reliability and comparison of RPE during variable and constant exercise protocols performed by older women. *International Journal of Sports Medicine*, *17*, 193–8.

IBM Corp. Released 2013. IBM SPSS Statistics for Windows, Version 23.0. Chicago, IL: IBM Corp.

Appendix A: Institutional Review Board Approval Letter

SUNY Cortland
Institutional Review Board

MEMORANDUM

To:	Samuel Guider Deborah VanLangen
From:	Sebastian Purcell, Reviewer *on behalf of* Institutional Review Board
Date:	5/11/17
RE:	Institutional Review Board Approval

In accordance with SUNY Cortland's procedures for human research participant protections, the protocol referenced below has been approved for a period of one year:

Title of the study:	The Relationship between Ratings of Perceived Exertion and Heart Rate in Division III Collegiate Soccer Players		
Level of review:	**Exempt**	**Protocol number:**	161757
Project start date:	Upon IRB approval	**Approval expiration date*:**	Note: Exempt research

* **Note: exempt research does not require continuation requests;** the SUNY Cortland IRB only requests annual email notification (to irb@cortland.edu) indicating that the research continues. The purpose of the continuation notification is to alert the IRB Administrator that the records of the original IRB approval must remain available. Unlimited continuations can be registered for exempt research under federal and SUNY Cortland IRB guidelines.

The federal Office for Research Protections (OHRP) emphasizes that investigators play a crucial role in protecting the rights and welfare of human subjects and are responsible for carrying out sound ethical research consistent with research plans approved by an IRB. Along with meeting the specific requirements of a particular research study, investigators are responsible for ongoing requirements in the conduct of approved research that include, in summary:

- obtaining and documenting informed consent from the participants and/or from a legally authorized representative prior to the individuals' participation in the research, unless these requirements have been waived by the IRB;
- obtaining prior approval from the IRB for any modifications of (or additions to) the previously approved research; this includes modifications to advertisements and other recruitment materials, changes to the informed consent or child assent, the study design and procedures, addition of research staff or student assistants, etc. (except those alterations necessary to eliminate apparent immediate hazards to subjects, which are then to be reported by email to irb@cortland.edu within three days);
- providing to the IRB prompt reports of any unanticipated problems involving risks to subjects or others;
- following the principles outlined in the Belmont Report, OHRP Policies and Procedures (Title 45, Part 46, Protection of Human Subjects), the SUNY Cortland College Handbook, and SUNY Cortland's IRB Policies and Procedures Manual;
- notifying the IRB of continued research under the approved protocol to keep the records active; and,
- maintaining records as required by the HHS regulations and NYS State law, for at least three years after completion of the study.

Miller Building, Room 402 • P.O. Box 2000 • Cortland, NY 13045-0900
Phone: (607) 753-2511 • Fax: (607) 753-5590

In the event that questions or concerns arise about research at SUNY Cortland, please contact the IRB by email **irb@cortland.edu** or by telephone at (607)753-2511. You may also contact a member of the IRB who possesses expertise in your discipline or methodology, visit **http://www.cortland.edu/irb/members.html** to obtain a current list of IRB members.

Sincerely,

Sebastian Purcell, *on behalf of*
Institutional Review Board
SUNY Cortland

Appendix B: Informed Consent Form

SUNY Cortland
Kinesiology Department

Protocol #: 161757
Expiration Date:05/2018

Document of Informed Consent

Kinesiology Department
State University College at Cortland

TITLE: The Relationship between Ratings of Perceived Exertion and Heart Rate in Division III Collegiate Soccer Players

STUDENT INVESTIGATOR: Sam Guider, (585) 545-8406

FACULTY SUPERVISOR: Deborah VanLangen PhD., Assistant Professor, Kinesiology Department, SUNY-Cortland

The research that you have been asked to participate in is being conducted by Sam Guider of the Kinesiology Department at SUNY-Cortland. We request your informed consent to be a participant in the project described below. **Please feel free to ask about the project, its procedures, or objectives.**

PURPOSE: The purpose of this study is to understand the relationship between ratings of perceived exertion (RPE) and heart rate (HR) based training load methods in Division III SUNY Cortland male varsity soccer players during soccer specific exercise of moderate to long duration.

PROCEDURES: Each participant must be a member of the SUNY Cortland men's varsity soccer team. Each participant must have completed a Spring 2017 three mile fitness test time of under 20 minutes as directed by SUNY Cortland men's varsity soccer coaches to be eligible for this study. Each participant must have clearance to play by SUNY Cortland Athletic Training staff to be eligible for this study. Each participant must have competed in the SUNY Cortland men's varsity soccer scrimmage that occurred on April 23rd, 2017. HR and RPE data from each participant already collected from the SUNY Cortland men's varsity soccer coaching staff will be used and analyzed. HR and RPE data from each individual from the 60 minute soccer scrimmage will be used to calculate Edwards Training Impulse and Session RPE training load values for each participant representing the scrimmage training load for each player.

FULL DISCLOSURE: No information will be withheld from participants throughout the duration of this study.

RISKS: The proper precautions will be to taken to ensure that the testing area, as well as all of the equipment being used, is safe for all participants involved in the study. There is less than minimal risk for breaching of confidential information collected for each participant in this study.

BENEFITS: The results of this study may indicate that a relationship exists between HR and RPE in soccer-specific exercise of moderate to long duration. The results of this study may also indicate the

Protocol #: 161757
Expiration Date:05/2018

relative strength of this relationship if a relationship is found. This may help in properly determining and progressing training loads for soccer athletes in order to optimally improve strength and performance, as well as decrease risk of overtraining and injury. This may also help coaches in determining which training load method is most accurate.

