Are Catapult One GPS Metrics Associated with Soccer Field Test Performance in Female Collegiate Soccer Players?

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ABSTRACT

BACKGROUND & PURPOSE: Global positioning systems (GPS) are becoming increasingly popular in field-based sports such as soccer, with many soccer programs, clubs, and teams utilizing this technology to optimize training and athletic performance. One of the primary uses of this technology is for monitoring player load; however, it is unknown if GPS performance metrics are associated with soccer player athletic performance assessed by common soccer fitness tests. The purpose of this study was to explore the utility of the Catapult One Sports GPS tracking system (Commonwealth Scientific and Industrial Research Organisation; Melbourne, Australia) in the assessment and monitoring of collegiate women's soccer players' athletic performance by exploring associations between Catapult One metrics (accelerations, power score, power plays) and common field assessments of soccer fitness (Yo-Yo intermittent recovery test level 1, 300-yard shuttle test, repeated sprint test). METHODS: Thirty-one female National Collegiate Athletic Association Division 1 soccer players (20.6 ±1.5 years) were analyzed for this study. Data collection took place over two weeks during the preseason. The Yo-Yo intermittent recovery test level 1 (Yo-Yo IR-1) was performed as the very first action of the official preseason followed by the 300-yard shuttle and then the repeated sprint ability test with five days between fitness tests. Each player wore a vest with a GPS pod placed between the scapulae. Accelerations are actions where the player accelerates at 3 m/s/s for at least one second. The power score is the total count of the athlete's accelerations, decelerations, and sprints. A power play is an explosive action where the power output exceeds 20 W/kg for over one second. Pearson product-moment correlations were used to explore the strength of associations between Catapult metrics and field-based fitness tests. Correlation coefficients were defined as small (r = .1-.29), medium (r = .3-.49), and large (r =.5-1). Statistical significance was set at $p < 0.05$. RESULTS: Sixteen players dropped out due to illness or injury. Acceleration count ($r = .959$, $p = .000$), power score ($r = .685$, $p = .000$), and power plays ($r = .931$, $p = .000$) each had large associations with the Yo-Yo IR-1 (22.54 ± 5.46 levels; $n = 28$). Three-hundred-yard shuttle test performance (59.69 ± 2.96 seconds; $n = 17$) was negatively associated with acceleration count ($r = -.589$, $p = .000$) and power plays ($r = -.827$, $p < 0.01$), while no significant relationship was observed with power score. Repeated sprint test performance (2.75% ± 1.49 % change in speed; $n = 15$) was not associated with any of the GPS metrics ($p > .05$). CONCLUSION: Catapult GPS metrics were largely associated with the Yo-Yo IR-1 and 300-yard shuttle test performances with power plays demonstrating the strongest relationship with women's soccer fitness. These data suggest that soccer athlete fitness can be monitored using the power play metric from the Catapult GPS tracking system. Future research should consider exploring these relationships across a regular season when changes in fitness typically occur.

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LIST OF ABBREVIATIONS AND TERMS

Abbreviation/Term	**Definition**
Collegiate	Player that competes in the NCAA or NAIA
Professional	Player in a recognized professional league
Elite	Player at the highest division in their country
World Class	Player regarded as one of the best in the world
International	Player playing for their country, not club
Yo-Yo IR-1	Yo-Yo Intermittent Recovery Test Level-1
RSA	Repeated Sprint Ability

CHAPTER 1

INTRODUCTION

GPS tracking systems are commonly used today because these devices offer a wide range of applications for managing fitness, enhancing performance, as well as predicting fitness (Catapult One, 2021)). Various sports teams, specifically soccer, undergo anaerobic field testing at the start of a season to gauge match fitness. The Catapult One GPS tracking system provides various key metrics that are critical to providing coaches or athlete's information to predict performance and anaerobic capacity. A problem with this information is that general coach does not contain the knowledge to analyze and interpret it without the proper resources. This can create problems with interpreting the data for players as well as correlating the data from anaerobic field tests or activities to anaerobic performance. This research aims to identify the best Catapult metrics, through the utilization of anaerobic field tests, to predict anaerobic performance.

Catapult One was started to give sports organizations the most accurate up-to-date GPS tracking measurements in fitness. Fitness, for this research study, primarily refers to aerobic and anaerobic capacity. Aerobic fitness is the body's ability to take oxygen and use it to produce energy for muscular contraction. Aerobic fitness is predominantly measured through a graded exercise test to get a maximal VO_2 value. The VO_2 max is the maximum rate of oxygen consumption. Anaerobic capacity is the maximal amount of ATP resynthesized during anaerobic processes during a short-durational maximal exercise event (Green & Dawson, 1993). Recent research has shown that throughout a soccer match, anaerobic capacity is more of a limiting factor than aerobic fitness (Wells et al., 2012). The main difference between professional and semi-professional soccer players is the level of division and rate of pay. Professionals will play in the highest division leagues of that country while maintaining a full-time salary. Semi-professional players receive payment for playing; however, they do not devote their full time to soccer. When comparing semi-professional soccer players to professional players, the performance data derived from field-based tests identified significant differences between the professional and semi-professional players (Wells et al., 2012). This suggests that professionals are more fit than semi-professionals when observing field-based tests that incorporate soccer-specific movements. This suggests that cardiorespiratory or aerobic factors are not the best determinants of soccer performance when compared to sport-specific movements.

Anaerobic performance is established to have a significant impact on soccer fitness and is different than aerobic performance which may reflect different performance capabilities (Meckel et al., 2009). Studies have investigated reliable and valid anaerobic field tests and have incorporated Catapult One into studies, but there has been a disconnect in correlating these field tests to Catapult metrics (Johnston et al.,2014; Varley et al., 2012). The inability to fully interpret the data and Catapult metrics can lead to a less efficient training design plan. This, in turn, could be consequential to the athlete’s load management and conditioning.

