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The Impact of Training Loads on In-Match Soccer Performance Variables: A Position-Based Case Report

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The Impact of Training Loads on In-Match Soccer Performance Variables: A Position-Based

Case Report

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A thesis

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Masters of Arts in Kinesiology and Sport Studies

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by

Garett Bingham

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Keywords: soccer, GPS, sRPE, collegiate, training loads

ABSTRACT

The Impact of Training Loads on In-Match Soccer Performance Variables: A Position-Based

Case Report

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It is critical to maintain multiple fitness characteristics during the soccer season through the use of training, but also to ensure that the training loads do not hinder subsequent match performance. The purpose of this thesis is to investigate the impact of the training load on key physical performance variables in the subsequent match. Five Division I female soccer players were analyzed across six weeks of training and matches. Training loads in the forms of odometer, high intensity odometer, estimated odometer and sRPE were accumulated at time points from one to five days prior to a match. The accumulated training loads were then correlated with the same performance measures from match play. The greatest significant correlations were seen in sRPE training loads when compared to match odometer and estimated distance. There does not appear to be negative effect on match performance when looking at any of the accumulated training load values.

DEADICATION

I would like to dedicate this thesis to my father – Grant Randall Bingham, Jr.

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CHAPTER 1

INTRODUCTION

Soccer is the most popular sport in the world. As such much research has been completed to investigate both match and training methodologies. The primary goal of this area of research is to better understand the physical demands of the sport, as well as how various training methodologies can be utilized to prepare athletes for these demands. Several methods have been used to quantify both internal loads experienced and external loads performed by players. External loads include measures of the work done by players, while internal loads are measures of the metabolic demands required to complete external work.

Time-motion analysis is a popular method for measuring the external work performed by players in both match and training settings. One technology that has been used for this purpose are specially designed global positioning system (GPS) units that allow for the collection of physical performance markers such as distances and velocities performed by individual athletes(Coutts & Duffield, 2010; Jennings, Cormack, Coutts, Boyd & Aughey, 2010; Rampinini et al., 2015; Varley, Fairweather, & Aughey, 2012). For the measure of internal training loads one popular method is the session rating of perceived exertion measure which has been used to establish a consistent measure of training loads across modalities (Day, McGuigan, Brice & Foster, 2004; Foster et al., 2001; Foster et al., 1995; McGuigan, Egan, & Foster, 2004; Sweet, Foster, McGuigan & Brice, 2004).

Along with improved methods of collecting time motion data come the ability to examine this data in new ways. One such process of interest revolves around the concept that due to the intermittent nature of soccer matches, and additional metabolic demands imposed by the

consistent need to accelerate and decelerate, the total distances reported does not actuarially portray the work completed by players. There have been some attempts to utilize the acceleration and deceleration data collected by GPS units to equate the work completed by a player to the work that would have been completed with the same effort was exhibited in a steady state activity, allowing for a more accurate representation of external load (Osgnach, Poser, Bernardini, Rinaldo & di Prampero 2010).

Statement of Problem

The purpose of this thesis is to investigate the impact of the training load on key physical performance variables in the subsequent match. To accomplish this, the study examines the relationship between total odometer, high intensity distances, estimated distances and Session rating of perceived exertion (sRPE) data from match play and the accumulated training and game volume for the preceding 5-,4-,3-,2- and 1-day periods. These variables were chosen for several reasons. Total distances and high intensity distances are frequently reported in studies regarding soccer performance (Alexander, 2014; Bradley et al., 2011; Datson et al., 2014; Folgado, Duarte, Marques & Sampaio, 2015; Rampinini, Coutts, Castagna, Sassi & Imprellizzeri, 2007). Estimated distance is an emerging measure that may provide additional value beyond just reporting odometer as a work volume measure, due to the proposed ability to account for acceleration and deceleration activities(Osgnach et al., 2010). Finally, sRPE will be utilized due to its ability to subjectively measure perceived training loads across training modalities (Day et al., 2004; Foster et al., 2001; Foster et al., 1995; McGuigan et al., 2004; Sweet et al., 2004).

<center>Hypothesis</center>

It is hypothesized that weekly training structured in a manner in which training volume managed as competitions approach will not interfere with the player's capacity to exhibit key performance variables in matches. It is also hypothesized that the estimated distance measure will provide a better representation of training load than total distance.

<center>Definitions</center>

1. Rating of Perceived Exertion: A subjective measure of training intensity for training and competitive activities (Foster et al., 1995).

2. Session Rating of Perceived Exertion: The product of the rating of perceived exertion an activity and the duration of the activity (Foster et al., 1995).

