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Comparison of External Load Patterns Over a Season in Collegiate Soccer Players

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Abstract

Soccer (football) is the most played sport in the world. In turn, soccer also accounts for a considerable number of injuries at all levels. Injuries in soccer are not only detrimental to team performance, but they can also place financial burden on organizations, in addition to causing harm to players health down the line. As such, it is important that these injuries are limited and managed to avoid the various consequences that accompany serious injury. PURPOSE: This study attempted to quantify the external loads of NCAA DI soccer athletes over the course of a Fall season. These external load values may help give insight to coaches and researchers into the amount of physical stress collegiate men's soccer players endure, and how that stress could affect injury risk. METHODS: Data was collected on The University of Akron Men's Soccer Team during the 2019 NCAA season by the University of Akron's strength and conditioning staff. This data included 16 games and approximately 11-15 GPS entries. Values exported included total duration of session, total distance (TD), total high-speed running distance (THSR; >20km/h), total sprint distance (TSD; >22.5 km/h), and total PlayerLoad (PL). Averages of all exported load values were compiled in addition to averages relative to player position. RESULTS: TD averages over the course of the season were equal to 10,873.39 m (defenders), 10,431.29 m (midfielders), and 9,988.60 m (forwards). Further, THSR values of 705.51 m (defenders), 699.42 m (Midfielders), and 702.48 m (forwards) were found. Other external load indicators across the season and across player positions also showed little variation. DISCUSSION: These findings provide some insight into the load endured by NCAA DI soccer athletes over the course of a season. Precise methods of data collection are unknown so the results should be taken with some skepticism. However, the data can still provide useful insights for future researchers who attempt to investigate external load metrics in soccer.

Introduction:

Sports injuries can come in a variety of forms and severities. Soccer, otherwise known as football, is the most played sport in the world, and accounted for 265 million players in 2006 (Fédération Internationale de Football Association [FIFA], 2006). Further, soccer has grown in the United States, where it is the cause of over 228,000 injuries per year in the United States alone (Chahla et al., 2018). Injuries in soccer can not only be detrimental to team performance, but they can also place financial burden on organizations, in addition to causing harm to players health down the line. Many physiological variables independent of skill can contribute to a soccer teams' success such as average jump height, leg extension power, and body fat percentage of a team. Interestingly, a similar trend has been found in total number of injury days per team (Arnason et al., 2004). In other words, the more days those players are out due to injury, the less likely the team performs well over the course of the season. Further, these injuries also can impact the financial situations of sporting organizations. According to a study conducted in the English Premier League (EPL), each Premier League club loses approximately 45 million British pounds (GBP) each season because of injury-related decrement (Eliakim et al., 2020). To put this in perspective, in United States Dollars (USD), this is about $62 million. Lastly, injuries can affect the long-term health of players as well. Playing soccer puts participants at risk to suffer devastating injuries. More precisely, soccer players are particularly prone to knee injuries, especially in match play (Waldén et al., 2016). These injuries could develop into serious chronic problems/diseases such as osteoarthritis (OA). The risk of developing OA almost doubles with every severe knee injury/surgery (Gouttebarge et al., 2018). With the negative impact of injuries on team performance and individual well-being, exploring possible opportunities to reduce injury risk could be helpful.

One troubling issue in world soccer is the increased commercialization of the sport, which in turn has increased the amount of domestic and international cup competitions. With an increase in competitions comes fixture congestion, which can be defined as two games with less than 96 hours recovery between games. More broadly, fixture congestion is the result of a lot of games with little rest in between. Current evidence indicates that fixture congestion may negatively impact some aspects of player performance. For instance, in soccer, < 3 or < 4 days of rest showed significantly higher injury rates when compares to > 6 days of rest (Soligard et al., 2016). However, there is still a lack of data in the area (Julian et al., 2021). Understanding of whether injuries are the result of reduced recovery or increases in match exposure and external loads is not yet comprehensive (Howle et al., 2020). As the sport is treading such a thin line of stress and recovery, Global Positioning Systems (GPS) have emerged as a promising instrument to help quantify stress on the body and possibly help predict injury risk. The use of wearable GPS in soccer allows teams and training staff to quantify external loads to provide a more objective measure of training load. In addition, GPS allow for intra-match/training monitoring, which could be utilized in making real time decisions. Although relationships between external load indicators have been explored, the link between GPS load measurements and injury risk is still unclear (Ehrmann et al., 2016).

Given the accessibility of GPS devices to help provide objective measurements of the load players endure, it would make sense to investigate how these external load values can be used to mitigate injury risk. This study attempted to quantify the external loads of NCAA DI in season soccer athletes. Without access to injury records, training external load values, or knowledge of exact data collection methods, data analysis was not performed. However, averages of these external load values may help give insight to coaches and researchers into the amount of stress on the body that collegiate men’s soccer players may endure, and how that could affect injury risk.