Given the lack of research correlating GPS tracking systems with anaerobic field tests, this study aims to bridge the gap between the two to form less complicated methods to assess anaerobic fitness in collegiate soccer players. This study aims to assist collegiate soccer coaches and athletes to utilize Catapult metrics in place of soccer-specific field tests. The objective of this study is to identify anaerobic metrics within the Catapult One GPS system that are associated with soccer-specific anaerobic field tests using a Pearson product-moment correlation. These objectives and aims are combined to answer the question, which Catapult metric(s) best correlates with soccer-specific anaerobic field tests in female collegiate soccer players?

This study will benefit collegiate-level soccer teams, in assessing anaerobic performance as efficiently as possible. Teams that use the Catapult One GPS tracking system and perform anaerobic field tests at the beginning of their competitive season will be able to easily identify the best metrics and interpret that data for their own use. Teams will also recognize that the tests utilized in this study will be excellent, due to the tests having been proven reliable and valid. As a result, athletes will not have to perform numerous maximal anaerobic performance field tests to predict their anaerobic capacity.

The purpose of this study is to better understand the utility of GPS tracking in the assessment and monitoring of collegiate women's soccer players' athletic performance by determining the association between Catapult metrics (accelerations, power score, power plays) and common assessments of soccer fitness (Yo-Yo intermittent recovery test level 1, 300-yard shuttle test, repeated sprint test). Based on each field tests design and the formula for each Catapult metric, the following hypotheses were developed:

1. The Yo-Yo Intermittent Recovery Test Level 1 (Yo-Yo IR-1) evaluates an individual's ability to repeatedly perform intervals over a prolonged period. Power plays and power scores will have a large positive correlation with the level of Yo-Yo IR-1 test as they represent variables such as accelerations, sprinting characteristics, and recovery.
2. The Repeated Sprint Test is a test of anaerobic capacity and the ability to recover between sprints and produce the same level of power repeatedly. It was hypothesized that

performance on this test will have a large and positive association each with power plays and power score

3. The 300-yard Shuttle tests anaerobic capacity as well as the ability to recover. Power plays and power scores will be largely and negatively associated with 300-yard shuttle performance. Accelerations will not produce a significant association.

CHAPTER TWO

LITERATURE REVIEW

Anaerobic metrics from the Catapult One system are being compared with soccer-specific field tests to assess anaerobic performance. This review contains information on the components of soccer: Tactical, Technical, and Fitness. However, the focus will be on the fitness component. This information will comprise of aerobic and anaerobic aspects of soccer fitness with the majority being detailed on anaerobic fitness. Each fitness test in order: Yo-Yo Intermittent Recovery Level 1 Test, 300- Yard Shuttle Run Test, Repeated Sprint Capacity Test will be investigated to ensure the test's validity and reliability. Likewise, the fitness tests, the Catapult Instrumentation will be investigated next to ensure the technology's validity and reliability. The last part of the literature review will cover the three different Catapult Metrics that were used for the correlations: Accelerations, Power Plays, and Power Score.

Components of Soccer

The game of soccer is broken down into three general components: tactical, technical, and fitness. Athletes must excel in all three components to achieve the highest level of soccer performance. A general understanding of the technical and tactical aspect will be provided, with a more detailed explanation of soccer fitness that discusses the role of aerobic and anaerobic fitness in soccer performance.

Tactical Component

The tactical component of soccer can be described broadly as soccer intelligence. Tactical skills combined with cognitive processes of players influence decision-making during games. Tactical principles are further defined as a set of norms that provide players the possibility of rapidly achieving solutions for problems that arise in the situations they face (Da Costa et al., 2009). Numerous situations arise during a game where the pace, frequency, and complexity of tactical situations cannot be accurately predicted. These situations demand that each player and coach possess the ability to adapt to each phase of the game. The phases of a soccer game are generalized into offense, defense, transitioning to offense, and transitioning to defense. The opposition adapts to each phase of the game in real-time, adding another adaptation component. As a soccer match progresses, each team's tactics become more evident through key game situations. Players and coaches can observe these tactics through the spatial organization of the players with respect to ball movement and the reactions of teammates and opponents (Duprat, 2007). "Within the team, players must conform to not only the tactical plan of the team but account for the tactical playstyle of each player. An analysis of tactical behaviors demonstrated that within the playing positions of outside backs, center backs, midfielders, and forwards, distinct behaviors affect the individual playstyle (Taylor et al., 2005).

Technical Component

The technical component of soccer refers to the skill-related performance of players. Technical skills such as ball possession, shooting, and dribbling, are considered critical to soccer performance and success (Huijgen et al., 2009). The velocity and accuracy of dribbling are of great importance in crucial moments of the game (Huijen et al., 2009). A multidisciplinary approach to talent identification in elite soccer players found that the most discriminating of technical proficiency were agility, sprint time, ego orientation, and anticipation skill while dribbling the ball. These skills complemented the study's conclusion that elite players are not significantly better at shooting the ball but are significantly better at dribbling the ball (Reilly et al., 2010). Dribbling the ball consists of a mixture of changes in direction, acceleration, and deceleration. Since soccer is a highly dynamic sport that consists of high-intensity intermittent moments, speed of recovery is vital to minimizing the risk of playing errors while dribbling(Bangso et al., 1994). Therefore, physical fitness plays a supporting role in the execution of technical skills valuable to soccer performance. Game analyses show that soccer requires a highly complex hybrid of physical fitness abilities including high aerobic and repeated sprint capacity, muscular strength and endurance, speed, agility, quickness and flexibility (Bloomfield et al., 2007).