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CHAPTER 2

REVIEW OF THE LITERATURE

<u>Time-Motion Analysis</u>

Early research involving motion analysis of in-match soccer performance was achieved through the use of video cameras placed near the field, often times only capable of following a single player for later analysis (Carling, Bloomfield, Nelsen & Reilly, 2008). The advent of technologies, such as computer based tracking systems and specialized global positioning system (GPS) units, provides an ability to both collect and analyze data relevant to the physical performance of athletes. Computer based tracking systems use digitized video to allow for player tracking, while GPS units are worn under the jersey in specially designed harnesses. Research on these methodologies have shown that both are valid and reliable in terms of reporting overall distances covered (Edgecomb & Norton, 2006).

There have been several versions of sports GPS units, with resolutions of 1, 5, and 10 Hz, utilized for athlete monitoring and research. As the technology has advanced and the sampling rate of position based on GPS signals have increased, so too has the accuracy of the measurement. The current generation (10 Hz) of sport GPS technology has been demonstrated to be superior to previous generations in regards to estimating both distances and velocities. However, it should be noted that even with the new units there is greater accuracy in measures of distance with longer runs, while soccer is a sport characterized by short runs sequenced together (Castellano, 2011; Jennings et al., 2010; Portas, Harley, Barnes & Rush, 2010; Varley et al., 2012). An examination by Rampinini et al. (2015) utilized a linear running course with varying intensities requiring acceleration and deceleration movements in an attempt to recreate demands

similar to those seen in soccer. In that study it was found that when compared to radar the total distance was recorded by the 10HZ GPS unit showed 1.9% and 4.7% error for total distance and high speed running respectively. It should also be noted that the error for very high speed running (>20km·hr) was found to be 10.5%. There is some research that may indicate that additional error may be introduced into measures when change of direction tasks are completed, again particularly at higher velocities (Coutts & Duffield, 2010; Jennings et al., 2010). Another consideration when utilizing this technology is demonstrated that while GPS units with a sampling rate of 10Hz were valid during activities of constant speed and acceleration, decelerations from high velocity (>20km·hr) showed ~30% error (Varley et al., 2012). As such, practitioners should understand that there is some inherent error in the measures acquired with these systems.

The research on female soccer player movement analysis has broken velocities into several different categories: standing (0 km·h^{-1}), walking (6 km·h^{-1}), jogging (8 km·h^{-1}), low-speed running (12 km·h^{-1}), moderate-speed running (15 km·h^{-1}), high-speed running (18 km·h^{-1}), and sprinting (25 km·h^{-1}). The literature regarding velocity bands classify high intensity running as the total distance covered during the match in the moderate-speed running, high-speed running and sprinting velocity bands (>15 km·h^{-1}) (Andersson, Randers, Heiner-Moller, Krustrup & Mohr, 2010; Krustrup, Mohr, Ellingsgaard & Bangsbo, 2005; Mohr, Krustrup, Andersson, Kirkendal & Bangsbo, 2008).

<div align="center">Physical Demands</div>

Datson et al. (2014) reviewed female soccer data from various levels ranging from international to domestic leagues finding that average distances covered in a match for players

was ~10 km, with 1.53-2.46 km occurring in the high intensity velocity bands(>18 km·hr^{-1}).

Previous examination of Division-I collegiate female soccer players found that distances covered

fell in the range of 8-10 km, with 0.6-1.4 km coming in the high intensity velocity bands (>15

km·h^{-1}) (Alexander, 2014). There is general consensus within the literature regarding female

soccer players concurs with the literature with men's soccer that the greatest distances are

covered by midfield players (Andersson et al., 2010; Bradley et al., 2011; Bradley et al., 2009;

Datson et al., 2014; Mohr et al., 2008; Rampinini et al., 2007).

Mohr et al. (2008) investigated the differences in physical performance measures

between top-class (national team level, playing in top US league) and elite (top level Danish and

Swedish domestic league) female soccer players. This investigation found that despite similar

number of soccer activities, and total distances the top-class players performed more high

intensity runs and covered a greater distance at these intensities. Additional research from

Andersson et al. (2010) attempted to further elucidate the factors impacting the demands of

women's soccer by comparing the performance of national level Danish and Swedish players

during international and domestic competitions. In this study it was found that similar to Mohr

et al. (2008) there was no difference in the number of activities or total distances covered, as well

as a greater of high intensities runs and distances during international matches versus domestic

matches. This line of research provides some indication that while there is evidence that high

intensity running is related to fitness characteristics such aerobic capacity and lactate threshold

(Krustrup et al., 2005), the level of competition may influence this performance variable. There

is also some indication that within NCAA Division I female soccer players the ability to perform

high intensity running is related to a players quadriceps muscle thickness and pennation angle

(McCormack et al., 2014). This would provide a basis that within the collegiate population, in

addition to aerobic fitness, adaptations to resistance training may have an influence on high intensity running.