Literature Review:

Injuries in Soccer

Injuries can place a large burden on the sport of soccer. For instance, in professional soccer incidence of injury has been shown to be about 8.1 injuries per 1,000 hours of exposure. During match exposure, injury incidence rates jump to 36 injuries per 1,000 hours of exposure which is about 10 times larger than training injury rates (López-Valenciano et al., 2020). Lower training injury rates versus match injury rates holds true across genders, participation levels, and age (Owoeye et al., 2020). In addition, on average, players incur about 2 injuries per season. To put that in perspective, teams with 30 players could expect 60 injuries per season (Ekstrand et al., 2011). Of the injuries that occur across soccer, the majority (60-90%) appear in the lower limbs. Men most commonly experience injuries to the hamstrings, whereas women most commonly experience knee and ankle injuries (Owoeye et al., 2020). The majority of soccer injuries are a result of trauma. Overuse injuries account for the remaining soccer injuries (9-34%). A predominant cause of injury in soccer is foul play, which accounts for 12-28% of all injuries. However, it is estimated that anywhere from 26-59% of injures result from non-contact cutting/ running and overuse. (Junge & Dvorak, 2004).

Non-Modifiable Risk Factors of Injury in Soccer

There are several risk factors that are not modifiable that can increase injury risk in soccer players such as player position, previous injuries, sex, and competitive setting/level (Owoeye et al., 2020). Positions in soccer can be divided into goalkeepers, defenders, midfielders, and forwards. Evidence suggests that goalkeepers are at a much lower risk than field players to incur an injury. In addition, forwards were found to be at a greater risk of injury than defenders or midfielders in some studies. This could be due to the higher contact nature of their position or an elevated amount of accelerations and decelerations. However, current data is inconclusive on whether injury risk is associated with player position (Della-Villa et al., 2018). Unlike player position, previous injury is a very sturdy and stable risk factor to predict injury risk. Various specific injuries increase future chance of obtaining that same injury. For example, an Anterior Cruciate Ligament (ACL) tear increases risk of re-tearing in the future. This also holds true with hamstring and ankle injuries (Owoeye et al., 2020). Likewise, an individual's sex can also be a risk factor. For instance, females are 2.8 times as likely than males to tear their ACL in soccer because of various factors, including anatomical structure (Trainers, 2016). However, men have higher rates of overall injury compared to females (Owoeye et al., 2020). Lastly, the competitive setting/ level also has a very large impact on injury risk. As mentioned previously, injury rates are higher in games when compared to training (Owoeye et al., 2020). However, even in training, scrimmages yielded higher injury rates than regular practice (Volpi et al., 2016). Although there are many non-modifiable factors that increase the risk of injury of soccer, there are various modifiable factors as well.

Modifiable Factors of Injury in Soccer

Further, there are several factors that can be modified to adjust risk of injury. For instance, there are numerous neuromuscular factors that can be associated with an increased risk of injury in soccer. For example, a low hamstring-to-quadriceps strength ratio is associated with higher rates of knee ligament damage in youth players. Further, poor dynamic stability and neuromuscular firing, muscular strength asymmetries, and leg dominance may also increase risk for injury in soccer players (Owoeye et al.,2020). Therefore, implementing a structured warm-up that emphasizes neuromuscular control and strength could be effective in reducing injury risk (Grooms et al., 2013). Such programs, such as the FIFA 11+ injury prevention program, has been shown to reduce risk of injury by as much as 30% (Sadigursky et al., 2017).

Further, load, in terms of exposure and exertion, is an emerging area of intrigue in the literature regarding its relation to injury risk and injury prevention. It has been found across a wide variety of sports that load can be either protective or increase risk of injury depending on if the load is optimal or suboptimal. In addition, avoiding large increases in load, and instead implementing a progression to increased load, has been shown to reduce injuries in soccer (Owoeye et al., 2020). In light of these findings, monitoring and tracking loads to create load thresholds may be helpful in reducing injury risk (Bowen et al., 2017).

Monitoring training load for injury prevention in soccer

Exorbitant loads, inadequate recovery, and large spikes in load can increase risk of injury in athletes (Jaspers et al., 2018). In turn, monitoring these loads to minimize injury risk could be beneficial for athletes in soccer. Monitoring load is typically performed by observing internal and external loads. Internal loads can be defined as the actual physiological and psychological response to a load. Typically, internal loads can be measured using values such as heart rate (HR), ratings of perceived exertion (RPE), blood lactate, and oxygen consumption. Conversely, external loads refer to objective measures of the load an athlete endures, separate from internal loads. Commonly used external load measures include various global positioning system (GPS) and accelerometer derived parameters such as acceleration, speed, and power output. Using a combination of external loads and internal loads may help provide better insight into training stress than using either in isolation (Cardinale et al., 2017). In some cases, collecting a combination of internal and external loads is not plausible, so only one of the load indicators can be assessed. In the absence of either internal or external loads, external loads in isolation could be a better indicator of injury risk than internal loads. There is limited evidence however, that some internal load values may help predict injury risk. For example, a study found a positive correlation between muscle strains and average HR (Mallo & Dellal, 2012). Nonetheless, it has been proposed that external load indicators are primarily associated with injury risk in comparison to internal load indicators (Jaspers et al., 2018).

Monitoring external load values for injury prevention

According to the International Olympic Committee consensus statement on load in sport and risk of injury, accumulated load has been identified as a risk factor of injury in running, baseball, cricket, orienteering, rugby, swimming, triathlon, volleyball, water polo, and soccer (Soligard et al., 2016). Therefore, using GPS to monitor cumulative load could be a very important tool for minimizing injury risk. In a study by Jaspers et al., (2018), there were several relationships found between external load indicators and overuse injuries in professional soccer players. Data sets were categorized into weekly loads up to four weeks. The external load values collected included total distance covered (TD), distance covered at high speed (THSR; >20 km/h), number of accelerations, number of decelerations, and acute-chronic workload ratio (ACWR). For TD, a very likely harmful effect was found in players that exceeded a high cumulative load (>59,185m) in a 2-week period. Likely harmful effects were found for high 1-week cumulative loads (>31,161m), medium 2-week cumulative loads (48,050-59,185m), and for high 3-week cumulative loads (>86,422m). In addition, likely harmful effects were found in medium 1-week THSR (634-1028m). Further, likely harmful effects were found for number of decelerations values and ACWR as well.

