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The Effect of Weekly Training Load on Match Result in American Professional Soccer

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THE EFFECT OF WEEKLY TRAINING LOAD ON MATCH RESULT IN AMERICAN PROFESSIONAL SOCCER

by

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(Under the Direction of Stephen Rossi)

ABSTRACT

BACKGROUND: During a professional soccer season, training load (TL) will fluctuate due to the need to prepare for the next competition. Based on the technical staff's daily and weekly evaluation, TL will be adjusted as they prepare the team and maximize individual performance and achieve a favorable result. Therefore, the programming of each match week (MW) TL may promote a favorable result. **PURPOSE**: The purpose of this study was to examine variation in daily GPS-derived TL variables based on match result using the Match Day Minus (MD-) system. This study provides descriptive TL data yet to be reported in this novel population. **METHODS:** Twenty-four male United Soccer League One (USL1) players were monitored through the full competitive in-season macrocycle. Using GPS units, metrics of interest were identified to best provide a full picture of training load. Duration (D), Total Distance (D_T), High Metabolic Load Distance (HMLD), Total Loading (L_T), Number of Accelerations (#A), and Number of Decelerations (#D), collectively make up weekly TL. The MD- system was used to categorize each training day. One-Way ANOVA was used for each MD- to compare results, with a Bonferroni Correction. **RESULTS:** D, D_T, HMLD, and L_T were the metrics of interest that had the largest effect throughout the MW. **CONCLUSION**: Based on the results of this study, weekly TL has been shown to influence match results in American professional soccer. Special consideration should be given to the metrics of interest during the MW in preparation for weekly competition.

KEY WORDS: Soccer, Training load, Match result, GPS, Professional

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by

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DEDICATION

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CHAPTER 1

INTRODUCTION

During a professional soccer season, athletes will experience fluctuations in weekly training load (TL) due to the various needs and demands experienced during a full competitive season. Coaching and performance staff (Sports Science, Sports Medicine, and Strength and Conditioning) can monitor daily TL to promote recovery and performance in individual athletes and the team (Halson, 2014). As performance technology has continued to advance, the practice of load monitoring has increased. With increased use, practitioners should ensure they follow best practice to promote longevity and informed use of the technology (Miguel et al., 2021).

Periodization has been defined as a structured plan of training utilizing periods of varying TL to promote long term development in physiological, psychological, and performance characteristics (Bompa, T. & G. Haff, 2016). Due to the nature of soccer, most competitions occur weekly, with mid-week games being a necessity in some leagues. The “Match Day Minus” system (MD-) was introduced for training session classification based on the next competition (Akenhead et al., 2016). The MD- system uses the number of days until the next match day to categorize training days. This allows staff to best strategize training and load management with the focus on the next match day.

Researchers have found the highest distance was covered on MD-3, tapering towards MD-1. The disruption of midweek games requires adjustments to the training schedule, with the highest distance seen in MD-4 in a 2-game match week (Martin-Garcia, 2018; DeJohn, 2022). Using MD- as a planning method for training sessions allows evidence-based decisions to be implemented into soccer, with the goal to promote recovery and performance. Martin-Garcia et

al. (2018) followed Akenhead's proposed system, categorizing each training session based on number of days from the next competition. Training on the day following competition (MD+1) was also analyzed, with players split into two training groups based on match participation. Players that played >60 minutes participated in a recovery session with low impact activity and regeneration exercises included. Players that played <60 minutes participated in a technical circuit followed by a Small Sided Game (SSG) with the addition of goalkeepers. The researchers found that External Load (EL) was greatest on MD-4, with variables of interest approaching competition level of intensity. They also found that significant differences were found based on positional groups within the team, this was also reported by Dellal et al. (2010) in French Ligue 1 players.

Performance and recovery of players are the two main goals within the technical staff. However, these may not always be attained during weekly training sessions, which may be due to a high interindividual variability despite similar levels of participation in training and competition (Nedelec et al., 2012). There is a lack of literature based on TL's effect on results for weekly and biweekly competition. Literature is also lacking in the practical application of technology-derived performance data and the effect on match results. The use of technology and evidence-based training sessions is best implemented when individual load and fatigue can be quantified separate from team load.

Global Positioning System (GPS) units are commonly used in professional soccer, as it allows staff to better monitor the load athletes are under during training and matches. GPS units collect upwards of 50 metrics constituting EL experienced by the individual athletes during activity. These metrics collected by the GPS units allow insight into the individual effort and allow for specific interventions for players following a training session (Miguel et al., 2021).

Understanding the metrics collected is important for the practitioner/researcher as over-complication of load accumulation and intervention could cause friction between the staff and players. Hennessey and Jeffreys, (2018) support the benefits of technology use and load monitoring within a sporting organization, assuming proper care is taken to maintain cohesiveness between staff and athletes. When proposing new implementations for monitoring, it is imperative that practitioner and athlete are both well-informed of the limitations and potential of technology's role in load monitoring. Metrics of interest are listed and defined in Table 1.

Malone et al. (2015) analyzed thirty soccer players within the English Premier League, measuring EL with GPS and IL with Session RPE (sRPE, session duration multiplied by athlete given RPE following a session) and HR. Pre-Season (six microcycles) and In-Season (six, six-week mesocycles, and three one-week microcycles at start, midway, and end time points). All sessions were categorized and analyzed using the MD- system. During Pre-Season, no differences were found in TL. During the in-season time points, they found that TD was greater in the first mesocycles than in the sixth, with %HR max values greater in the third mesocycle compared to the first. When comparing sessions through the week, clear periodization was only reported on MD-1 with the lowest TD found regardless of mesocycle during In-Season training sessions. No difference was seen between MD-5 through to MD-2 through the season. TL's potential effect on match result is limited from a performance perspective, with quantification of TL regardless of performance constituting most of the current literature. Ryan et al. (2022) investigated TL in a Men's Soccer team competing in the National Collegiate Athletic Association Division 1 using similar methods to Malone et al. (2015). Pre-Season was split into two periods, Pre 1 and 2. In-Season was split into four periods, In 1, 2, 3, and 4. Positional groups were categorized the same way as Malone's study. They used similar metrics of interest

and added analysis for perceived recovery and time in speed zones. They found significant differences during Pre1 in %HR between Center Midfielders (CM) and Center Backs (CB), Wide Midfielders (WM), and Center Forwards (CF) $p>0.01$. Full Backs (FB) spent more time in higher speed zones compared to all other positions, with CM spending greater time in lower speed zones compared to CB and FB. During in-season, positional changes were varied with the general trend of Wing Backs (WB) and CB having higher intensity in all performance metrics compared to all other positions. These differences highlighted the need for individual monitoring within a team dynamic.

Research exploring the effect that weekly TL has on match result is minimal, Oliveira et al. (2020) reported on this in the top European soccer competition. They analyzed five positions within the same team, with all players being put into one of the five groups. Their main findings were only for MD-1, with MD-5 through MD+1 analyzed. They found longer training sessions on MD-1 preceding draw > loss > win. TD was also higher in win > draw > loss alongside higher Average Speeds in draw > win > loss. To coincide with a small amount of research on match performance and weekly TL, there is minimal literature on American professional soccer and to date, zero peer-reviewed for United Soccer League 1 (USL1). USL1 is a third-tier professional soccer league within the United States.

The purpose of this study is to examine variation in daily GPS-derived TL variables based on match outcome using the MD- system. This study will provide descriptive TL data yet to be reported in this novel population.

CHAPTER 2

METHODOLOGY

Participants

Twenty-four male (n=24) USL1 soccer athletes (25.5 ± 2.4 years, 179.9 ± 8.9 cm, 76.1 ± 9.8 kg) participated in this study during a 28-week competitive season. This will include 30 individual Match Weeks (MW), with all 30 USL1 season matches included in the analysis. Each MW will consist of all training sessions leading up to the end-of-week competition which constitutes the match's previous training window.