The concept that the quality of the opponent has an influence on the distances covered at high intensity was one of several possible explanations considered by Rampinini et al. (2007). Similar to the female soccer studies it was also found that the level of competition for a UEFA Champions League level team also dictated the distances covered at high intensities, with greater distances occurring in matches against the best teams played compared to the worst teams. In addition to level of competition this study also demonstrated that distances covered at high intensity was higher at the end of the season when compared to the beginning and middle of the season. The authors include changes in overall or specific fitness, tactics, or teamwork as possible explanations for the increased high intensity distances as the season progresses. The researchers in this study also propose that the variation seen in high intensity distances are most likely based on factors presented by the opponents play style, fitness and tactics due to lower variation of high intensity running in subsequent matches against the same opponent.

In addition to physical capabilities, environmental factors may play a role in the amount of high intensity running performed by soccer players during a match. Mohr et al. (2010) examined the impact of playing a match in a hot environment (~30˚C), and found a greater decline of high intensity distances in the final 15 minutes than that seen in previous research (Andersson et al., 2010; Bradley et al., 2009). The authors speculate that the additional level of fatigue experience by the athletes may be a result of a greater level of dehydration, and note that muscle temperatures higher than that seen during matches played at 15˚C. There higher temperature may have metabolic implications regarding enzyme kinetics, when including the fact that players with a higher aerobic capacity were more capable of performing high intensity

running in this environment would support that idea. These results may indicate that the regional location, time of the year, and even the time at which the match is played may have an influence on the ability to perform to maximal capacity.

A limitation of total distance covered during a match is the omission of discrete movement data, such as accelerations and decelerations. According to Osgnach et al. (2010) "a massive metabolic load is imposed on players not only during the maximally intensive phases of the match but every time acceleration is elevated, even when speed is low. Based on work by di Prampero et al. (2005), in which the metabolic cost of acceleration was accounted for through correlation to uphill running, Osgnach et al. (2010) analyzed soccer match play and determined that based on the estimated metabolic costs of accelerations, players would have covered ~20% greater distance than the reported distance if running were completed at steady state. This concept illustrates a possible shortcoming when reporting only total distance covered. The GPS units designed for sports performance monitoring and analysis contain not only GPS instrumentation that allow for the collection of distances, but also accelerometers that can calculate this measure through the use of the 100Hz accelerometer found in the Catapult Minimax units.

Offering some congruency to research on the metabolic demands of acceleration, analysis of the in match time-motion characteristics indicates that accelerations and decelerations are large contributors to fatigue and performance decreases during matches, at least when considered acutely. Akenhead et al. (2013) analyzed acceleration and deceleration profiles in 15-minute blocks across match play and found a downward trend in distances covered in acceleration and deceleration as halves progress. Additionally, it was found that in the 5-minute period preceding and following the peak 5-minute period of distances covered in acceleration or deceleration

distances covered were significantly lower, with a return to baseline 10-minutes post peak. The authors suggest that this oscillation in acceleration occurrences may be related to energy regeneration and metabolite clearance needs following the high metabolic demands associated with the acceleration and deceleration activities.

Based on this information, there may be physically demanding work being performed by athletes that is not being accurately measured by distances covered alone. The measure may provide some additional insight into the demand of both sport training sessions as well as matches. Additionally, as the measure is calculated and reported by the Catapult GPS system in the same manner as odometer, there is not additional effort to retrieve this measure.

<div align="center">Session Rating of Perceived Exertion</div>

Session rating of perceived exertion (sRPE) is a metric used to quantify internal training loads, and is a product of the duration and intensity as reported from a category ratio modified Borg scale (Foster et al., 2001; Foster et al., 1995) (Table 1). Extensive research has been done on the use of the sRPE measure as a method of quantifying training loads. Early research by Foster et al. (1995) examined the relationship between known physiological intensity measures such as heart rate reserve and blood lactate accumulation, finding that sRPE was useful for determining intensity. Later work by Foster et al. (2001) compared sRPE values to heart rate based training scores in which time spent in various heart rate zones (10% incremental zones from 50%-100%) were multiplied by a weighted value (1-5). While the sRPE scores tended to overestimate training loads the correlation with the heart rate scores were consistent across training methods.

Table 1.
Rating of Perceived Exertion Scale

Rating	Verbal Anchor
	Rest
1	Very Easy
2	Easy
3	Moderate
4	Somewhat Hard
5	Hard
6	
7	Very Hard
8	
9	
10	Maximal

Adapted from Foster et al (2001).