Fitness Component

Aerobic and anaerobic components are two major aspects of soccer performance and both are important to determine whether a player can maintain the pace and frequency of the game. The balance between aerobic and anaerobic power is important in evaluating elite soccer players (Sporis et al., 2009). Soccer is predominantly an aerobic game with anaerobic energy being essential to high-intensity runs and sprints (Stolen et al., 2005). The game of soccer demands that players be proficient in both terms of aerobic and anaerobic fitness, with research attributing anaerobic components of high importance for overall performance (Al-Hazzaa et al., 2001).

Aerobic Fitness in Soccer

To be successful at a professional soccer level , a player must have a high aerobic capacity (Stolen et al., 2005). Soccer games consist of long-term running with lots of brief actions such as sprinting and jumping throughout the gameVO_2 maximal testing is the most common measure of aerobic fitness in soccer where players cover large distances throughout a game. Heart rate and body temperature measurements suggest that for elite soccer players the average oxygen uptake during a match is around 70% of the maximum oxygen uptake (Bangso et al., 2007). Traditional means to measure aerobic fitness have centered on the VO_2 max test; however, this has been shown not to be a sensitive measure for specific aspects of soccer in a match situation (O'Reilly et al., 2012). While aerobic fitness is important to maintaining the pace of the game, research indicates it is not a determinant of match fitness. Investigating VO2 max values ranging from lower divisions in professional soccer to the highest divisions in professional soccer showed no significant differences in VO_2 max (Haugen et al., 2014).). However, aerobic fitness is still an important factor in soccer performance. 9 players from Notre Dame's women's soccer program underwent a Bruce protocol test where they reached a VO_2 max of 42.2 ± 4.9 ml/kg/min (Clark et al., 2003). Compared to another division 1 program, Texas A&M, 26 female players underwent the same Bruce protocol test, reaching a VO_2 max of 44.87 ± 4.61 ml/kg/min (Miller et al., 2007). According to the American College of Sports Medicine, the range of VO2 scores for both female collegiate programs classify them in upper range of the "Good" category in the 75th percentile range (ACSM, 2013). The results from the ACSM classification shows that aerobic fitness is still important to soccer fitness. This research shows that across different sexes, players at the collegiate level to professional level possess a largely indistinguishable VO_2 max and peak aerobic fitness level.

Anaerobic Fitness in Soccer

Anaerobic capacity is the maximal amount of ATP resynthesized via anaerobic metabolism (by the whole organism) during short-duration maximal-intensity exercise (Green & Dawson, 1993). Soccer players must be able to recover quickly from short, intense bursts of energy to maintain pace during critical game moments. On average, a player completes 150-250 short, high-intensity actions during a single game (Bangsbo et al., 2007). These actions are crucial for the developmental process in those aspiring to reach the professional level., Professional players sprint more often and sprint at higher intensities than player of lower skilled levels. Elite international players participate in approximately 28% more high intensity running (2.43 km vs 1.9 km) and 58% more sprints (650 m vs 410 m) than average professional soccer players (Evangelos et al., 2016). Similarly, world class players performed more high-intensity running during a game and performed better at the Yo-Yo test than moderate professional players (2.26 ± 0.08 vs 2.04 km) (Mohr et al., 2003). Male professional soccer players outperform lower-level professionals in soccer-specific movements but largely share the same peak VO_2 max (Wells et al., 2012). For this reason, it would be better to test professional soccer players in soccer-specific movements rather than a graded exercise test for VO_2 max. Professional soccer players significantly differ in anaerobic performance rather than aerobic performance (Wells et al.,2012).

Assessing Soccer Fitness

One must incorporate sport-specific movements that players undergo throughout a match when assessing anaerobic fitness. Players' high-intensity movements are positively associated with their anaerobic energy pathways (Castagna et al.,2006). Research demonstrates that the outcome of a match may be determined by the anaerobic capacity of players, thus making it a valuable component of the comprehensive assessment of athlete fitness (Bangsbo et al., 2008). When investigating short-distance sprinting speed and power in amateur and professional players, professional athletes differed significantly with an increase in these variables compared to amateurs (Cometti et al., 2001). Research concludes a higher level of strength and power variables is preferable to excel at a high level of soccer (Wisloff et al., 1998). In a study comparing professional Greek soccer players to the U-21 and U-17 players of the same club, it was found that professionals presented significantly higher values in a standard jump and a countermovement jump compared to U-21 by 11.3% and 10.5% and U-17 by 10.5% and 9.4%, respectively (Papaevangelou et al., 2012).

Acceleration and power are great predictors of soccer performance and are necessary to excel at the professional level (Kaplan et al., 2009). Acceleration is anytime the body speeds up or when the velocity increases. Given the number of times throughout a soccer match the player will change direction, acceleration is important to speed performance in the sport. Comparing top German professional to amateur players at 30-m sprint tests, professional players were significantly faster than amateur, even at 10 meters (Kraemer et al., 2002). With the average distance of sprinting during a match being 15-17 meters, this research shows that quick acceleration at the start must be given more emphasis rather than top speed at the professional level (Kraemer et al., 2002). Power is how much force and velocity a player exerts at any given moment. Increasing the force or velocity of muscular contraction in the lower leg muscles, critical soccer skills such as sprinting, jumping, or accelerating may improve (Bangsbo, 1994).

For these reasons, soccer-specific tests have been created to have the most accurate measurements to gauge soccer fitness. The Yo-Yo Intermittent Recovery Test Level 1 (YIRT-1) evaluates a player's ability to repeatedly perform intervals over a prolonged period. The 300-yard shuttle test is designed to evaluate an athlete's speed and agility. The repeated sprint ability test (RSA) measures the resistance to fatigue and the ability to recover. These three tests have all been used to predict anaerobic components in from collegiate to professional level soccer players (Bangsbo et al., 2008; Gottlieb, 2015; Ivanjko et al., 2005).