In another study by Xiao et al.,(2021) collegiate DI female soccer players were examined to compare external load indicators with injury. Interestingly, their findings suggested that accumulated TD and player load are associated with risk of lower extremity injury. In other words, the averages of TD and player load were significantly higher in injured players when compared to non-injured players. In another study on professional soccer players by Nobari et al., (2021), it was found that high loads of TD, high speed distance, sprint distance, and repeated sprints increased the risk of non-contact injury. This means that risk of non-contact injuries could be higher during weeks with high sprint workloads. Although these external load indicators may be able to help determine injury risk, they may not be sensitive enough to determine injury severity or differentiate between different tissue injury types (Enright et al., 2020).

Methods:

Data was collected on The University of Akron's Men's Soccer team during the 2019 season by the university's strength and conditioning staff. This study was approved by The University of Akron Institutional Review Board (Appendix A). The database consisted of 18 games and contained 11-15 GPS recordings per game. However, only 16 of the games were recorded in full duration. The strength staff utilized 10 Hz GPS technology (Optimeye X4, Catapult Sports, Melbourne Australia) to collect external load values over the course of the season. Ten hertz sampling rates show good reliability and validity in comparison to 1Hz and 5Hz (Macfarlane et al., 2016). As the database was accessed after the fact, and was not intended for analysis, precise methods of data recording are unknown. Data sets were uploaded and stored using Catapult's OpenField software (Catapult Sports, Melbourne Australia) after each game and was subsequently stored in OpenField Cloud (Catapult Sports, Melbourne Australia). Before the data were obtained, University of Akron strength staff deidentified the players within OpenField.

Players were organized by position (e.g., defenders, midfielders, and forwards) and assigned a number (e.g., forward 1,2,3). Goalkeeper data was not collected during the 2019 season. The identities of the players were not seen by the principal investigator.

Following the deidentification of players by strength staff, all 2019 game data was accessed and exported in a bulk comma-separated values (CSV) file and was viewed in Excel 2019 (Microsoft Corporation, Redmond Washington). Values exported included total duration of session, Total distance (TD), total high-speed running distance (THSR; >20km/h), total sprint distance (TSD; >22.5 km/h), and total PlayerLoad (PL). Discussion of PlayerLoad and how it is calculated is discussed elsewhere (Bredt et al., 2020). Only individuals that were members of the 2019 University of Akron Men's Soccer Team who played in 1 or more regular season games were included in analysis. After the data was exported, sessions that were not > 90 minutes in total duration were excluded from the data pool. Further, players that did not participate in at least 50% of the total session/game duration were filtered out of the data. Averages of all exported values were compiled in addition to averages relative to player position. Average time between games was calculated using the time between sessions in the database.

Results:

The quantification of the external load values total distance, total high-speed running distance, total sprint distance, and total PlayerLoad are displayed in Table 1 below. In total, there were 171 total GPS entries across 16 games, which is approximately 11 entries per game. Respectively, there were 88 defender entries, 56 midfielder entries, and 27 forward entries. Average time between games across the season was approximately 108.7 hours. In other words, the team had an average of 108.7 hours of rest before the subsequent game began.

Table 1

External Load Indicator Averages

External Load Indicators	Defenders	Midfielders	Forwards	All players
Total Distance (TD)	10,873.39 m	10,431.29 m	9,988.60 m	10,588.90 m
High Speed Running Distance (THSR;>20km/h)	705.51 m	699.42 m	702.48 m	703.03 m
Sprint Distance (TSD;>22.5 km/h)	286.12 m	259.74 m	251.28 m	271.98 m
Player load (PL)	1,056.30 arb	998.00 arb	922.91 arb	1,016.14 arb

Note. Total distance, total high-speed running distance, total sprint distance is expressed in meters (m). Player load is expressed in arbitrary units (arb).

Figures 1-4 display the information presented in Table 1 in a tangible manner.