In addition to endurance training methods, sRPE has also been shown to be an acceptable measure of resistance training loads, allowing for the accumulation and comparison of training loads across training modalities. Multiple studies have shown that as the intensity of resistance training increases in terms of the percentage of one repetition maximum (1RM) increases there is a corresponding increase in RPE, and that a sRPE value accurately represents the RPE for individual working sets of an exercise (Day et al., 2004; Sweet et al., 2004). Additionally, McGuigan et al. (2004) utilized sRPE along with salivary cortisol levels following resistance training and found similar results in a corresponding increase with both measures as training intensity increased.

The use of sRPE to quantify soccer specific training has also been investigated, and demonstrated to be a worthwhile measure of internal load. Impellizzeri et al. (2004) compared sRPE values with multiple heart rate based internal training load scores and found strong correlations ($r = 0.50$ to 0.85) with all heart rate based methods. Similar results were reported by Casamichana et al. (2013) when comparing sRPE to the Edwards method of calculating internal

training load based on heart rate data. Based on this collection of research it is reasonable that the sRPE measure can be utilized across training modalities to provide a good measure of internal training load.

<center>Training Methodologies and Considerations</center>

Due to the nature of the sport training for soccer requires a variety of different training modalities to prepare athletes for competition. Soccer players must have requisite levels of endurance, both aerobic and anaerobic, as well as strength to meet the demands of match play. Aerobic endurance in soccer is critical in clearing lactate and replenishing phosphocreatine stores during periods of low-intensity activity, while anaerobic endurance is needed to withstand the accumulation such as lactate during periods of high-intensity (Krustrup et al., 2005; Stolen, Chamari, Castagna & Wisslof, 2005; Tomlin & Wenger, 2001). Strength on the other hand underpins characteristics need to be successful such as speed and agility (Wisloff, 2004).

Research had indicated that the use of various types of interval based training methods are an effective approach at increasing VO_2 max, particularly 3-8 minutes of activity separated by 2-3 minutes of recovery. Common application of the interval system come in the form of soccer specific track running and small sided games. When utilizing track running, it has been shown that adding a dribbling task to the task increases energy cost by 8% (Stolen et al., 2005). These methods provide efficient means to maintain or improve aerobic and anaerobic energy systems while keeping total work volume low.

In a review of the literature regarding the importance of strength on endurance activities Ronnestad and Mujika (2014) showed that endurance related improvements through strength training include, but are not limited to: improved exercise economy, anaerobic capacity,

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improved lactate threshold, reduced or delayed fatigue, and maximal speed. These adaptations all culminate in an overall improvement in endurance performance.

Periodization is a method of training in sport that emphasizes different fitness characteristics at different times of the year to elicit peak performance in the competitive season. Due to the complex demands of soccer it is important to ensure that all characteristics are being addressed. Bompa and Carrera (2005) suggest that the year be broken into a preparatory phase and a competitive phase. During the preparatory phase it is suggested that the energy systems be trained in a manner in which the aerobic system is established allowing for subsequent building of the anaerobic energy systems. Resistance training is utilized in the preparatory phase to first establish anatomical adaptations, before moving on to developing strength and ultimately the ability to express power. During the competitive phase an attempt to maintain these characteristics should be employed through the use of both field training and resistance training.

Another key concept of the training process is tapering, which is the idea that a reduction of training volume as competition approaches will allow for a dissipation of accumulated fatigue, and enhance the ability of an athlete to express their preparedness. This tool has been used widely used with a great deal of success in eliciting optimal performance from athletes preparing for an individual competition (Aubry, Hausswirth, Louis, Coutts & Le Meur, 2014; Bosquet, Montpetit, Arvisais & Mujika, 2007; Tonnessen et al., 2014). In a meta-analysis by Bosquet et al. (2007) it was found that optimal tapering for endurance athletes included a 40-60% decrease in volume and was most successful when lasting only two weeks. Due to the more congested competition schedule and season length within collegiate soccer classic tapering methods cannot be utilized; it may be important to utilize the tapering concept within the competition week in

order to maintain fitness characteristics while simultaneously avoid an accumulation of fatigue that may impair match performance.

Studies indicate that key physiological characteristics such as strength and power output are blunted for a period of 48-72 hours following a match (Andersson et al., 2008; Hoffman, Nusse, & Kang, 2003). This line of research demonstrates that in addition to the fatigue experienced acutely during a match some fatigue persists into the subsequent days; raising questions as to if similar alterations occur following bouts of training within the week leading up to matches. The annual schedule for National Collegiate Athletics Association (NCAA) soccer consists of twice a week matches. The format utilized by the vast majority of division I women's programs consists of matches being played on Friday evenings and Sunday afternoons.