Yo-Yo Intermittent Recovery Test Level-1

The aim of the YIRT-1 is to examine physiological demands that relate to real-time situations a player faces during a match like bursts of acceleration, change of direction, and sprinting. This test is utilized to assess soccer players' anaerobic capabilities across varying overall skill levels (collegiate to pro) (Rampinini et al., 2012). Landmark research conducted by the leaders in anaerobic performance in elite soccer players found a significant correlation between Yo-Yo test performance and time to fatigue in an incremental running test ($r=0.79$, $p<0.05$) and maximal oxygen uptake ($r=0.71$, $p<0.05$) (Krustrup et al., 2003). In addition, the test had a high sensitivity allowing for a detailed analysis of differences. The major findings in the study demonstrated that the Yo-Yo test had high reproducibility and performance was closely related to soccer match performance (Krustrup et al., 2003). The reliability and application of the Yo-Yo test has been evaluated by utilizing elite Scandinavian soccer players (N=117). Testing and retesting of the Yo-Yo test in 117 elite professional men's soccer players found that the Yo-Yo IR test has a high reproducibility and sensitivity (Krustrup et al., 2006). The players complete the Yo-Yo IR-2 on two to four occasions with each test being at least 48 hours apart. The intra-individual difference between the two Yo-Yo tests performed were found significantly different with the international elite soccer players covering more distance than the moderate elite players (1059 ± 35m vs 771±26m). The coefficient of variation was 9.6%. The Yo-Yo performance was associated with intermittent treadmill performance protocol ($r = 0.74$, $P < 0.05$) and VO_2 max ($r = 0.56$, $P < 0.05$) (Krustrup et al., 2006). There was a stronger correlation comparing the intermittent treadmill protocol to the Yo-Yo test rather than VO_2 max. Individual differences in the performance of athletes in sports that involve intermittent exercise can be examined with a variation of the Yo-Yo test.

Three Hundred-yard Shuttle Test

Field-based team sports contain repeated maximal efforts with rest varying in length in between. The repeated maximal efforts put high physiological demand on athletes, specifically their anaerobic capacity. One of the possible indicators of training levels is a speed stamina assessment which the 300-yard shuttle test meets the criteria. Research shows that a better result in the 300-yard test and a higher level of maximal lactate, means a higher level of training readiness for soccer-specific movements (Ivanjko et al., 2005).

A study investigating the test-retest reliability of the 300-yard shuttle was conducted on field-based team sports such as Rugby, Basketball, or Tennis that involved movements pertaining to anaerobic capacity. Seventeen American soccer players participated in this study where they performed a 300-yard shuttle test. The players performed 6 back and forth shuttles for a total of 12 sprints between two markers placed 20 meters apart. The test-retest showed an intraclass correlation of 0.97 and concluded the 300-yard shuttle test was reliable (Gottlieb, 2015).

Another study explored the reliability of a field anaerobic shuttle test. Twenty-six male and female collegiate and professional soccer players participated in this study (Thomas et al., 2002). The shuttle test was performed in a gymnasium where the participants ran between two makers set 20 meters apart. The participants then ran as fast as possible 12 times, 6 times back and forth, with quick stops and starts that mimic soccer-specific actions throughout a match. These soccer-specific actions followed the standard 300-yard protocol just in an indoor setting. An intraclass reliability coefficient was found to be acceptable for the field anaerobic sprint test with a value of .96 (ICC = .96) (Thomas et al., 2002). This study shows that this version of the anaerobic shuttle test is found to be reliable.

One study's aim was to examine the construct validity of a variation of a standard anaerobic shuttle test with soccer players. Thirteen professional male soccer players from a Norwegian first division team(elite players in the highest division league in Norway) participated in this study. The anaerobic shuttle test, called the INTER test, consisted of multiple repetitions, with the players running between two markers placed 20 meters apart a total of six times back and forth (Aandstand & Simon, 2013). These players were tested initially, and then re-tested seven days later. There was no significant correlation between exercise tolerance time in the INTER test and VO_2 max ($r = 0.49$, $P = 0.16$) as well as no significant correlation in exercise tolerance time or distance covered ($P = 0.15$) between the INTER test and retest (Aandstand & Simon, 2013). This indicates that the INTER test reflects other fitness components rather than the laboratory determined VO_2 max in professional male soccer players.

Repeated Sprint Capacity

The Repeated Sprint Capacity test examines a player based on their ability to recover and anaerobic capacity. One study conducted investigated ways to further develop and increase reliability and validity in a repeated sprint ability tests for professional women's soccer players. Nineteen elite professional women's soccer players in the Australian league participated in this study. Players completed a repeated-sprint test consisting of 6 x 20-meter maximal effort sprints and at the completion of each sprint, players performed a 10-meter deceleration and a 10-meter active jog recovery (Gabbett, 2010). A significant relationship ($r = 0.96$, $p < 0.001$) was discovered between the 20-meter sprint time on the first repetition of the repeated-sprint test and total repeated sprint time (Gabbett, 2010). In addition, the validity of the RSA protocol was tested by investigating differences between players at different professional divisions of women's soccer. It was found that the repeated-sprint test was valid in discriminating between the players of different skill levels in that the more skilled players had significantly lower ($p < 0.01$) total repeated-sprint times than the lower skilled players (20.9 ± 0.5 s vs. 23.3 ± 0.4 s) (Gabbett, 2010). These skill levels ranged from players from the immediate first division team to players of the same club at a lower divisional level. To determine test reliability, 10 of these professional women's soccer players performed the test on two occasions with 7 days of no repeated-sprint tests in between. It was found that the total sprint time proved to be highly reproducible (ICC = 0.91; TE = 1.5%) (Gabbett, 2010). The results demonstrate that the developed repeated-sprint test offers a reliable and valid method of assessing repeated sprinting ability in professional female soccer players.