All first team players were monitored during weekly training and matches, only players that contributed at least 45 minutes in the match following the training window were analyzed. Players were cleared by the Athletic Trainer weekly, prior to full team practice and participation in data collection. Goalkeepers were also monitored daily but are not included in this study due to the differences seen in physical performance (Ziv & Lidor, 2011). Each subject was informed of the risks and benefits of participating in this study and educated on the process of data collection and monitoring. All methods were approved by the Institutional Review Board at Georgia Southern University.

Design

Each player was assigned their own GPS unit during the study to ensure instrument reliability. Each participant wore a specially made vest provided by STATSports, with the unit sitting in a pouch between the scapulae. These units have been validated at collecting movement data at an accurate level with <5% movement bias (Beato et al., 2018). Using the roster numbers assigned to each player for the season, each pod was marked with their number. Each player was

educated to ensure they used only their assigned equipment. Each unit captured movement data at 18 Hz GPS and 10 Hz Global Navigation Satellite System. The units and system (STATSports, TeamSeries, Belfast, UK) were introduced to the participants in pre-season with an acclimation period of 6 weeks prior to the study and data collection. Following collection for the day, each pod was downloaded, and the session data extracted using the STATSports TeamSeries Software, Version 1.0.01111. Data was refined and clipped in the software prior to being exported to a Microsoft Excel Spreadsheet.

In preparation for collection, the units were placed into the subject's respective vest prior to arrival at the practice location. Each player was assigned their own coat hanger with their vest to ensure they only used their specific equipment. For each collection, the units were turned on at least 30 minutes before training to allow for satellite linkup in accordance with the manufacturer recommendations. Subjects wore the equipment during on-field pre-activation for up to 15 minutes prior to the collection period. Data for this study was collected from official warm up to the last staff-led drill. At the conclusion of practice, all vests and units were collected by the researchers using the same method of distribution with players returning their allotted equipment to the storage rack. Individual training and rehabilitation were not included in this analysis. Each training session was held at the regular practice field or in some cases, a satellite facility, due to inclement weather conditions.

During a typical week of practice, the coaching staff adjusted sessions based on previous result, next competition, and travel requirements. Recovery days often occurred two days post-competition with certain subjects being omitted from practice until later in the week. As the week progressed, player participation increased due to recovery methods implemented by the technical staff. These recovery methods included minimizing high performers from training

earlier in the MW. Prior to competition volume and intensity were lowered to maximize readiness for the next competition.

MD- System

During the competitive season, MW will consist of a varying number of training sessions from as many as five sessions to possibly zero sessions. This is determined by the coaching staff and adjusted as they see fit based on the schedule. For this study, each session is categorized based on days out from competition using the MD- system (Malone, 2015; Stevens, 2017; DeJohn, 2022). Five days out designated as MD-5, four days out designated as MD-4, three days out designated as MD-3, two days out designated as MD-2, one day out designated as MD-1. Match outcome will be categorized as a win (W), loss (L), or a draw (Dr). Due to travel implications, some MW session(s) may not be able to be collected. Each match result and corresponding weekly TL was compared to each other, investigating the effect of load in contributors on match result.

External Load

As stated by Miguel et al. (2021), the uniformity and globalization of metrics should be promoted within performance departments and research environments. They detail the use of which specific EL metrics should be implemented. TL was calculated using EL parameters captured by the GPS units. Outlined key metrics include session duration (D, min), total distance (D_T, m), high metabolic-load distance (HMLD, >25.5 W/kg; m), total loading (L_T, Total of all forces without weightings applied; au), Number of Accelerations (#A), Number of Decelerations (#D), Number of Sprints (#S). Table 1 provides definitions for all EL metrics of interest.

Statistical Analysis

IBM SPSS Version 25.0 (SPSS, Inc., Chicago, IL) will be used for all analysis. The Shapiro-Wilk test for normality was run on all variables. A One-Way ANOVA was run for each MD individually, comparing between corresponding MW results (win, loss, or draw). Nonparametric data was analyzed using a Kruskal-Wallis ANOVA. All variables were categorized and compared between training days in the MD- structure. Significance was set at $p \leq 0.05$. Effect size for all significant post hoc relationships was calculated using Cohen's d and was assessed using the following delineation: <0.2 = small; 0.2 to 0.79 = moderate, and ≥ 0.8 = large (Cohen, 1992).

CHAPTER 3

RESULTS

MD-5

Results indicate that TL on MD-5 has a significant effect on match result. D, D_T, HMLD, and L_T all showed a significant effect on match result (n=60). D: $F(2,58)=6.182$, p=0.004. D_T: $F(2,58)=18.432$, p<0.001. HMLD: $F(2,58)=6.243$, p=0.004. LT: $F(2,58)=12.220$, p<0.001. Following a Bonferroni Correction, post-hoc differences were identified. D: Win (55.66 ± 15.25 min) to Draw (69.18 ± 11.90 min, p = 0.003, d=0.992. D_T: Win (1.59 ± 0.427) to Loss (2.14 ± 0.426), p=0.009, d=1.289 and Draw (2.65 ± 0.603), p>0.001, d=2.03, Loss to Draw, p=0.002, d=0.977. HMLD: Draw (0.30 ± 0.16) to Win (0.16 ± 0.083), p=0.009, d= 1.098 and Loss (0.20 ± 0.084), p=0.021, d=0.782. L_T: Win (47.79 ± 14.39) to Loss (62.12 ± 13.51), p=0.042, d=1.026 and Draw (75.41 ± 19.11) p<0.0001, d=1.632, and Loss to Draw p=0.016, d=0.803

MD-4

Results indicate that TL on MD- has a significant effect on match result. D, D_T, HMLD, L_T, and #A all showed a significant interaction (n=145). D: $F(2,143) = 3.583$, p=0.030. D_T: $F(2,143) = 4.786$, p=0.010. HMLD: $F(2,143) = 6.620$, p=0.002. L_T: $F(2,143) = 5.971$, p=0.003. #A: $F(2,143) = 4.990$, p=0.008. Following a Bonferroni Correction, post-hoc differences were identified. D: Loss (70.55 ± 22.92 min) to Draw (79.09 ± 12.17 min), p=0.033, d=0.465. D_T: Win (2.52 ± 0.608) to Draw (2.94 ± 0.505), p=0.013, d=0.751. HMLD: Win (0.271 ± 0.118) to Draw (0.376 ± 0.125), p=0.001, d=0.863. L_T: Draw (81.98 ± 16.95) to Win (70.42 ± 17.11), p=0.017, d=0.678 and Loss (69.51 ± 24.63) p=0.006, d=0.589. #A: Draw (56.40 ± 17.81) to Win (45.76 ± 15.33) p=0.019, d=0.640 and to Loss (46.39 ± 22.04) p=0.024, d=0.4995.

MD-3

Results indicate that TL has a minimally significant effect on match result with D showing a significant interaction (n= 166). D: $F(2,164) = 7.044$, p=0.001. Following a Bonferroni Correction, post-hoc differences were identified. D: Draw (93.19 ± 18.68 min) to Win (85.768 ± 9.406 min) p=0.039, d=0.5018 and Loss (82.94 ± 15.02 min) p=0.002, d=0.6047.

MD-2

Results indicate that TL has a minimally significant effect on match result with D, and HMLD showing a significant interaction (n=176). D: $F(2,174) = 4.650$, p=0.011. HMLD: $F(2,174) = 5.101$, p=0.007. Following a Bonferroni Correction, post-hoc differences were identified. D: Loss (87.29 ± 20.87 min) to Win (80.09 ± 9.63 min) p=0.041, d=0.443 and Draw (79.47 ± 13.88 min) p=0.022, d=0.441. HMLD: Loss (0.294 ± 0.0966) to Draw (0.363 ± 0.148) p= 0.006, d=0.552.