It is essential to provide training that promotes that enhances the fitness level of the physical characteristics essential for performance, particularly the capabilities to perform high intensity activities. However, it must also be assured that the training does not provide deleterious effects on the ability for athletes to perform in matches through the accumulation of fatigue that may mask fitness. As such multiple methods have been utilized in an attempt to quantify the internal and external loads experienced during both matches and training. The emergence of GPS systems has provided a tool for these efforts; as such it is important to examine the data provided from these tools in attempts to elucidate how they can be best used to benefit the athlete.

CHAPTER 3

THE IMPACT OF TRAINING LOADS ON IN-MATCH SOCCER PERFORMANCE

VARIABLES: POSITION-BASED CASE REPORT

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Abstract

It is critical to maintain multiple fitness characteristics during the soccer season through the use of training, but also to ensure that the training loads do not hinder subsequent match performance. **PURPOSE:** The purpose of this thesis is to investigate the impact of the training load on key physical performance variables in the subsequent match **METHODS:** Five Division I female soccer players were analyzed across six weeks of training and matches. Training loads in the forms of odometer, high intensity odometer, estimated odometer and sRPE were accumulated at time points from one to five days prior to a match. The accumulated training loads were then correlated with the same performance measures from match play. **RESULTS:** The greatest significant correlations were seen in sRPE training loads when compared to match odometer and estimated distance. **CONCLUSION:** There does not appear to be negative effect on match performance when looking at any of the accumulated training load values.

<u>Introduction</u>

Soccer as a sport is characterized as being largely aerobic based due to the duration of matches, however also consists of intermittent high intensity anaerobic bursts of action related to sprinting, jumping and kicking (Stolen et al., 2005). There is some indication that the ability to accelerate, including change of direction movements, is a key factor in determining performance (Wragg, Maxwell, & Doust, 2000). Following on this idea, there is an ever increasing body of literature examining the physical performance characteristics across position, level of play, age and gender (Alexander, 2014; Andersson et al., 2010; Datson et al., 2014; Mohr et al., 2008; Stolen et al., 2005). By far the most common measures reported in regards to measuring physical performance in soccer are the total and high intensity distances covered in a match (Andersson et al., 2010; Bradley et al., 2009; Di Mascio & Bradley, 2013; Di Salvo et al., 2009; Mohr et al., 2008).

Recent years have seen the arrival of GPS units specially designed for use in sport. These units provide the ability to collect individual data consisting of the distances and velocities performed by each athlete. This technology is a welcome replacement to the prior method of time motion analysis in which video was analyzed manually to provide estimates on the distances a player traveled as well as the velocities in which those actions were completed. The utilization of this technology allows for the quick collection of both gross movement data such as overall distances covered, accelerations, decelerations and jumping, as well as filtered data such as the distances covered in customizable velocity bands. This technology has also allowed for the development of new measures, such as "estimated distance" which attempts to provide an estimated distance that would be performed if activity was performed at steady state utilizing

measures of acceleration and deceleration actions performed (di Prampero et al., 2005; Osgnach et al., 2010).

To this point there has not been much research regarding the impact of weekly training loads on match performance. The purpose of this thesis is to investigate the impact of the training load on key physical performance variables in the subsequent match. To accomplish this, the study examines the relationship between total odometer, high intensity distances, estimated distances and sRPE data from match play and the accumulated training and game volume for the preceding 5-,4-,3-,2- and 1-day periods. We will also attempt to examine the estimated distance measure as an alternative to total distance as a measure of training load. We hypothesize that weekly training structured in a manner in which training loads were managed based on daily reporting as competitions approach will elicit a greater capacity to exhibit key performance variables in matches. We expect the estimated distance measure will provide a better representation of the training demands than the measure of total distance.

Methods

Subjects

Data were gathered from five female soccer players (Age: 21.1±0.7 years, Stature: 166.6±5.7 cm, Mass: 62.4±4.4 kg), of three different positions (central attacking midfielder: n=1, central defensive midfielder: n=1, central defender: n=2, and outside back: n=1) during the 2014 NCAA women's collegiate soccer season. In total six matches and the preceding training loads were included for analysis. For inclusion in analysis players must have completed the entire first and second half of each of the matches that were reviewed and all training sessions in the five days leading up to the match. Sport training sessions were planned and conducted by the team

coaching staff with the intention of managing fatigue. The coaching staff received daily reports following all sport training sessions and matches, which included team averages for sRPE, total odometer and high intensity odometer. The data used for analysis in this study was exempt from review of the East Tennessee State University Institutional Review Board, as the data was collected as part of an existing athlete monitoring program, and was analyzed retrospectively.