Oliver et al. developed a laboratory protocol to assess the reliability and validity of prolonged repeated-sprint ability during soccer-specific exercise. On a non-motorized treadmill, 12 soccer players completed a protocol that was designed to replicate the demands of competing in one half of a soccer match while monitoring sprint performance. The protocol successfully recreated the repeated sprint ability demands that players underwent in a soccer match (Oliver et al., 2007); however, the sample population of 12 soccer players is a study limitation. The mean coefficient of variation was 2.5 % for the total distance covered and 3.8% for the total distance sprint (Oliver et al., 2007). One study differed from those previously mentioned in that the researchers measured mean sprint time rather than total sprint time. Utilizing a repeated sprint ability protocol, male soccer players completed this protocol on six separate occasions for the purpose of testing reliability and validity. When comparing mean sprint time to total running time, the correlation coefficient was deemed not significant. However, in conclusion, it was found that the soccer-specific field test demonstrated high reliability (CV= 1.8%) (Wragg et al., 2000). When comparing the mean sprint time in the repeated sprint test and total running time in the laboratory protocol had a correlation coefficient of r = -0.298 (P = 0.516) (Wragg et al., 2000). This suggests that the two tests involved are not closely related which largely means the energetics involved are different. Protocols of repeated soccer-specific sprint tests, whether in a laboratory setting or field setting, demonstrated that soccer-specific types of repeated sprint tests contain overwhelming reliability and validity and are accurate measures of assessing anaerobic capacity in soccer players.

Catapult One GPS System

The importance of collecting and analyzing the movement demand data of team sport athletes during training sessions and matches has been established (Coutts et al., 2010; Di Salvo et al., 2007; Sirotic et al., 2009). GPS tracking systems are crucial to improving team performance. Movement demands such as distance covered and high-speed running have demonstrated a relationship to the match performance of individuals and whole teams (Johnston et al., 2012). Throughout the season, soccer teams practice daily as well as have many games that results in a lot of data. GPS tracking systems can utilize this data to elevate team performance. GPS tracking systems, specifically Catapult One, are utilized for sports not only relating to soccer. Catapult One covers a diverse selection of sports that all revolve around anaerobic components such as basketball, rugby, or cricket (Catapult, 2021). The Catapult One GPS tracking system has trackers, or pods, which can record measurements at 10 Hz for widespread GPS coverage. For this reason, any type of Catapult product used needs to include the same technology that this specified product must record measurements at 10 Hz.

A pilot study required participants to complete a team sport circuit which enabled the assessment of 10 Hz and 15 Hz GPS units (Catapult Innovations) under sport-specific actions. The findings of this study revealed that 10 Hz GPS units were a valid and reliable measure of total distance and average peak speed. When compared to the 1 Hz, 5 Hz, and 15 Hz models, the 10 Hz proved to have improved measures of movement demands with greater validity and interunit reliability (Johnston et al., 2014). Compared to other leading GPS tracking systems like FieldWiz, there were no significant differences in the error of measurement for distance covered and peak speed. Furthermore, it was established that both systems, 10 Hz units, were deemed reliable and valid across sport-specific testing (Willmott et al., 2019). One study compared the measurement accuracy of the 10 Hz Catapult tracker units to a 50 Hz radar gun to measure maximum sprint velocity. Based on the findings, both provided valid and accurate measures of the 40-m Vmax sprint assessment. There was a typical error of estimate of 1.7% between the measures; however, this error was found to be small and not significant (Roe et al., 2017).

Catapult One Metric - Accelerations

High-velocity running distance is a valid measure of physical performance since it is associated with a higher standard of play with world class professional soccer players covering 28% greater in-game distance than moderate-level counterparts (Mohr et al., 2003). Acceleration is the rate of change in velocity and physically demanding activity to perform repeatedly. Accelerating is more energetically demanding than constant-velocity movement (Osgnach et al., 2010). In a maximal 5-second sprint, only half of the total work is achieved within the first 1.5 seconds, but a peak power output that is 40% greater than the average power output is reached after only half of a second (Di Prampero et al., 2005). "During a maximal 5-s sprint, not only is 50% of the total work achieved within the first 1.5-s, but a peak power output (W*kg^-1) 40%

greater than the average power output is obtained after only approximately 0.5s" (Di Prampero et al., 2005). This research demonstrates that acceleration demands a great usage of energy only part of the way through a maximal sprint. Furthermore, it was found that performing an acceleration from the lower velocity can match or surpass the power output that is required to maintain the higher velocity (Osgnach et al., 2010). Based on the research, it can be concluded that accelerating is not only a metabolically demanding task, but a player does not need to be at a high velocity to be physically challenging (Varley & Aughey, 2013). From a soccer standpoint, it can be shown that accelerating is just as crucial or more crucial than velocity when investigating the anaerobic capabilities of elite soccer players.

Catapult defines an acceleration bout based on research that assessed acceleration-based running intensities of professional rugby league players during matches (Duthie & Delaney 2015). Acceleration threshold was set the same for every soccer position and there are currently no sport-specific recommendations for setting Catapult acceleration threshold values. While this is helpful for calculating match data, this conclusion would have no effect on a controlled anaerobic-based protocol or test. From this study, Catapult developed a method to determine what qualifies as an acceleration. For Catapult, acceleration is quantified by the measurement of meters per second per second (m/s/s), as it is the first derivative of velocity (m/s). Accelerations are a simple count of the number of times that an athlete's acceleration is greater than the acceleration threshold for at least 1 second (Catapult, 2021). Users can customize the threshold to meet the needs of their sport and athlete.