LENGTH of PARTICIPATION: The study design is for the analysis of previously collected physiological data of HR and RPE measures of anticipated participants. Informed consent for the use of this data is the only active participation required of participants in this study.

CONFIDENTIALITY: Your HR and RPE responses as well as descriptive statistics of height, weight, and age are strictly confidential. Only the lead investigator and presiding faculty member will have access to your responses. All of the data from the experiment will be stored in a locked cabinet, and the data on the computer will be stored with your identity protected.

FREEDOM TO WITHDRAW: Participation in this study is completely voluntary, and you may withdraw from the study at any time for any reason. You will not have any negative consequences from the investigators if you do not participate in this study, or if you decide to withdraw once you have started. Additionally, you may ask the researcher to destroy any responses you may have given.

For more information about this study, please contact Sam Guider at (585) 545-8406 or Samuel.guider@Cortland.edu. This study has been approved by the Institutional Review Board at SUNY Cortland. For more information about research at SUNY Cortland or information about the rights of research participants, please contact the Institutional Review Board by email irb@cortland.edu, or by phone (607) 753-2511.

I have read the description of the project for which consent is requested, understand the activities requested for my involvement in this project, and I hereby consent to participate in this study.

Name: _____ Telephone#: _____
(*print*)

Signature: _____ Date: _____
(*sign*)

Researcher's Signature: _____ Date: _____

Appendix C: Borg's CR-10 RPE Scale

rating	description
0	NOTHING AT ALL
0.5	VERY, VERY LIGHT
1	VERY LIGHT
2	FAIRLY LIGHT
3	MODERATE
4	SOMEWHAT HARD
5	HARD
6	
7	VERY HARD
8	
9	
10	VERY VERY HARD (MAXIMAL)

Appendix D: Polar Team 2 HR Monitoring System

Appendix E: Scatterplot of Edwards' TRIMP vs. Session RPE TL by position

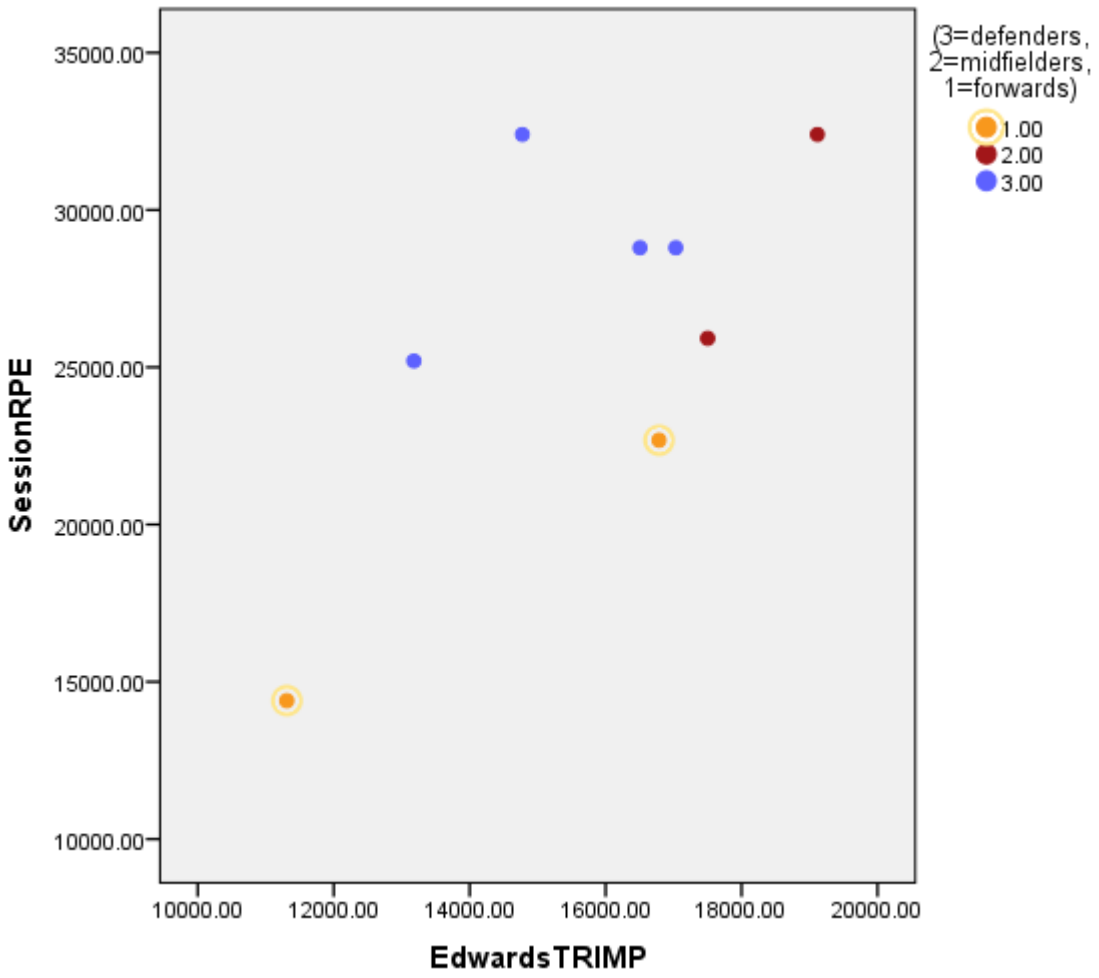

Figure 1. Session RPE TL vs. Edwards' TRIMP by position. A significant, positive, strong correlation was found between Session RPE TL and Edwards' TRIMP ($p<0.05$)