Data Collection and Analysis

Data were collected from both training sessions and matches using Catapult Minimax S4 GPS devices. The GPS unit was worn by the athlete in a specially designed harness beneath the jersey. Following all sessions the data was exported using Catapult Sprint software. All game measures that were completed during overtime periods were excluded from match data, but included in accumulation data. Training accumulation data includes only the period in which the player was active, excluding data collected by the GPS units during match halftime breaks and breaks in training. Rating of perceived exertion data was collected from all players following all sessions utilizing a modified Borg scale (1-10), the durations of sessions were also logged allowing for the calculation of a sRPE value.

The coefficient of variation was calculated for each performance variable to establish the variation in measures across the analyzed matches for each player. As to investigate the accumulation of training volume in the days preceding the match the accumulations of odometer, high intensity odometer, estimated distance and sRPE were calculated of 1 to 5 days prior to the match (MD-1 – MD-5). The GPS data was utilized for all field training sessions; accumulated RPE data includes all other training modalities such as resistance training and recovery sessions. The training session schedule can be viewed in Table 1, while the sRPE training load for each

day can be found in Table 2. A Pearson correlation was run on the accumulated training load

values to determine the relationship between match performance values and training at each time

point. All statistics were performed in SPSS v.22.

Table 1. *Training Schedule*

	MD-1	MD -2	MD -3	MD -4	MD -5
Game 1	Off	AM – Weights PM – Sport Training	Sport Training	OFF	Match
Game 2	Off	Sport Training	AM – Weights PM – Sport Training	Recovery	Match
Game 3	Recovery	Match	Sport Training	Training	Weights
Game 4	Sport Training	Sport Training	Sport Training	AM – Weights PM – Sport Training	Off
Game 5	Off	Sport Training	Sport Training	Sport Training	Weights
Game 6	Off	Sport Training	Weights	Off	Match

Table 2. *Training Load (sRPE)*

	MD-1	MD -2	MD -3	MD -4	MD -5
Game 1	0±0	544.0 ± 156.8	308.0 ± 189.3	0.0 ± 0.0	930.0 ± 147.0
Game 2	0±0	282.0 ± 61.8	289.0 ± 140.3	30.0 ± 0.0	570.0 ± 320.3
Game 3	45±0	540.0 ± 224.5	117.0 ± 48.6	330.0 ± 69.6	109.8 ± 67.1
Game 4	60±0	230.0 ± 0.0	162.0 ± 88.2	452.0 ± 109.6	0.0 ± 0.0
Game 5	0±0	210.0 ± 73.5	308.0 ± 44.0	480.0 ± 107.3	65.5 ± 20.3
Game 6	0±0	310.0 ± 40.0	69.0 ± 32.2	0.0 ± 0.0	864.0 ± 217.0

Results

The coefficient of variation for each performance measure across the analyzed matches

for each player is included in Table 3. The correlation between the performance variables from

match play and the accumulated values from the training week can be found in Table 4.

The greatest correlations were seen in accumulated sRPE. The measures of both odometer and estimated odometer showed the same trend in correlations. High intensity distance from match play did not show any strong or significant correlations to the accumulated training loads.

Table 3. *Coefficient of Variation Amongst SIX Match Variables by Position*

	CDM 1	CAM 2	CB 1	CB 2	OB
Odometer	5%	4%	5%	6%	6%
High Intensity Odometer	18%	14%	17%	18%	16%
Estimated Distance	5%	4%	5%	6%	5%
Rating of Perceived Exertion	6%	9%	27%	23%	15%

Table 4. *Correlations Between Match and Accumulated Training Loads*

		Odometer	High Intensity Odometer	Estimated Distance	sRPE
Odometer	MD1	-.068	.009	-.085	.173
	MD2	.353	.134	.340	.164
	MD3	.322	.229	.312	.192
	MD4	.199	.305	.205	.084
	MD5	.454*	.128	.449*	.289
High Intensity Odometer	MD1	.015	-.044	-.020	.164
	MD2	.320	.032	.308	.170
	MD3	.306	.118	.298	.133
	MD4	.029	.310	.050	.107
	MD5	.284	.232	.314	.334
Estimated Distance	MD1	-.081	-.001	-.101	.167
	MD2	.375*	.140	.364*	.177
	MD3	.333	.240	.326	.200
	MD4	.191	.319	.201	.087
	MD5	.451*	.153	.452*	.300
sRPE	MD1	-.152	-.044	-.159	-.070
	MD2	.523**	.178	.504**	.230
	MD3	.641**	.251	.619**	.362*
	MD4	.468**	.386*	.473**	.286
	MD5	.733**	.411*	.722**	.411*

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

<u>Discussion</u>

The purpose of this study was to investigate the impact of accumulated training loads preceding match play on physical performance measures. Based on the results showing marginal variation in the total and estimated distances covered indicate that the current training structure being utilized does not prevent repeatable match performance in regards to these measures. However, the comparably large variations in high intensity odometer are far less correlated to the activity during the training week. It should be noted that similar variability of distances covered at high intensities has been previously reported (Gregson et al., 2010).