Catapult Metric - Power Score

Explosive type efforts such as sprinting, jumping, and kicking are essential to overall soccer performance. These explosive efforts depend on the maximal strength and anaerobic power of mostly the lower limbs (Cometti et al., 2001). Anaerobic power refers to the maximal power or work overtime that is developed during an intense, maximal short-term physical effort. Anaerobic power reflects the energy usage of high- energy phosphates like ATP and PCr over this period. \. Research has shown that some strength and anaerobic power characteristics have differentiated elite from non-elite soccer players (Gauffin et al., 1989). Comparing the highest division in Swedish professional soccer to the lowest division, it was concluded that high-level soccer players had greater strength because training intensity increased as the division level increased (Oberg et al., 1986). Concentric isokinetic peak torque of the quadriceps and hamstring muscles was reportedly different between the divisional levels of soccer players (Oberg et al., 1986). A more recent study compiling 81 participants of senior soccer players in Portugal were divided into three distinct competitive levels (elite, sub-Elite, and non-elite) and were examined for differences in anaerobic capabilities. All participants underwent a countermovement jump and running anaerobic sprint test. The body composition across all three competitive levels was found not to be significantly different and largely homogenous; however, the performance values significantly differed. The elite senior men's players presented higher values of highest jump, maximum force produced, and greater anaerobic power. Research can be shown that elite soccer players differentiate from lower-level players in anaerobic power capabilities (Tereso et al., 2021).

Catapult calculates a power score that is based on anaerobic factors. The power score is measured in watts per kilogram of body weight. The power score is the total of the athlete’s accelerations and decelerations which are combined with the number of sprints. This gives an indication of the performance intensity level for that session (Catapult, 2021). Based on data collected at Catapult, it is concluded that power is the metric that will most likely vary the most between player and positions with professionals generally generating a higher power score than non-professional players of their respective sport. Catapult further concludes that the most explosive players have higher power scores and since soccer is a high-intensity sport, athletes should constantly be attempting to increase this metric.

Catapult Metric - Power Plays

A power play is like a power score but differs in terms of sprinting characteristics. A power play is classified as a simple count of the intense actions a player undergoes during a full match in their respective sport. A power play is a significant action where the power output recorded is above 20 watts per kilogram for more than one second (Catapult, 2021). Power plays are more physically demanding, which gives an indicator of how anaerobically fit a player currently is. Catapult concludes that the most explosive players on the field will have an elevated count of power plays when compared to players who are not as fit or technically skilled. skilled.

CHAPTER 3

METHODOLOGY

Study Design

This was a cross-sectional study that utilized secondary data and quantitative methods approach to testing the hypotheses. Player demographics (height, weight, age, sex), anaerobic field test performance (repeated spring test, Yo-Yo intermittent recovery test level 1, 300-yard shuttle test) and Catapult One GPS tracking system metrics (accelerations, power score, power plays) recorded during fitness testing were gathered from the database of the Middle Tennessee State University women's soccer team. Data collection took place across two weeks during the women's soccer preseason training on the university's outdoor soccer facility on a grass field. Data were analyzed to explore associations between soccer specific anaerobic field test performance and the Catapult performance metrics tracked during the field tests.

Participants

Thirty-one female National Collegiate Athletic Association division 1 soccer players (17-25 years) were analyzed for this study. All participants were healthy and injury free at the time of fitness testing. Players that suffered an injury or illness during the two weeks testing period were exempt from the remaining fitness testing, as determined by the head coach.

Table 1

Participant Characteristics

	Height (cm)	Weight (kg)	Age (yrs)

N=31	167.06±3.98	63.64±4.2	20.6 ±1.5

Procedures

At the start of training, all players received a tentative schedule that outlined their daily training regimen for the preseason. A typical day of preseason training consisted of a fitness session, a regular training session or practice, and either an additional practice or a preseason match against another school. All players were required by the coach to complete the three fitness tests: Yo-Yo Intermittent Recovery Level-1 Test, 300-yard Shuttle Test, and the Repeated Sprint Ability Test. These tests were performed within the first two weeks of the start of the official NCAA preseason time period. On days a fitness test was scheduled, the player's load was reduced for the remainder of the day to promote recovery. The Yo-Yo IR-1 test was performed as the very first action of the official preseason followed by the 300 Yard Shuttle test 5 days later and then the Repeated Sprint Ability test 5 more days after the shuttle. The players followed a standard recovery procedure of jogging, stretching, and any extra recovery methods such as ice baths or Normatec compression sleeves. The ice bath recovery procedure was mandatory for all players after the last training of the day with Normatec as a supplemental option for players if needed.

Before the anaerobic fitness tests were conducted, each player was equipped with a Catapult GPS tracker so that anaerobic metrics could be collected from the fitness tests to compare to the results for each player. The three anaerobic field tests were performed at the beginning of their preseason, as all collegiate soccer teams go through this process. Before the fitness tests, Catapult pods or trackers were distributed to each player for the purpose of collecting this data. Every player wore a Catapult vest and pod in the proper position according to Catapult's instruction manual (Catapult, 2021). The coaches documented the results of each fitness test and enforced rules to ensure players were not breaking the rules of the fitness tests. After being properly equipped, each player followed a dynamic stretching routine that was administered by the strength coach. After the stretching routine was completed, each participant, on separate days, performed a Repeated Sprint Test, a YO-YO IR1 test, and a 300-yard shuttle test. These three fitness tests were performed all within fourteen days of each other with regular soccer training occurring later that same day. Players practiced multiple times daily throughout this fourteen-day period. Prior to the completion of the fitness tests, players were notified on which day and which fitness test they would complete. Over this fourteen-day period, players had at least 3 days in between before they completed another fitness test. At the conclusion of the fitness tests, the data were uploaded and then extracted from the Catapult GPS tracker system and compared to players and their results. The uploaded and extracted from the Catapult system only reflects the Catapult Metrics and player demographics. The data attached from the appropriate Catapult Metric is then compared to the field fitness tests results.