MD-1

Results indicate that TL has a significant effect on match result. D, D_T, HMLD, and L_T show a significant interaction (n=133). D: $F(2,131) = 19.636$, p<0.0001. D_T: $F(2,131) = 6.798$, p=0.002. HMLD: $F(2,131) = 3.936$, p=0.022. L_T: $F(2,131) = 3.886$, p=0.023. Following a Bonferroni Correction, post-hoc differences were identified. D: Draw (91.219 ± 20.54 min) to Win (73.26 ± 5.22 min) p<0.0001, d=0.500149 and Loss (75.62 ± 9.39 min) p<0.0001, d=0.429. D_T: Draw (2.64 ± 0.483) to Win (2.32 ± 0.337) p= 0.004, d=0.768 and Loss (2.43 ± 0.300) p=0.018, d=0.522. HMLD: Loss (0.2829 ± 0.07511) to Draw (0.349 ± 0.185) p=0.035, d=0.468. L_T: Win (61.77 ± 12.43) to Draw (69.52 ± 14.50) p=0.047, d=0.573.

CHAPTER 4

DISCUSSION

In the present study, American professional soccer players were monitored during a competitive season to compare weekly TL and match performance (Win, Loss, Draw). The purpose of this study was to examine variation in daily GPS-derived TL variables based on match outcome using the MD- system. The findings indicate a significant effect of TL on match result primarily on MD-5, MD-4, and MD-1. D, D_T, HMLD, and L_T were the variables of interest that had a significant effect throughout the MW.

To our knowledge, this is the first study to analyze weekly TL and its effect on match performance in American Professional Soccer. Comparing the daily TL leading up to a competition (MD-) allows practitioners to plan future training sessions based on current data.

The results of the present study indicate an inverted bell-shaped curve, with significant differences observed at the beginning and end of the MW. MD-5, MD-4, and MD-1 contained the most significant effect on MW results. All variables had a significant effect in at least one MD, except for #D which did not have any significant effect during the MW. All significant effects showed overall lower amounts of TL through the week and on each day in the MW. All metrics included in this study were reported as weekly TL and included high intensity metrics (HMLD, L_T, #A, #D) and low intensity metrics (D, D_T). High intensity metrics provide insight into the more demanding requirements of the sport. HMLD represents any movement $\geq$ 25.5 W/Kg, providing an individualized response to movement due to the player's mass being used in the calculation. L_T represents the sum of all forces experienced by the player and is calculated using the accelerometer within the GPS unit. Providing a count of #A and #D allows for an

account of the total number of starting and stopping high intensity movement. Akenhead et al. (2015), reported an increase in physiological and perceived exertion following higher volumes of acceleration in trained soccer players. This demonstrates the need to monitor acceleration and load accumulated by players. Low intensity TL is represented by D and D_T, as they both represent the entire practice session. This includes frequent water breaks, transitioning from drills, and a varied number of repetitions determined by the technical staff for individual groups within the team. As significant effects were found in MD-5, MD-4, and MD-1, weekly TL were reported to have a significant effect on match performance. Specifically, for MD-5 included D, D_T, HMLD, and L_T; MD-4 included D, D_T, HMLD, L_T, and #A; MD-1 included D, D_T, HMLD, L_T.

In the current study, TL during MD-5 showed a significant effect with the least amount of TL resulting in a win, followed by a loss and draw. MD-5 TL variables were significantly different when compared between match performance. As reported, D for MD-5 was lower in a Win (55.66 ± 15.25 min) compared to a Draw (69.18 ± 11.90 min, $p = 0.003$, $d=0.992$). Longer D of practices during MD-5 was seen to negatively affect performance on MD, with the longest durations resulting in a Draw > Loss > Win.

Oliveira et al. (2020) reported the lowest D resulting in a Draw (30.3 ± 1.2 min) and higher D resulting in a Loss (64.9 ± 2.4 min), with no difference in wins (56.3 ± 1.3 min). D_T was found to be lowest in a Win (1.59 ± 0.427 miles) and highest in a Draw (2.65 ± 0.603 miles), D_T for a Loss was found in between (2.14 ± 0.426 miles). These results show a significant effect with a less than favorable match result with higher TL during the MW (Win < Loss $p=0.009$, $d=1.289$, Win < Draw $p>0.001$, $d=2.03$, and Loss to Draw, $p=0.002$, $d=0.977$). HMLD values were lowest in a win (0.16 ± 0.083 miles), compared to a Loss (0.20 ± 0.084 miles) and Draw

(0.30 ± 0.16 miles). HMLD was found to have a significant effect on result (Draw > Win p=0.009, d= 1.098, and Draw > Loss p=0.021, d=0.782). L_T was observed with lowest values resulting in a Win (47.79 ± 14.39 au) and highest values resulting in a Draw (75.41 ± 19.11 au), losses again were observed in between (62.12 ± 13.51 au). L_T was found to have a significant effect on result (Win < Loss p=0.042, d=1.026, Win < Draw p<0.0001, d=1.632, and Loss < Draw p=0.016, d=0.803). Oliveira et al. (2020) reported no significant findings for any GPS variables on MD-5, in the current study significant differences were found for D_T, HMLD, and L_T.

The current study analyzed a team competing in USL1, the third tier of the American professional soccer pyramid. Depending on the travel schedule of the team examined for the current study, MD-5 was often used as a recovery day. Recovery protocol was used to achieve lower TL for that day compared to the remaining MD-s. This would allow players to step-back from the team and recover on their own, promoting a ready state when training resumed later in the week. As the competition monitored by Oliveira et al. (2020) is a secondary competition, the amount of MWs that are participated in are lower leading to a smaller sample size from within the same season. The Champions League is the highest competition for clubs that compete in Europe and is idolized as the top competition and achievement for teams belonging to the confederation (Union of European Football Associations, UEFA). It is a secondary competition occurring outside of regular league play. The differences when comparing results from the current study and Oliveira et al. (2020) may also be a result of the difference in the type of athlete observed and competition structure in each study. Champions league is a secondary competition to regular league play, comprised of less overall MWs compared to a regular season in USL1. More matches require less training sessions, with the competition being organized

around regular league play for the teams competing in the confederation competition. Irrespective of the differences between the two teams and level of competition, it should be noted that a secondary competition will only increase overall load, both match and training. With the addition of mid-week games, which is standard for Champions League, training must take a backseat to matches. This impacts recovery, technical, and tactical oriented sessions during the MW that would benefit the players and team collectively. The addition of matches is a dynamic that will challenge the technical staff to operate efficiently in a way that is most conducive to team performance, despite losing valuable time on the training pitch. These differences may be due to longer training sessions occurring in the current study compared to the Champions League, due to the nature of the competition being a regular league vs secondary competition. With significant differences between TL metrics in the beginning of the MW, training sessions on MD-5 have been shown to have a significant effect on match performance with lower load resulting in a Win, and highest load resulting in a Draw or Loss.

Special consideration should be given to the day following matches (MD+1), with it often being used as a full rest day from training, conditioning, and recovery. The current results indicate that it may benefit performance if MD-5 was treated as another recovery day, and possibly a light technical workout as opposed to a regular practice. This extra day of "recovery," albeit technical, may promote lower weekly TL as the MW approaches the heavier days seen at MD-3 and MD-2. As shown in Figures 1-6, it is apparent that overall load is lower with MD resulting in a win. Modric et al. (2021) observed that match performances were more favorable when there were higher levels of HSR experienced in training sessions through the MW with total TL lower. These results do not concur with the current findings but offer another avenue of exploration with special regard to high-intensity TL.