Figure 1

Average Total Distance Across Player Positions

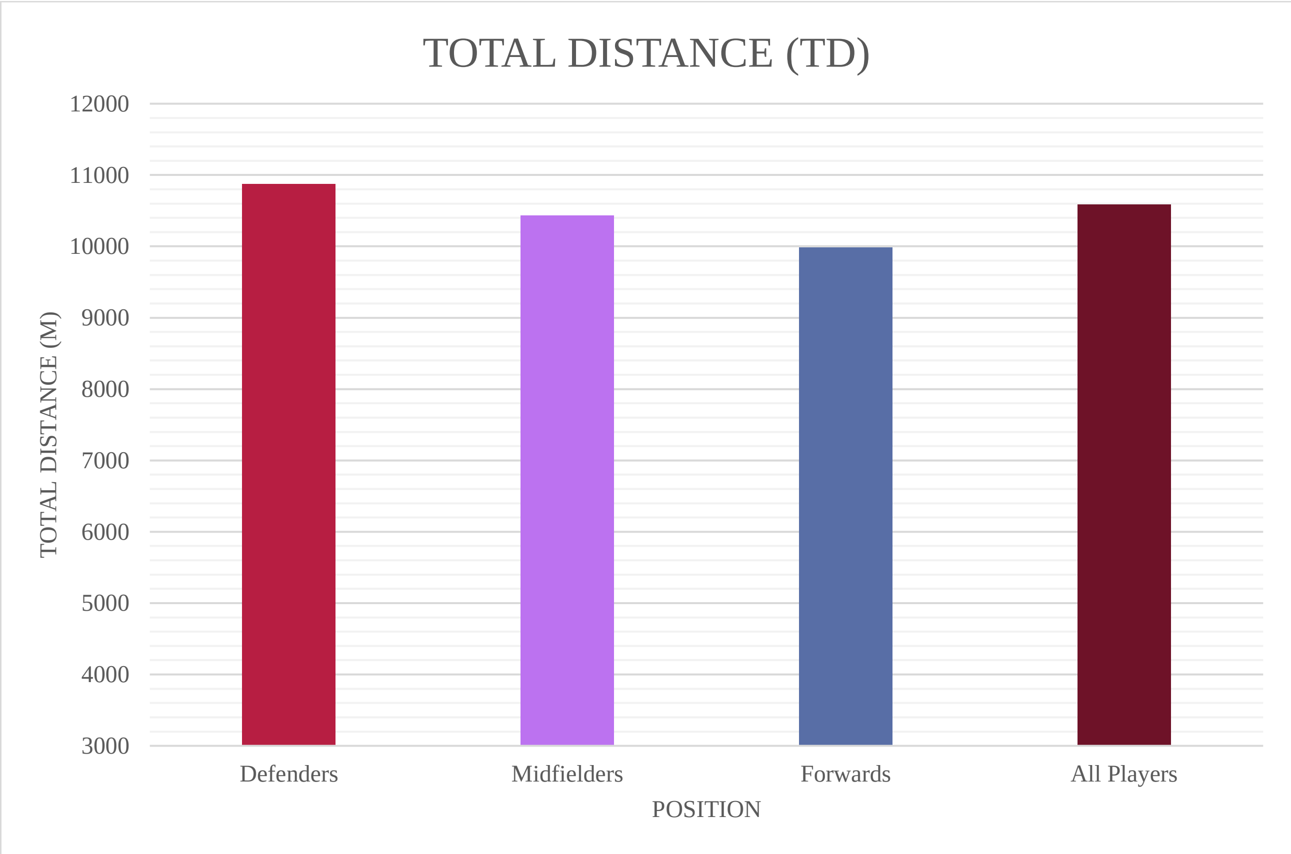


Figure 2