The coaching staff for that season had decided that three different fitness tests were to be administered during the preseason period. The purpose of these three different fitness tests was to determine which tests were a better representation of soccer-specific fitness. In addition, these three fitness tests are very similar to other division 1 NCAA women's soccer programs fitness tests. This was another factor in the coaching staff trying to determine what fitness tests the players would perform for that season. All three fitness tests focus on player's ability to recover after a high-intensity soccer specific action.

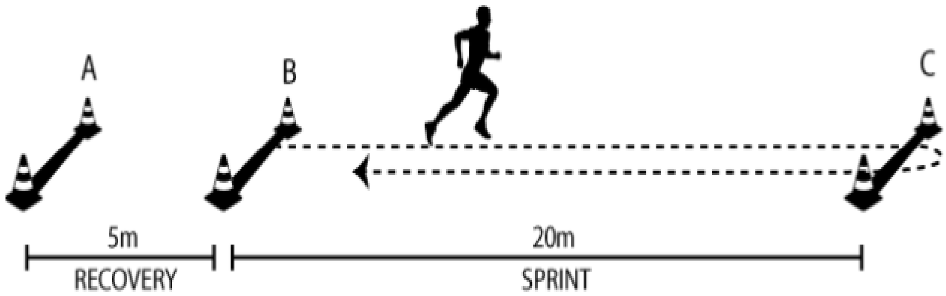
Soccer Fitness Tests

The YO-YO IR1 test

The Yo-Yo IR1 test aims to tests player's ability to recovery after a protocol of constant sprinting and changing of direction. This test is extremely popular not only among NCAA Division 1 Programs but is widely used around the world with varying professional teams. The Yo-Yo intermittent Recovery Test Level 1 (YIRT1) consists of two cones placed 20m apart, with another cone placed 5m behind the starting point (Wood, 2018). The player begins to run forward at the time of the first signal and adjusts her running speed so that the second cone, 20m away, is reached at the time of the next signal. The player turns here, and runs back to the starting cone, again timing the run so she reaches this cone at the next signal. When the starting cone is reached, the player continues forward at a slower speed and runs around the cone placed 5m behind the starting cone. The player then waits at the starting cone for the next signal and continues the cycle. The time allowed for each 20m run becomes increasingly shorter per level The course is repeated until the player is unable to maintain the indicated speed for two trials. The level at which she is unable to finish a trial for the second time is recorded. Once each participants had a recorded level from the YIRT-1 test, a correlation was completed comparing the Catapult metrics: accelerations, power plays, and power score to the level of the YIRT-1 test. *See Figure 1.* Accelerations were calculated and counted by Catapult if the participant reached an acceleration threshold rate of at least 3 meters per second per second (3 m/s/s).

Figure 1.

Yo-Yo Intermittent Recovery Test Level-1 Format

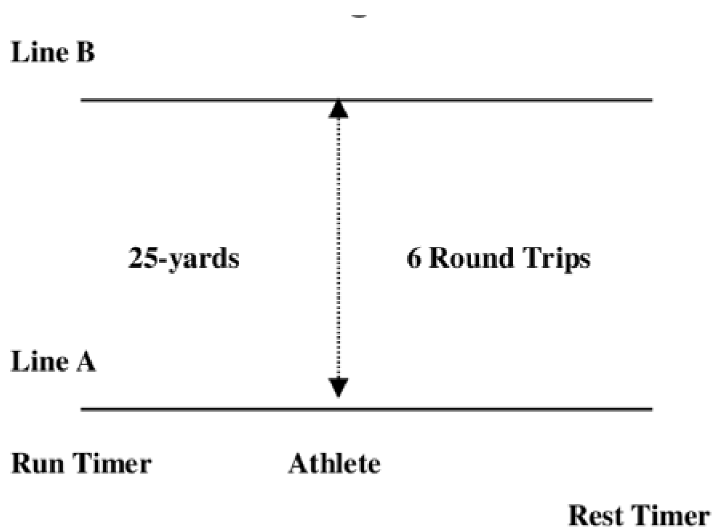


300-yard Shuttle Test

The 300-yard shuttle test is another widely popular fitness test and focuses on players constantly accelerating and decelerating while increasing their speed. The 300-yard shuttle test is a test of anerobic capacity, the maximal amount of energy that can be generated over a period. Marker cones and lines were placed 25 yards apart to indicate the sprint distance. Players started with one foot on the line (Wood, 2018). When instructed by the timer, the player ran to the opposite 25-yard line, touched it with their foot, turned and ran back to the start. This was repeated six times without stopping (covering 300 yards total). After the participants finished repeating the same sprint pattern, that would count as the first repetition. After a rest of two minutes, the next repetition began. At the conclusion of the second repetition, the participants had another 2 minutes of rest before completing a final third repetition. After each participant has completed the 3 repetitions, the average of the 3 repetitions was calculated and correlated to the Catapult metrics: accelerations, power plays, and power score. *See Figure 2.*