There are several possible explanations for the higher variability in high intensity odometer than that seen in total odometer. The first explanation involves the ability of the technology to accurately record the distances covered at these speeds. There have been several studies that have demonstrated that error in the recording of distances increases as the velocity increases (Coutts & Duffield, 2010; Jennings et al., 2010; Rampinini et al., 2015). There is also some evidence to suggest that the level of competition may have an impact on the amount of distances covered at high intensities (Andersson et al., 2010; Mohr et al., 2008; Rampinini et al., 2007). According to Bradley and Noakes (2013) the score line also may dictate high intensity activity, due to tactical implications. Additional factors that have been shown to influence high intensity running in matches are: temperature (Mohr et al., 2010), phase of the season (Rampinini et al., 2007), as well as if the match is the first or second match of the week (Alexander, 2014). This would indicate that the occurrences of high intensity activity are based on response to a variety of in-match and environmental factors. However, while these factors may dictate the level to which high intensity distances are performed, it is very important to understand that the physiological status of the athlete determines their capacity to perform these

activities. It has been shown that aerobic and anaerobic fitness levels are directly related to the performance of high intensity running (Krustrup et al., 2005; Mohr et al., 2010). There is even some indication that resistance training adaptations may be associated with the ability to perform high intensity running in this population (McCormack et al., 2014).

All but one of the matches analyzed for this study were the first match of the week, and all occurred in the latter half of the season during the conference phase and playoffs, with all of the opponents finishing in the top half of the standings. Half of the matches were played in the afternoon, while the other half were played during early to late afternoon. The same tactical formation was employed during each of the matches. At this time the most significant factor influencing the variability seen in high intensity running cannot be reasonably determined.

The total and estimated odometer from match play both showed a weak but significant correlation with the accumulated distance at MD-5. Of the six matches selected for analysis five of the matches were played on the Friday of the standard Friday/Sunday match format while the final match was played on a Sunday (Table 1). This by default includes the data from the previous Sunday match for three of the matches analyzed in this study. This is the most likely explanation for the correlation due to weak correlations seen in these measures at the other accumulation time points. These measures also correlated similarly with the estimated distance accumulated at MD-5, unlike odometer accumulation there is a weak but significant correlation with accumulated estimated distance MD-2 that is not seen with the odometer measures. One explanation may be a focus on intensity rather than duration at this time point as the estimated distance value is proposed to account for acceleration and deceleration activities.

The highest and strongest correlations were seen in accumulated sRPE measures, particularly with match odometer and estimated distance. High correlations at MD-2 and MD-3 may be directly related to the consistent frequency of activity at those time points each training week analyzed. This would also provide some explanation to the drop in correlation at MD-4 as training only took place at that time point for half of the weeks analyzed. Similarly to the odometer value correlations, the strong correlations seen at MD-5 are best explained by the match play existing at that time point for three of the six weeks. The matches existing on MD-5 also are most likely to be causing high correlations with high intensity distances and sRPE at that time point. The training loads reported may provide some baseline for the training loads that can be incurred by athletes at this level without a reduction in match performance. It may also indicate that consistent training only two days prior to a match will not be a hindrance to these athletes.

The intention of the in-season training schedule was to manage fatigue during the training week while still applying a training stimulus and maintaining technical and tactical proficiency. Analysis of the actual recorded loads (as sRPE), show that training load is reduced dramatically from MD-5, largely due to the three matches that occur at this time point, but spikes (+68%) again at MD-2 (even when disregarding the single match that occurred at MD-2, this trend still exists). When looking at the total training load for the week leading into each match, there is a drop in weekly load from the first match to the second match, but the loads are relatively similar leading into the remaining games.

All significant correlations found were positive in nature and would indicate that there was no negative impact on match performance by the training loads imposed. These findings would indicate that those players that completed that greatest work in match play were also

exposed to the greatest training loads. It may be that there is a threshold under which the fitness acquired or maintained through training exceeds the fatigue that it induces, and that the loads performed by these athletes were within an acceptable level. Another explanation to this phenomenon may be that those players with a higher sport specific fitness are capable of higher training loads than those with a lower level of fitness. It may be beneficial to establish protocols in which sport specific fitness characteristics and be monitored in relation to training loads. This may provide some insight into what characteristics are underlying performances as well as how those individual characteristics are impacted by imposed training loads. There were some non-significant negative correlations seen in performance measures when compared to MD-1 data. This may provide some indication that training loads the day prior to a match may provide a hindrance to performance, however due to the very small sample size in this study additional research is needed.