MD-4 showed significant differences between match results in the variables of interest (D, D_T, HMLD, and L_T, #A). These results differ slightly from the findings of MD-5, with both low and high intensity load resulting in varied performance outcomes. As reported, D for MD-4 was lower in a Loss (70.55 ± 22.92 min) compared to a Draw (79.09 ± 12.17 min) and Win (72.5 ± 11.98 min). With the lowest average session resulting in a loss, this may be due to a lapse in technical and/or tactical work administered by the coaching staff. The findings indicate that when daily TL are below weekly peak levels for MD-4, the match would have a higher chance of a win or a draw. Technical/Tactical focused work that can be planned on MD-4 may lead to ideal daily TL. Additional Technical work for skill practice and tactical work for match prep would be advantageous to the match performance and thus the result. As MD-4 is early in the MW, it may often be overlooked as a recovery day or conditioning depending on the schedule. A session with a Technical/Tactical focused training sessions can provide players with sport skill practice and a comprehensive plan for the upcoming match. Not implementing one of these sessions on a MD- (possibly seen through higher load representing more conditioning and small-sided games) style of session could negatively impact performance in the match. This difference in D resulted in a significant effect between a Loss and a Draw ($p=0.033$, $d=0.465$). D_T preceding a win (2.52 ± 0.608 miles) was lower than a draw (2.94 ± 0.505 miles) with a significant effect on match result ($p=0.013$, $d=0.751$). In the current study, lower D_T resulted in a better performance (win) compared to higher D_T (draw), with an average of 0.42 miles covered more by the players prior to a loss. This could influence match performance with MD-4 used as either conditioning or recovery, and more accumulated load resulting in a poorer performance. Depending on the schedule, technical staff's may be able to add active recovery into the practice itself, allowing sessions following a heavy travel schedule to ready the players for the upcoming match.

Oliveira et al. (2020) reported significantly higher TL in High-Speed Running Distance (HSRD) values preceding a win > draw > defeat. These results differ from the results found in this study. The current study reported lower HMLD on MD-4 resulted in a win (0.271 ± 0.118 miles) vs a Draw (0.376 ± 0.125 miles) with significance found (p=0.001, d=0.863) but no significant difference between Win and Loss for HMLD. L_T and #A were also found to have a significant effect on match result. For L_T, an interaction between Draw (81.98 ± 16.95 au) and Win (70.42 ± 17.11 au) was found to be significant (p=0.017, d=0.678), with Draw and Loss (69.51 ± 24.63 au), also found to be significant (p=0.006, d=0.589). For #A, an interaction between Draw (56.40 ± 17.81) and Win (45.76 ± 15.33) was significant (p=0.019, d=0.640), with Draw and Loss (46.39 ± 22.04) also resulting in a significant reaction (p=0.024, d=0.4995). These results indicate that both metrics must be balanced, if either is too high or too low, they may negatively affect performance. With both L_T and #A showing a significant effect on match result, it is suggested that technical staff's should tailor their training sessions accordingly.

The current study suggests higher volumes of high intensity movement during a training session result in positive results. These metrics indicate higher volumes of high intensity movement during a training session, as seen in the current study, resulted in a draw or loss. During the MW, MD-4 is reported to have the most significant effect on match result, with 5 of 6 variables impacting the performance following the training period before the match. MD-4 was typically seen as a heavier day from the coaching staff, with their objective to taper towards the MD at the end of the week. With lower TL for MD-4, better results (draw or win) were seen in matches. MD-4 TL should increase slightly from MD-5 TL, as better results corresponded with an increase between the two MD-s. MD-3 TL would then be the highest during the MW. This increase would allow a steady taper to occur following MD-3 into M-2 and MD-1.

MD-3 reported one variable of interest (D) showing a significant effect. D was found to be highest on MD-3 that preceded a Draw (93.19 ± 18.68 min) compared to a Win (85.768 ± 9.406 min) and Loss (82.94 ± 15.02 min). The significant effect was seen because of the interaction between all three results; Draw to Win p=0.039, d=0.5018 and Loss p=0.002, d=0.6047. These findings indicate a small effect. No GPS metrics were found to have a significant effect, which differed from Oliveira et al. (2020), which reported higher HSRD resulted in a loss > win > draw, and average speed values were higher preceding a loss > draw > win. HMLD was found to have no significant differences or effect on match performance. As MD-3 is the mid-point of the standard MW, it is reported that this is usually the highest load day in the week. This peak would allow for a general taper in load towards the MD. This peak was seen on MD-3, with corresponding metrics at their highest in the current study. As significance was only found for D, it can be proposed that MD-3 is the most ideal MD- to peak load and then taper TL on the following days of the MW.

MD-2 showed a significant effect on match result in two variables of interest (D, HMLD). D was reported as being highest preceding a loss (87.29 ± 20.87 min) compared to a draw (79.47 ± 13.88 min) and win (80.09 ± 9.63 min), with a significant effect between a Loss and Win (p=0.041, d=0.443) and draw (p=0.022, d=0.441). HMLD had a similar effect as D, with higher values resulting in a draw (0.363 ± 0.148) compared to a loss (0.294 ± 0.0966 p= 0.006, d=0.552). HMLD was not shown to influence wins (0.336 ± 0.11). Oliveira et al. (2020) found higher D_T and D for a loss > win > draw. These results correspond with the current study, with MD-2 D resulting in Loss > Win > Draw. Previously, studies have indicated that a general taper is seen in MD-2 and MD-1 with the highest amount of load experienced earlier in the MW on MD-5 and MD-4 (Malone et al., 2015 & Akenhead et al., 2016). These findings were not

compared with results from corresponding matches and may not provide the most accurate indication of results experienced. Weekly TL monitoring may have the potential to advise technical staff to the possible effect of their sessions (Martin-Garcia et al., 2018). As mentioned previously, Technical/Tactical focused training sessions may prepare the team for the upcoming match while remaining at less than peak levels of load.

MD-1 showed significant differences in variables D, D_T, HMLD, and L_T. MWs that result in a Win were lower across all variables of interest, followed by Loss then Draw. D was found to be highest preceding a Draw (91.219 ± 20.54 min) and lowest preceding a win (73.26 ± 5.22 min), and a loss was lower than a draw but slightly higher than a win (75.62 ± 9.39 min). Significant effects were found between all three results; Draw to Win $p<0.0001$, $d=0.500149$, and Loss $p<0.0001$, $d=0.429$. D_T was found highest preceding a Draw (2.64 ± 0.483), followed by the Loss (2.43 ± 0.300) and Win (2.32 ± 0.337). These results show a significant effect that D_T may have on match performance, Draw to Win $p= 0.004$, $d=0.768$ and Loss $p=0.018$, $d=0.522$. HMLD was highest preceding a draw (0.349 ± 0.185) compared to a loss (0.2829 ± 0.07511) and comprised a significant effect ($p=0.035$, $d=0.468$) on match result. HMLD preceding a win (0.2826 ± 0.07599) was not significant. Lower values of L_T were reported preceding a win (61.77 ± 12.43 au) compared to a draw (69.52 ± 14.5 au), with a significant effect on match result seen $p=0.047$, $d=0.573$. L_T preceding a loss (64.33 ± 10.89 au) was not shown to influence match result. Oliveira et al. (2020) found HSRD were higher in Draw > Win > Loss and Average Speed were highest in MWs that resulted in a Win > Draw > Loss respectively. As D, D_T, HMLD, L_T was shown to have a significant effect, caution should be shown in training on MD-1 because of the effect TL may have on performance. Malone et al. (2015) reported significantly reduced TL in English Premier League players on MD-1.

From the current study, it was unexpected to see the results indicating higher TL results in a Draw > Loss > Win, across the MW and within each MD-. From a technical staff perspective, this would add difficulty for planning and preparation based on the findings presented. As the findings indicate better results followed lower TL during the MW, it may be difficult to implement ideal structure without more context. The methods applied in the current study can provide a retrospective look at training microcycles.

Silva et al. (2021) reported increases in Match performance, quantified with HSR and #A following MWs that had higher levels of HSR ($r = 0.497$, $p<0.01$) and #A ($r = 0.367$, $p<0.01$) during training sessions. These findings indicate that higher levels of high intensity performance metrics during training result in better match performance. This study quantified match performance based on the higher or lower totals of each metric and did not account for match result. As the results for the current study indicate, higher levels of HMLD did not equate to a better match result. Weekly TL for HMLD was lowest in MWs that ended in a Win (1.41 miles), followed by Loss (1.47 miles), followed by Draw (1.76 miles).

As the results indicate higher levels of performance surmise from less weekly TL, particularly on MD-5, MD-4, and MD-1, it could be proposed that these days within the match week could be used for technical proficiency work, with higher intensity work taking place on MD-3 and MD-2. High intensity training taking place in the middle of the MW, with the beginning and end lighter comparatively. This ramp up in TL from MD-5 peaking at MD-3 may induce the best results within this population, as MWs are used to prepare for competition. Perhaps technical sessions taking place at the beginning and end of the MW and more physically taxing sessions during the middle would lead to a higher level of performance based on these results.