Average Total High Speed Running Distance Across Player Positions

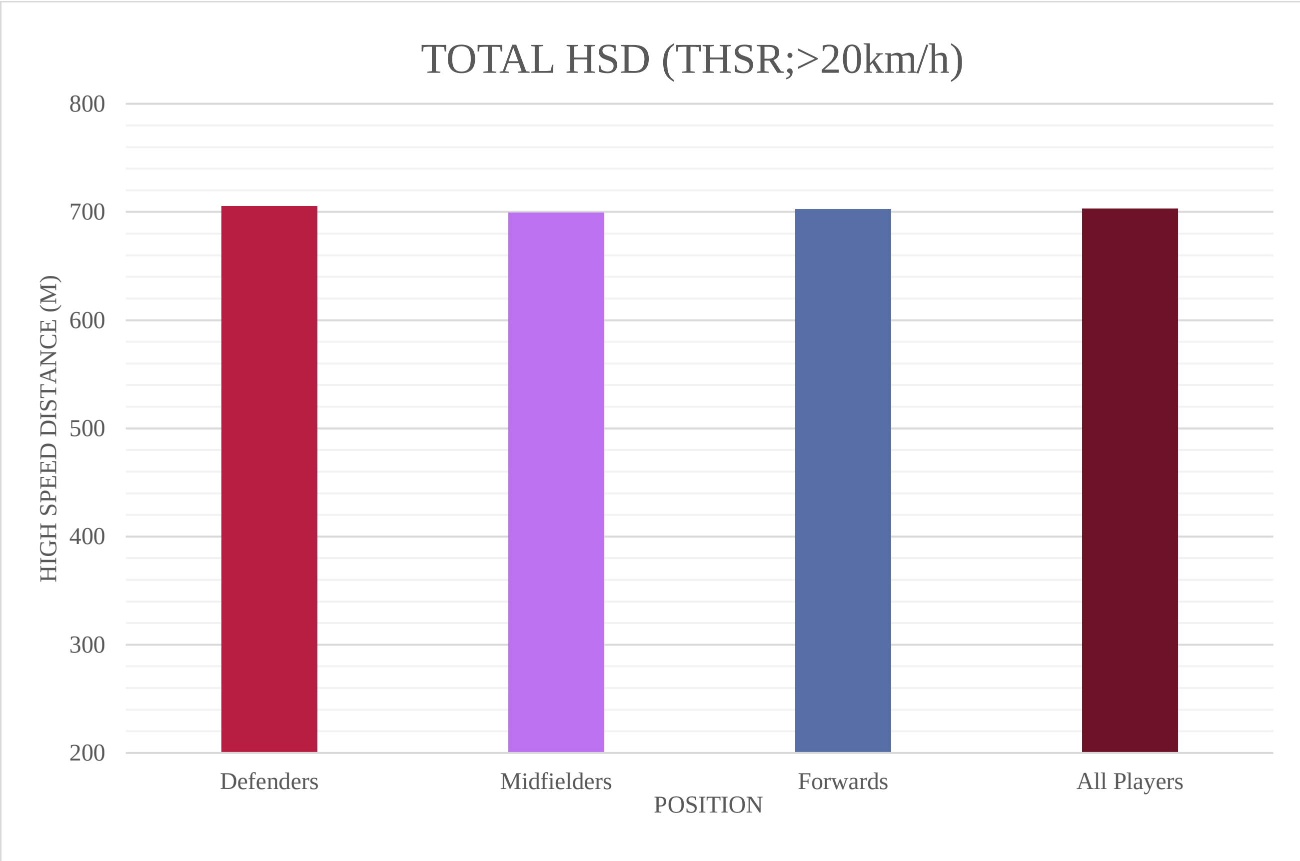


Figure 3