A secondary aim of this paper was to investigate the use of an estimate of the equivalent distance a player would have accrued if the work had been completed at steady state; accounting for the increased metabolic of acceleration. Based on the results of this study, and in particular the similar correlations to odometer, it does not appear that this measure will provide a significant amount of additional data for monitoring purposes beyond that of odometer. At this time the recommendation would be to continue to use the total distance measure for descriptive match data to maintain consistence with existing literature.

Based on the data collected in this case study it would appear as though the total match distance covered is consistent across contests, and was not related to the training and match volume in the preceding 5 days. It also does not appear that the training volume does not relate to the ability for players to record high intensity distance, and that this measure is mostly likely

impacted by the technical and tactical aspects of each respective match. The data does appear to

some extent to provide some justification for a tapered training week to maintain performance

across matches.

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CHAPTER 4

CONCLUSION

The analysis of match data shows that the players maintained consistency in performance when viewed as total distance covered, however the distance covered at high intensity showed greater variability. This is most likely due to technical and tactical factors that are not captured when only physical data is analyzed. There may be some indication that the players that performed the greatest work in matches, in terms of total distances covered, were also capable of performing greater loads in training based on sRPE measures. The positive correlations with game performance and weekly training loads may indicate that the demands of the weekly training were sufficient to maintain fitness levels while avoiding the accumulation of fatigue to the extent that performance would be negatively impacted.

In regards to the estimated distance measure, while it may capture additional information in terms of training load, it does not appear to provide much benefit over the established total distance measures currently being used in the literature to measure performance. While this measure may take into account demanding actions such as change of direction, acceleration and deceleration that are missed when simply monitoring distance, from a training load monitoring stand point it appears it may be redundant. There may be need for investigation into the direct monitoring of these factors rather than utilization of the estimated distance as a proxy.

Future Research

It is clear that while GPS technology is useful for describing what a player does on the pitch, it may be time to shift the focus to how the players are accomplishing these values. Going forward in addition to the descriptive data an effort should be made to utilize the data

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collected by GPS units to establish individualized performance characteristics. The inconsistent

schedule of training and matches may distort the potential impact of training and performance,

detailed analysis of each season week may allow for the development of an ideal weekly training

model. Additionally, the adaptation of regular training drills prescribed to train certain physical

characteristics may be used to monitor the adaptation to training.

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APPENDIX

ETSU Institutional Review Board Approval

East Tennessee State University
Office for the Protection of Human Research Subjects • Box 70565 • Johnson City, Tennessee 37614-1707
Phone: (423) 439-6053 Fax: (423) 439-6060

May 8, 2015

Garett Bingham
binghamg@goldmail.etsu.edu

Dear Garett,

Thank you for recently submitting information regarding your proposed project "The Impact of Training Loads on In-Match Soccer Performance Variables."

I have reviewed the information, which includes a completed Form 129.

The determination is that this proposed activity as described meets neither the FDA nor the DHHS definition of research involving human subjects. Therefore, it does not fall under the purview of the ETSU IRB.

IRB review and approval by East Tennessee State University is not required. This determination applies only to the activities described in the IRB submission and does not apply should any changes be made. If changes are made and there are questions about whether these activities are human subject research in which the organization is engaged, please submit a new request to the IRB for a determination.

Thank you for your commitment to excellence.

Sincerely,
Stacey Williams, Ph.D.
Chair, ETSU IRB

Accredited Since December 2005

VITA

GARETT BINGHAM

Education:	M.A. Kinesiology and Sport Studies
	    East Tennessee State University, 2015
	B.S. Kinesiology
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Experience:
    Tuition Scholar - Teaching
        East Tennessee State University, 2013-2015
    Sport Science/Strength and Conditioning Coach – Women's Soccer
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    Help Desk – Student Worker
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    Business Process Analyst
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    Software Tester
        ACS – Tempe, AZ, 2008-2009
    File Processor/Learning Coach
        ACS – Tempe, AZ, 2005-2008

Professional Certifications:
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    American Heart Association – CPR/AED/First Aid

Courses Taught:
    PHED 1150 Weight Management, ETSU Fall 2013, Spring 2014
    PEXS 3080 Teaching Aerobic Conditioning, Fall 2014
    PEXS 3032 Psychomotor Development in Children, Spring 2015

Software:
    Microsoft Office (Word, Excel, Powerpoint)
    Polar Team2
    Catapult Sprint
    National Instruments Lab View
    MySQL

Hardware:
    Polar Heart Rate Monitors
    Catapult Minimax GPS
    Noraxon EMG
    Force Plates
    Metabolic Cart