CHAPTER 5

CONCLUSION

Following a season-long analysis of an American professional soccer team, weekly TL was shown to have a significant effect on match result. This monitoring period included thirty individual MWs that were analyzed and compared based on corresponding match result. D, DT, HMLD, and LT were the metrics that had the most significant effect throughout the week. During any given MW, MD-5, MD-4, MD-1 should be carefully planned and prepared for due to the results from this study indicating the largest effect occurring on these MDs. Recovery should be prioritized early in the MW, with conditioning and physical preparation best occurring in the middle, before tapering into the MD at the conclusion of the MW.

TABLE 1

Metric	**Unit**	**Definition**
D	min	THE TOTAL DURATION OF THE SESSION(S)
D_T	m	TOTAL DISTANCE COVERED BY PLAYER(S) IN SELECTED SESSION/DRILL
HMLD	m	DISTANCE COVERED PERFORMING ANY ACTIVITY ABOVE 25.5W/KG.
L_T	au	USING ACCELEROMETER DATA ALONE, GIVES A TOTAL OF THE FORCES ON THE PLAYER OVER THE ENTIRE SESSION WITHOUT ANY WEIGHTINGS BEING APPLIED
#A	#	ACCELERATIONS BETWEEN 3.0-10 M/S/S WITH MINIMUM DURATION OF 0.5S BY DEFAULT
#D	#	DECELERATIONS BETWEEN 3.0-10 M/S/S WITH MINIMUM DURATION OF 0.5S BY DEFAULT

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APPENDIX A

LITERATURE REVIEW

The recent modernization of soccer has come with new dynamic tactical elements that were unused of prior to the 21'st century. Tactical systems within professional soccer are built upon a team of conditioned athletes, with an approach for full team attacking and defending. This has radicalized the need for individual and team monitorization to ensure performance, fitness, and recovery are in the most optimal state. Due to the involvement of defenders in attacking formations, increased distance covered by midfielders, and an increased amount of high intensity running from attackers, positional monitoring has become standard within the scope of practice for coaching and performance staff. Load monitoring is not a new concept within team sports and has been well documented in the last 20 years (Foster et al., 2001 & Impellizzeri et al., 2004) and specifically within soccer (Scott et al., 2014; Malone et al., 2015; Akenhead et al., 2016; Martin-Garcia et al., 2018).

Methods of load monitoring and measurements have made great advances alongside the increased demand for load monitoring. Foster et al. (2001) proposed the use of Rating of Perceived Exertion (RPE) as a valid measuring tool in various exercise activities with the application of quantifying TL. RPE as a method of measuring load allowed practitioners an evidence-based method for monitoring athletes. RPE had previously been used as the foremost method for measuring IL in laboratory and research setting, with Borg (1974) proposing the 6-20 RPE scale.

The need for monitoring athletes is rooted in the desire to reach new levels of performance and exceling within one's sport. With the refinement of wearable technology and

EL measuring devices such as GPS units, load measurement has become a standard practice within sports such as Rugby, Soccer, American Football, Cricket, and Baseball. EL accumulated by players during training sessions and matches are measured all through use of a monitoring pod. Generally, all monitoring pods have GPS capabilities, with some having Global Navigation Satellite System (GNSS) and Local Positioning System (LPS). GPS capable pods provide data specific to the individual using the device with anthropometric measurements considered when calculating load.

Various methods of collection have developed and improved since the turn of the century. This has been driven by increased demand for fatigue monitoring alongside performance (Halson, 2014). Monitoring the top professional leagues all the way through to collegiate and semi-professional opens the door for a variety of methods. Athletes and coaches alike are taking more of a scientifically backed approach to load monitoring. Internal Load (IL) is comprised of the subject's psychophysiological response to prescribed exercise by a member of the coaching staff (Impellizzeri et al., 2018). Whether in training or competitions, individuals will have varying internal responses to the same stimuli experienced during physical activity. IL can be and is comprised of a myriad of methods, including Heart Rate (HR), RPE, Training Impulse, Biomarkers, Psychomotor speed, and subjective questionnaires within regard to individual perception of sleep, effort, or fatigue. EL can be defined as the amount of work done by an athlete measured independently of internal physiological response. EL collection can be accomplished through Time-Motion analysis, power output measurements, and neuromuscular function. GPS technology accomplishes time-motion analyses using positional data and provides a vast number of variables to quantify load during use. As measuring EL is done irrespective of the internal response and current state of fatigue, it is commonly used alongside a method(s) of

IL collection (Halson, 2014). Technology and cost are driving factors for organizations and teams' processes in collection of TL data, with subjective load measuring becoming common in all areas of sport due to the low-cost advantages versus high-cost technology.

Season long analyses of TL has been documented within the literature with varying methods of collection and calculation of TL. As mentioned previously, the MD- system is the main system used by practitioners and therefor researchers. Analyses have also been done using classification of week type, comparing the type of week to itself and so on. Azcárate et al. (2018) analyzed 4 microcycles within the Spanish second division. They classified microcycles based on when the week begins and ends. They found length of training weeks did not affect players accumulated load throughout any microcycles, alongside training strategies did not compensate for load supplementation in players that did not contribute a significant amount to the weekly match. Silva and Nobari (2021) investigated volume and intensity during the practice week and how load affected match performance based on GPS metrics. Moderate positive correlations were found, between match High Speed Running (HSR) and total weekly load HSR were found, r=0.497, and between mean week intensity and match HSR r=0.498. Weaker positive correlations between match accelerations and mean week averages were also found r=0.366.

EL monitoring is the main method used within professional and amateur sporting organizations, as measuring devices do not require specialized equipment that may be unattainable to said organizations. Accumulating TL affect's individuals uniquely as an internal physiological response will vary based on the same external stimuli (Impellizzeri et al., 2019). Monitoring athletes with EL devices can allow practitioners to supervise team and individual load and recovery. Performance staff are able to set thresholds and key performance indicators for an individual, driven by EL performance data that is captured during training and

competition. Dellal et al. (2010) proposed that tailoring training sessions based on position and individual performance within soccer has shown to have been successful in the French Ligue 1. They proposed positional training differences based on performance within matches. In matches center midfielders were required to participate in more duels than forwards, and wide attacking players requiring more high intensity running than central defenders. Their findings indicate that positional training would benefit athletes' performance in matches.

MW's will vary in preparation for each upcoming match, particularly in tactical implementation and refinement following the previous match. From a coaching outlook, a combination of drill type, intensity, and session goal will push athletes towards improvement from their previous performance. Small-sided games have been shown to be the most optimal path for improvement in terms of endurance performance, with the game-like approach being superior to practice drills. (Morgans et al., 2014). As stated by Aguiar et al. (2012) varying intensity of MW's coupled with the use of small-sided games is seen as the most optimal training method when executed correctly. The varying use and protocol for small-sided games limits the known effects in various areas of performance, with the need to investigate further known.