Average Sprint Distance Across Player Positions

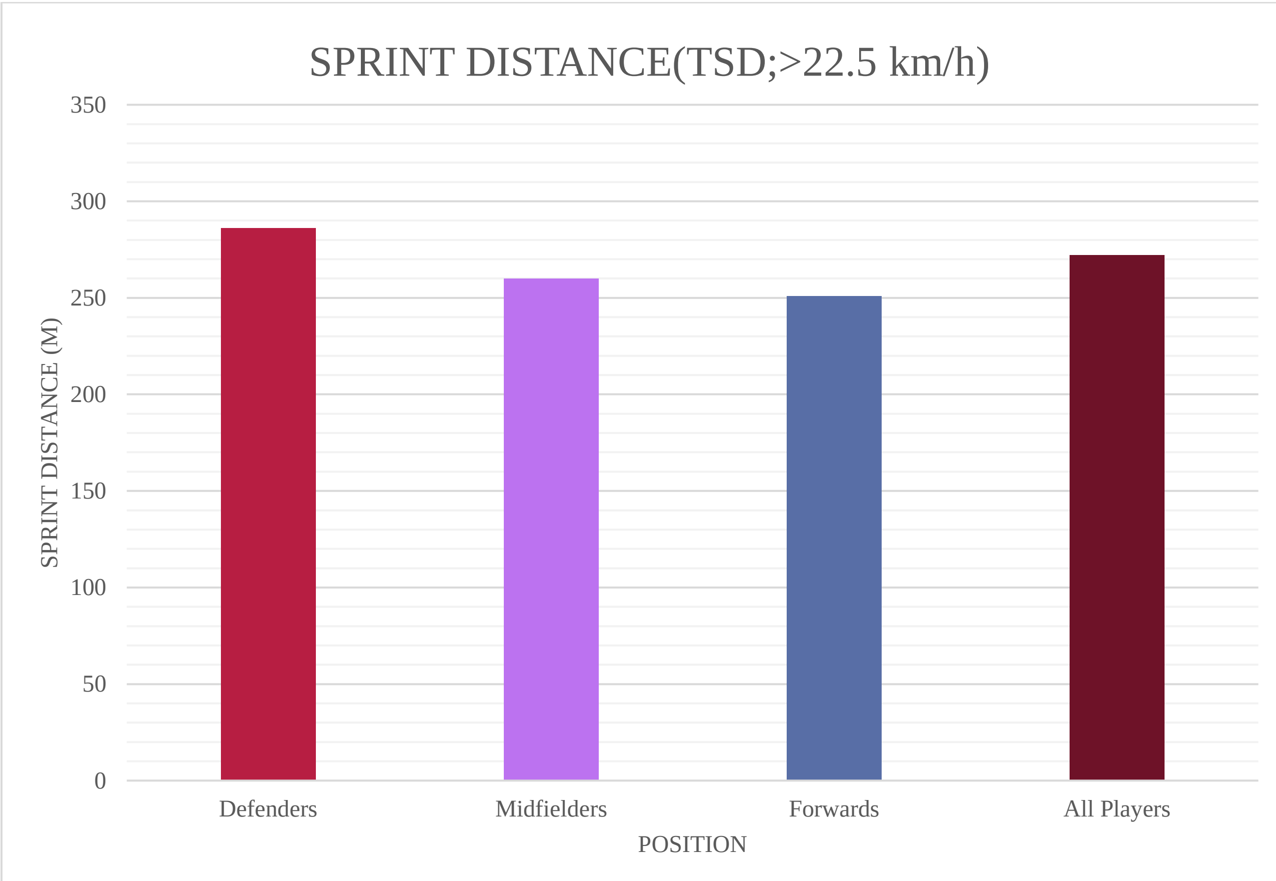
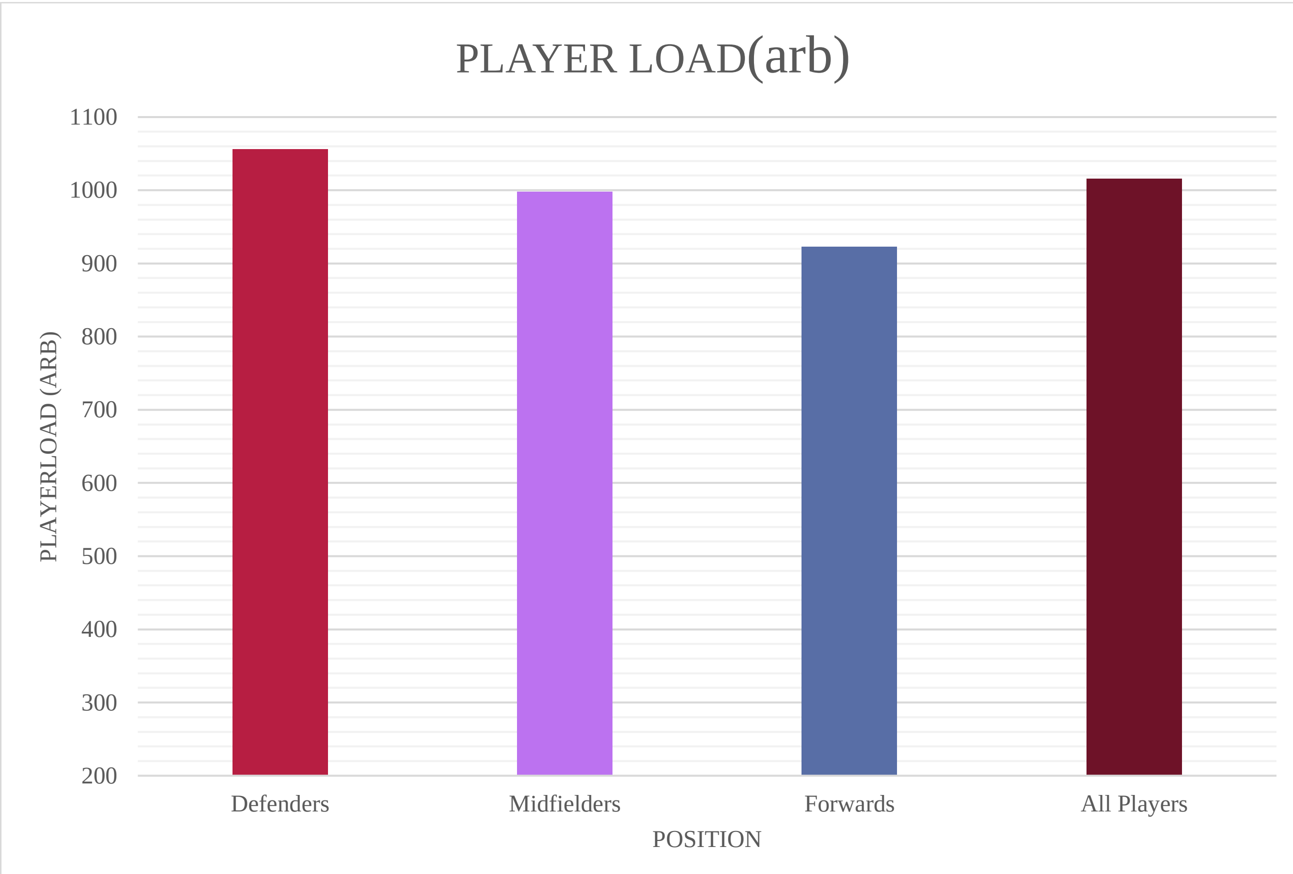