TL's effect on performance is investigated within a small number of leagues throughout the world, with no American Soccer presence in the literature. Calculating weekly TL from the MWs training window has minimal research. Azcárate et al. (2017) classified MWs into four categories based on the next match, they grouped players into groups based on time played in the previous match. They found significant differences between all playing-time groups $p < 0.05$ in total volume. Significant differences were only found between week type 1 and 4 $p>0.01$. The researchers also found significant difference between all participation groups in perceived TL, $p>0.01$ $F2=67.992$. Due to the differences found, it is stated that training strategies do not

account for a lack of playing time during matches. Silva and Nobari (2021) found moderate correlations between Match High-Speed-Running and Volume of weekly TL, while also finding match acceleration correlated with weekly TL. These findings indicate HSR, and acceleration training volumes had a significant effect on the match performance, with higher-intensity training performance leading to an increase in performance in the match. Oliveira et al. (2020) examined the distribution of weekly TL and how it accounts for match result in the top Union of European Football Associations competition, Champions League. They analyzed five positions within the same team, with all players being put into one of the five groups. Their main findings were only for MD-1, with MD-5 through MD+1 analyzed. They found longer training session on MD-1 preceding draw (95.1 ± 1.5 min) > loss (91.5 ± 1.6 min) > win (84.7 ± 0.5 min). TD was also higher in win (3628.6 ± 57.2 m) > draw (3391.3 ± 153.3 m) > loss (3236.1 ± 113.7 m) alongside higher Average Speeds in draw (130.7 ± 17.6 m/min) > win (86.0 ± 6.9 m/min) > loss (54.8 ± 7.1 m/min). HSR was also higher in draw (42.8 ± 0.6 m) > win (36.1 ± 1.7 m) > loss (35.8 ± 1.7 m). The researchers used the Hooper Index and sRPE as their methods to calculate IL. Significant differences were found in MD+1 for the Hooper Index between win and draw, ES: -3.86 (-4.82) (-2.75), $p<0.01$. No significant differences were found in sRPE on any MD.

In conclusion, the effect of weekly TL has been investigated in a minimal number of leagues, with zero in the American professional Soccer system. The lack in research offers an opportunity to highlight the possible differences compared to European leagues. Provided by previous researchers, are a variety of methods for TL calculation. The different methods allow for an informed approach to weekly TL monitoring. With the validity of GPS units proven in previous research, coaching and performance staff can use these units to quantify and monitor TL based on EL experienced by the athletes.

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APPENDIX B

FIGURES

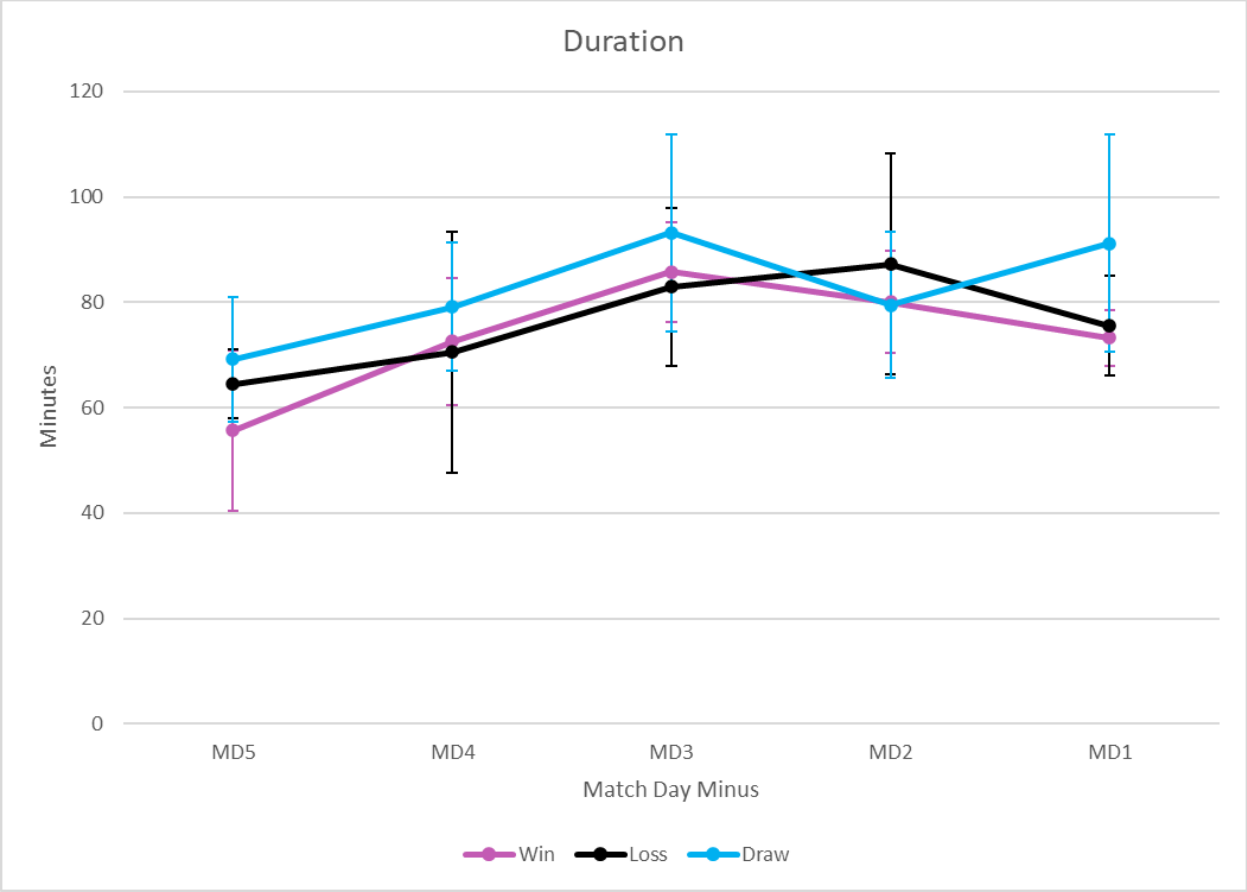

FIGURE 1. DURATION DURING THE MW

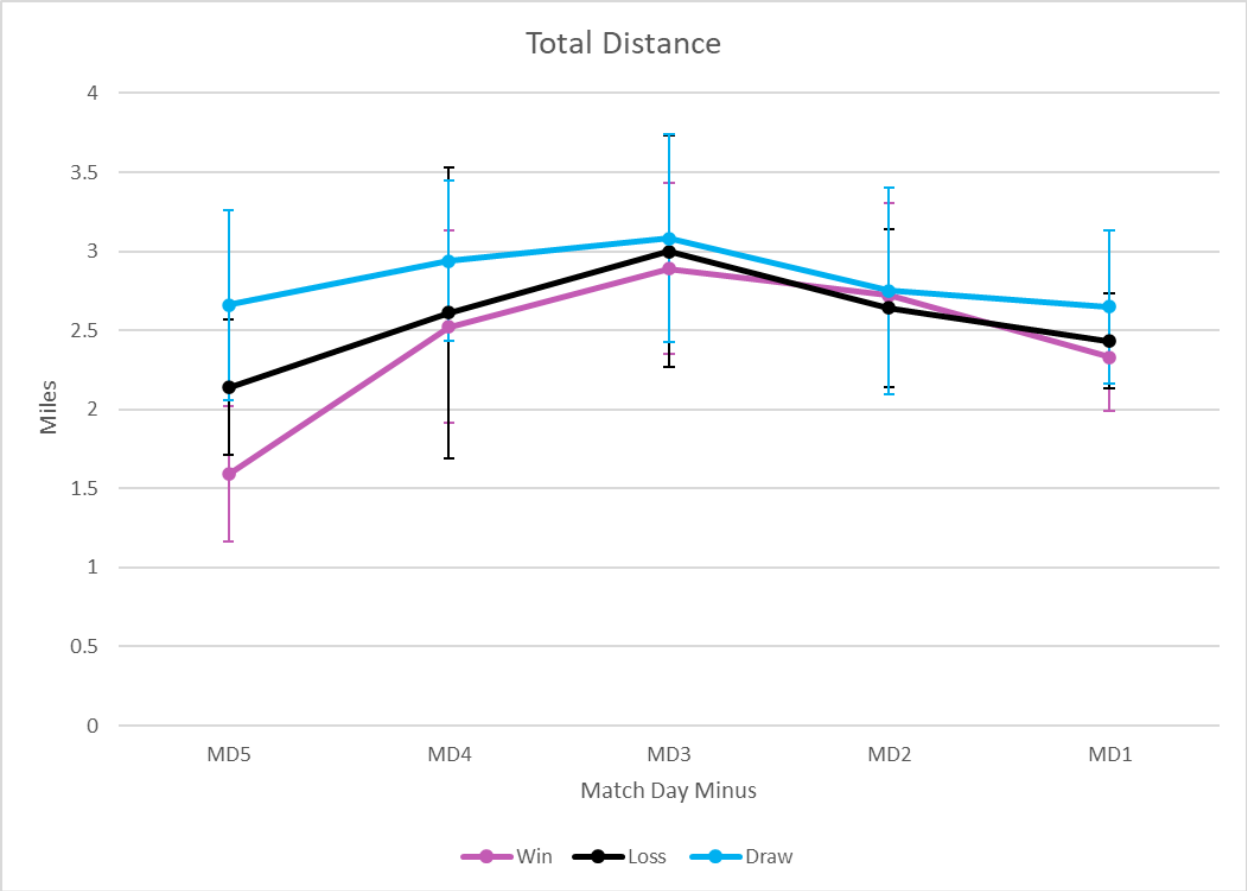

FIGURE 2. TOTAL DISTANCE ACROSS THE MW

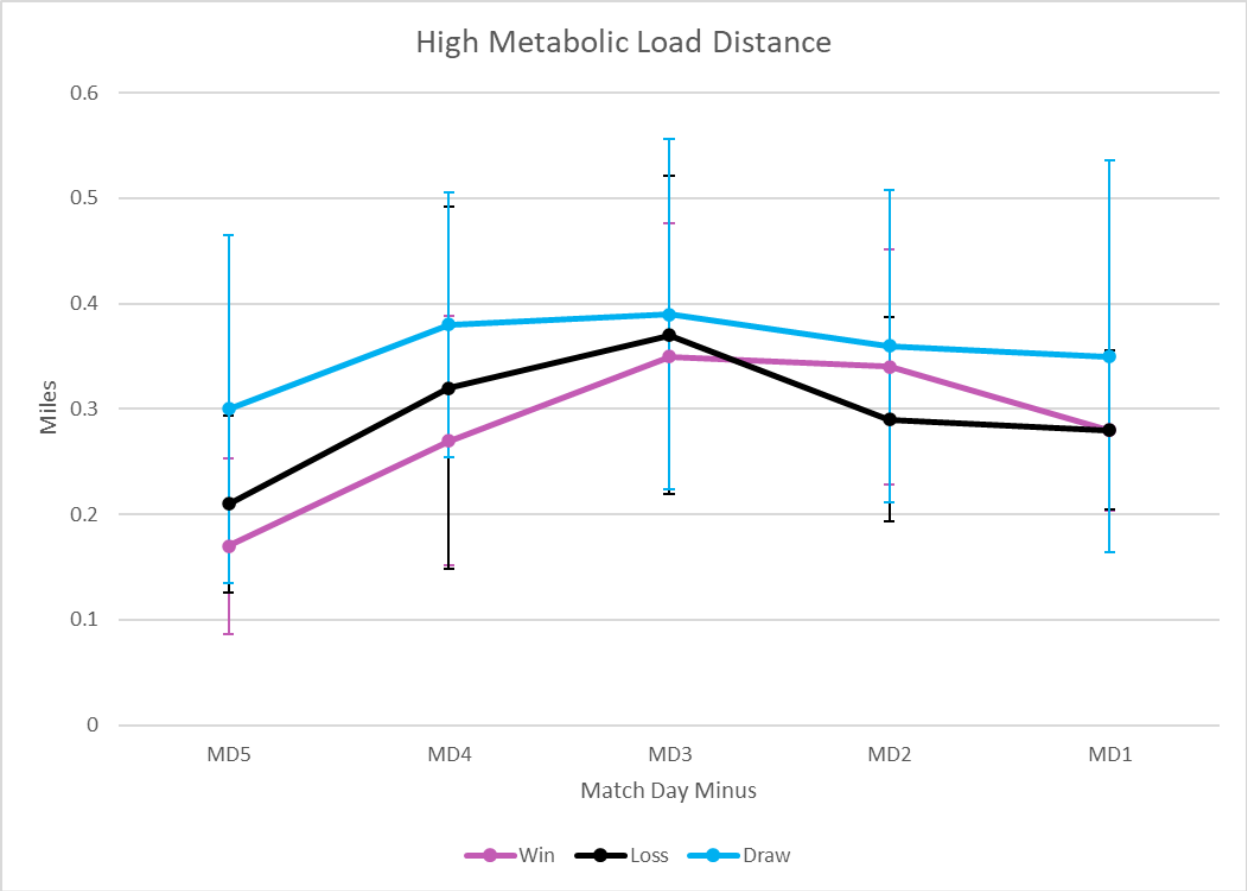

FIGURE 3. HIGH METABOLIC LOAD DISTANCE ACROSS THE MW

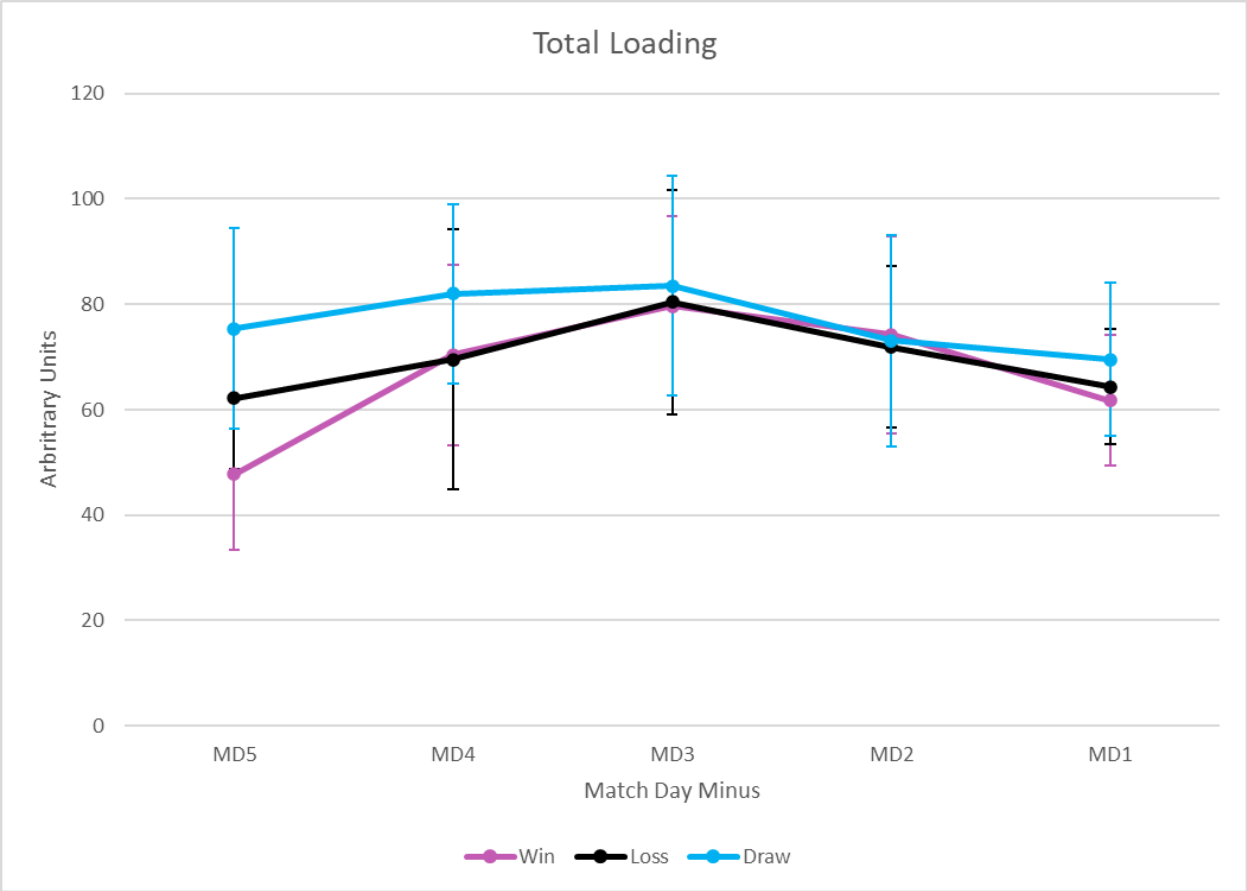

FIGURE 4. TOTAL LOADING ACROSS THE MW

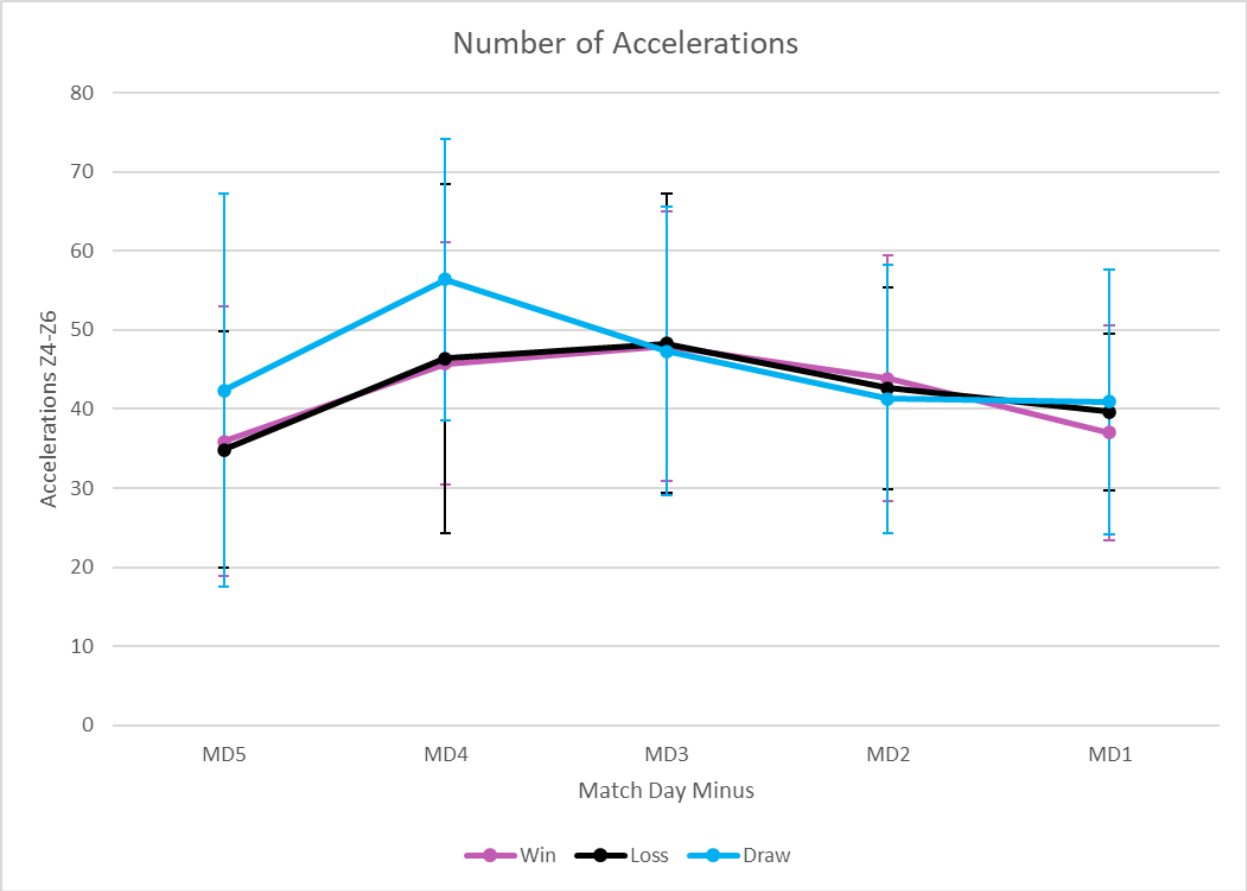

FIGURE 5. NUMBER OF ACCLERATIONS ACROSS THE MW