Figure 4

Average Player Load Across Player Positions



Further, average HSD and PL for defenders, midfielders, and forwards were averaged per game across the season. The results are presented in Figure 5 and Figure 6.

Figure 5

Average High-Speed Distance per Game Across the Season

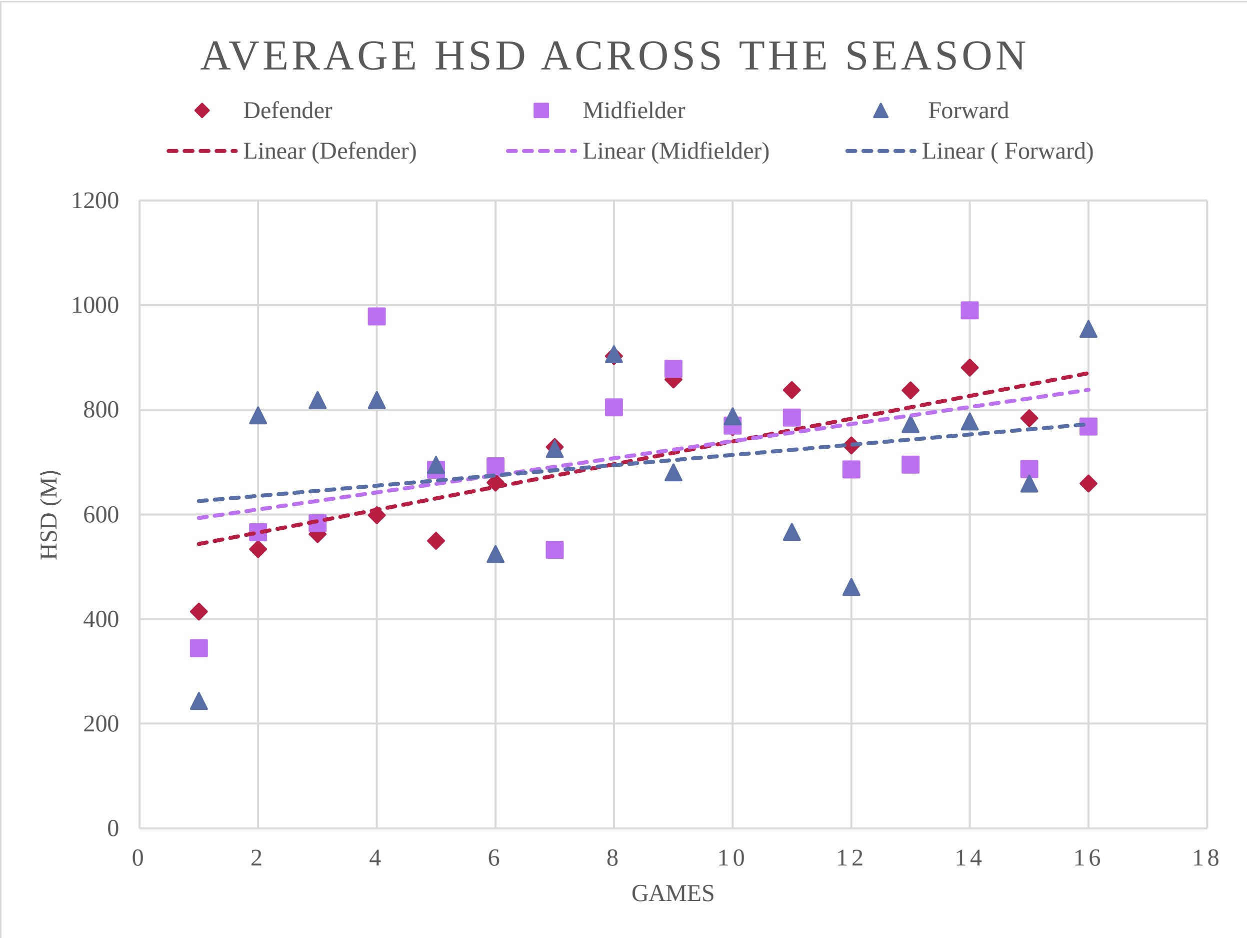
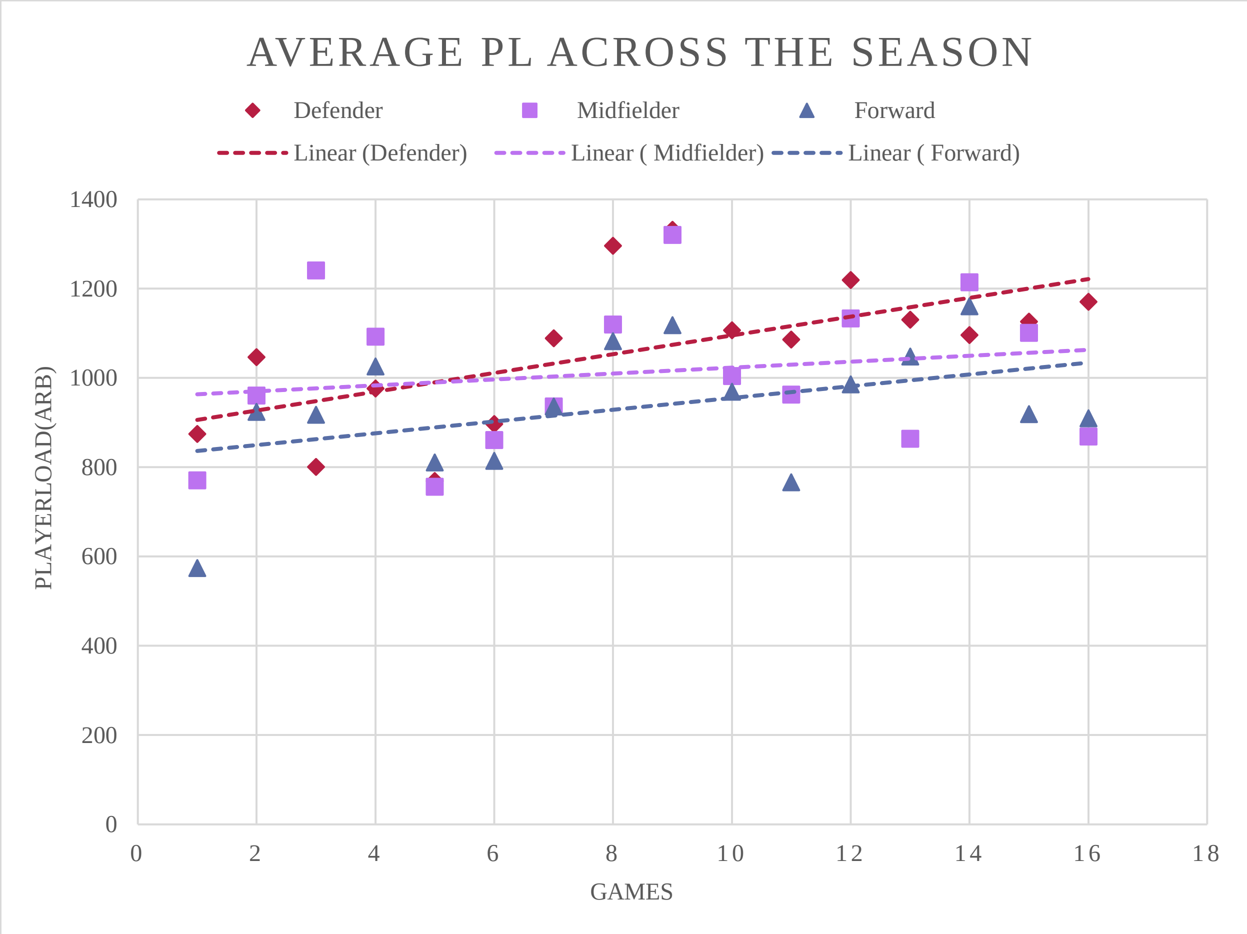