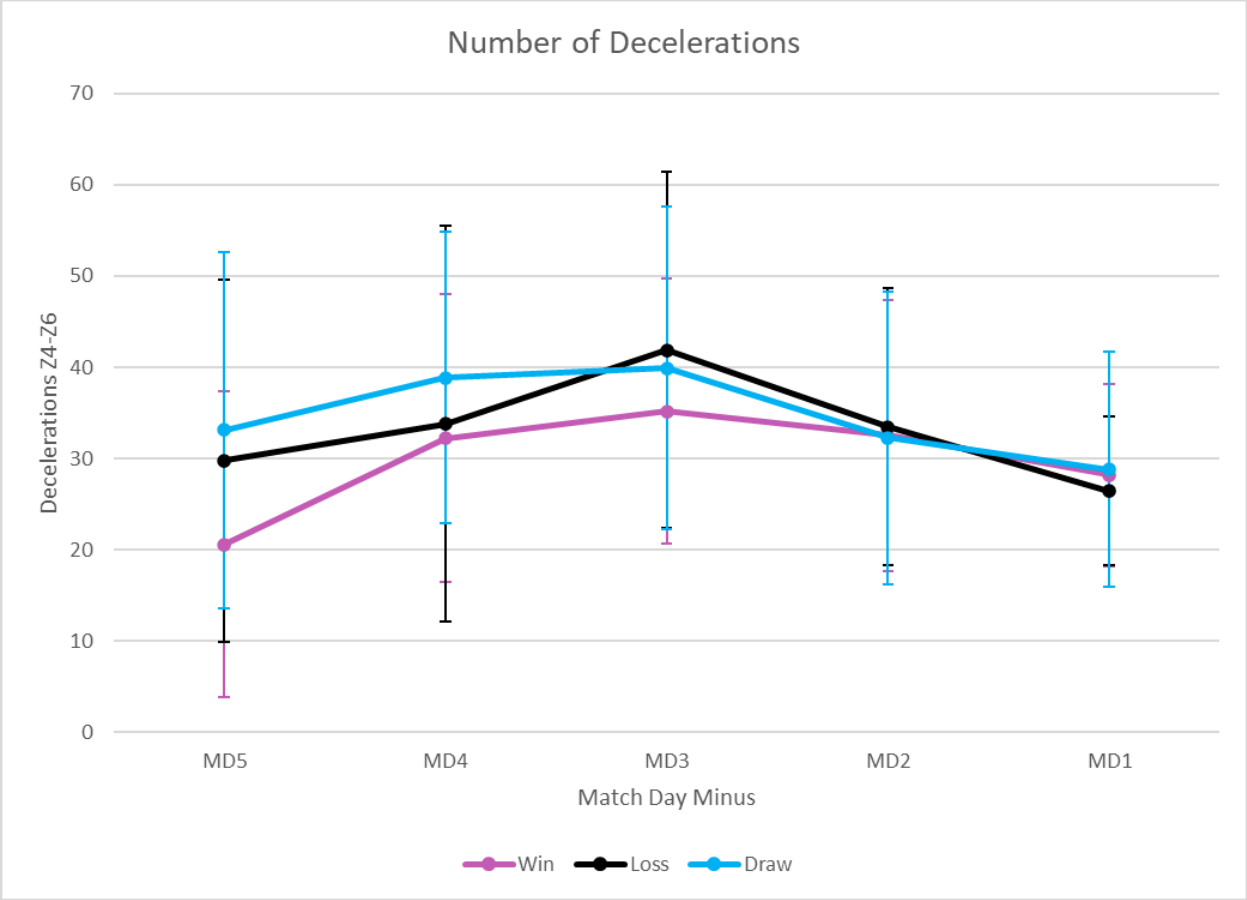

FIGURE 6. NUMBER OF DECELERATIONS ACROSS THE MW

	MD-5	MD-4	MD-3	MD-2	MD-1
Duration	Short	Long	Long	Moderate	Short
Distance	Low	Medium	High	Medium-High	Low-Medium
Loading	Low	High	High	Medium	Low
Training Focus	Recovery Low Impact Low Intensity	Tactical prep Increased HMLD Drill Volume High	High Intensity Peak HMLD Large SSG	Mid Intensity Decreased HMLD Small SSG	Technical Prep Lowest HMLD Drill Volume Low

FIGURE 7. AN IDEAL TRAINING WEEK BASED ON RESULTS OF THIS STUDY