Figure 6

Average Player Load per Game across the Season



Discussion:

These findings provide some insight into the load endured by male NCAA DI soccer athletes over the course of a season. No statistical analysis was performed on the data sets. Slight positive linear trends can be observed across the season for average Pl and average HSD. One interesting takeaway that was noted is that all players over the course of the season averaged about 10,589 meters in total distance covered per game. In addition, time between games was about 109 hours. Jaspers et at., (2018) found several relationships between high cumulative total distance loads and risk of overuse injury. For example, likely harmful effects were found for high 1-week cumulative loads (>31,161m). When players are participating in about 2 games per week, averaging 10,589 meters of total distance per game, and practicing between, this could put players in a position where they are more susceptible to acquire an overuse injury. In addition, likely harmful effects were found in medium 1-week THSR (634-1,028m). When observing the averages presented in this study, players accumulated 703 meters of THSR on average per game.

There were a great deal of limitations and roadblocks over the course of this study. The most prominent limitation is that the data is being accessed 2 years after it was collected. In addition, no precise information was kept about the methods of data collection. One issue that arose from this was determining how long a player participated. As data was not kept on players playing minutes, and GPS systems may or may not have been turned off when players were subbed off, total session duration was most likely not an accurate indicator of playing minutes. However, it was the only information available. Not knowing the exact total duration of each player most likely affected the results of the averages presented in Table 1. However, data from all the players was treated the same way to maintain continuity throughout. Secondly, the accuracy of playing positions in particular games can also be questioned. Exact lineups were not input into the software. So, players that were labeled a defender at the start of the season kept that positional title throughout the season. In soccer, formations and positions can be switched in a fluid manner unlike other sports. Therefore, a player that played defender in game 1 may have played in the midfield in game 2. Sample sizes of defenders (88), midfielders (56), and forwards (27) were also vastly different. Within the boundaries of the available data, this distribution was the best estimate at the positions. Positional averages in Table 1 may not be entirely accurate because of these factors. Overall, although the precise methodology of data collection wasn't standardized, it still can provide useful insights for future researchers who attempt to investigate external load metrics in soccer.

There are many areas where this study could be improved in future research. The most glaring is that precise methodology of collection should be established prior to collecting data. This would provide much more credibility and flexibility for the data. In addition, collecting practice data in addition to game data would also be helpful to get a broader view of how much load players endure every week during the season. Further, collecting internal load values alongside external load values could also be helpful. Utilizing HR sensors, which are common in some wearable GPS systems, as well as collecting RPE, could provide useful additional insights. Lastly, collecting injury records during the season could help provide further understanding of how commonly used external load indicators may be related to injury risk.

This project provided a great opportunity for me to more fully understand research and all the work that goes into it. As someone with little background in data analysis and GPS systems, I quickly realized that this project was going to be a great deal of work. However, I could not think of a better way to end my undergraduate career than delving into literature and acquiring knowledge with autonomy and freedom. I am incredibly grateful for this experience and to those who made it possible.

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Appendix A: Exemption Approval

Office of Research Administration
Akron, OH 44325-2102

NOTICE OF APPROVAL

Date:	8/16/2021	
To:	Colton Dowd	
From:	Kathryn Watkins	Associate Director and IRB Administrator
IRB Number:	20210701	
Title:	Comparison of External Load Patterns Over a Season in Soccer Players	

Approval Date: 8/16/2021

Thank you for submitting your Request for Exemption to the IRB for review. Your protocol represents minimal risk to subjects and qualifies for exemption from the federal regulations under the category below:

- ☐ **Exemption 1** – Research conducted in established or commonly accepted educational settings, involving normal educational practices.
- ☐ **Exemption 2** – Research involving the use of educational tests, survey procedures, interview procedures, or observation of public behavior.
- ☐ **Exemption 3** - Research involving the use of benign behavioral interventions in conjunction with the collection of information from adult subjects through verbal or written responses (including data entry) or audiovisual recordings, and subjects have prospectively agreed to the intervention.
- ☑ **Exemption 4** – Research involving the collection or study of existing data, documents, records, biospecimens specimens, pathological specimens, or diagnostic specimens.
- ☐ **Exemption 5** – Research and demonstration projects conducted by or subject to the approval of department or agency heads, and which are designed to study, evaluate, or otherwise examine public programs or benefits.
- ☐ **Exemption 6** – Taste and food quality evaluation and consumer acceptance studies.
- ☐ **Exemption 7** – Research involving the use of a broad consent for the storage or maintenance of identifiable information and/or biospecimens for future research.
- ☐ **Exemption 8** – Research involving the use of a broad consent for the use of identifiable information and/or biospecimens for future research.

Annual continuation applications are not required for exempt projects. If you make changes to the study's design or procedures that increase the risk to subjects or include activities that do not fall within the approved exemption category, please contact the IRB to discuss whether or not a new application must be submitted. Any such changes or modifications must be reviewed and approved by the IRB prior to implementation.

Please retain this letter for your files. This office will hold your exemption application for a period of three years from the approval date. If you wish to continue this protocol beyond this period, you will need to submit another Exemption Request. If the research is being conducted for a master's thesis or doctoral dissertation, the student must file a copy of this letter with the thesis or dissertation.

☐ Approved consent form/s enclosed

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