Figure 2

300-Yard Shuttle Test Format



Repeated Sprint Test

The repeated sprint test aimed to test player's ability to recovery after a protocol of constant high-intensity sprints. This mimics player sprinting and recovering throughout a match. Marker cones and lines were placed 30 meters apart to indicate the sprint distance. Two more cones were placed a further 10 meters along on each end (Wood, 2008). At the instructions of the timer, the subject placed their foot at the starting line, then on 'go' two stopwatches were started simultaneously, and the subject sprinted maximally for 30m, ensuring that they did not slow down before they reached the finish line. One stopwatch was used to time the sprint, the other continued to run. The time of the first sprint was recorded as the participants continued to the next phase of the test. The participants then used the 10-meter cone to slow down and turn and returned to the 30m finishing point, which then became the next start line. The second sprint that was recorded was in the opposite direction. Each 30-meter sprint started 30 seconds after the previous run started. This cycle continued until ten sprints were completed and recorded, which started at 30 sec, 1 min, 1.5 min, 2 min etc after the start of the first sprint. After this test has been completed, each participant has run 10 sprints with the recorded time for each repetition. The data was then calculated by taking the average of the first 3 sprint repetitions, the average of the last 3 sprint repetitions, and then calculation of the percent change between the average sprints for each participant. Once the percent change for each participant had been calculated, a correlation was performed comparing Catapult accelerations, power plays, and power score to of the percent change difference. *See Figure 3.*

Figure 3

Repeated Sprint Ability Format

Instruments

Catapult Playertek GPS Tracking System

A Catapult GPS tracker was used to measure anaerobic capabilities, specifically sprint-related characteristics that match soccer-specific actions. Catapult is established to be reliable and valid for tracking specific anaerobic variables when compared to other GPS tracking systems

(Varley et al., 2012; Wilmott et al., 2019).Catapult used an acceleration threshold that a player must reach for a period to count as an acceleration. This threshold was set at 3 meters per second per second for at least one second. Catapult allows the person in charge of the data to classify speed zones or specific sprint speed thresholds. For this study, the sprint speed zone was set at 13.1 miles per hour, which is reflective of a review that investigated speed zone threshold speeds in Division 1 NCAA women's soccer programs (Hodun et al., 2016). A power play is a significant action where the power output recorded is above 20 watts per kilogram for more than one second (Catapult, 2021). The power score is the total of the athlete's accelerations and decelerations which are combined with the number of sprints. This gives an indication of the performance intensity level for that session (Catapult, 2021). Accelerations are a simple count of the number of times that an athlete's acceleration is greater than the acceleration threshold of 3 m/s/s for at least 1 second (Catapult, 2021).

Statistical Analysis

A Pearson product-moment correlation was used to determine if there was a significant relationship between the Catapult GPS metrics and each of the three soccer fitness tests. The closer the correlation coefficient was to 1 or -1, the stronger the correlation. The closer the correlation coefficient was to 0, the weaker the correlation. Correlation coefficients were defined as small (r = .1-.29), medium (r = .3-.49), and large (r =.5-1) (Source). Statistical significance was set at $p < 0.05$.

CHAPTER 4

RESULTS

The team consisted of thirty-one players in a Division 1 NCAA women's soccer program. As the preseason progressed, less participants were able to perform the 2nd and 3rd scheduled 300-yard shuttle and repeated sprint ability fitness tests. By the end of this period, 16 players had dropped out either due to illness or injury. The first action of preseason was the Yo-Yo IR-1 *(n*=28*)* test where 28 out of 31 players participated. The second fitness test, the 300-yard shuttle *(n*=16*)*, the participant count dropped to 16. On the last fitness test of preseason, the repeated sprint ability test *(n*=15*)*, participant count had dropped one more to 15.

Performance statistics for field tests and GPS metrics can be found in Tables 2-2.3. Intercorrelations between field test performance and GPS metrics can be found in Tables 3-3.2. The Yo-Yo IR-1 and 300-yard shuttle test showed significant associations with Catapult metrics. All Catapult metrics were found to have large positive associations with the level of the Yo-Yo IR-1 test achieved. Power plays and accelerations were found to have large negative associations with the average time of the 300-yard shuttle test (See Table 3.2).

Table 2.0

Yo-Yo Intermittent Recovery Test Level-1 and Catapult Metric Descriptives (n=28)

	Mean	Standard Deviation	Range
Acceleration Count	54.71	11.67	(22, 71)
Power Score	3.24	1.06	(1.78, 4.78)

Power Plays	32.96	12.11	(14, 51)
Level of Yo-Yo	22.54	5.46	(11, 38)

Table 2.1

300-Yard Shuttle Test Performance and Catapult Metric Descriptives (n=16)

	Mean	Standard Deviation	Range
Acceleration Count	15.69	5.91	(8, 29)
Power Score	4.65	0.84	(2.93, 6.24)
Power Plays	15.25	12.11	(2, 29)
Average Shuttle time (seconds)	59.69	2.96	(51, 78)

Table 2.2

Repeated Sprint Ability Test Performance and Catapult Metric Descriptives (n=15)

	Mean	Standard Deviation	Range
Acceleration Count	30.76	4.67	(16, 36)
Power score	2.58	.19	(2.13, 2.97)

Power plays	12.94	2.2	(8, 18)
Speed change (%)	2.75	1.49	(1.25, 4.4)

Table 3.0

Associations between Yo-Yo Intermittent Recovery Test Level-1 Performance and Catapult Metrics (n=28)

		Acceleration Count	Power Score	Power Play Count
Level of Yo-Yo	Pearson Coefficient (*r*)	.959**	.685**	.931**
	P	.000	.000	.000

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

Table 3.1

Associations between 300-Yard Shuttle Test Performance and Catapult Metrics (n=16)

		Acceleration Count	Power Score	Power Play Count
Average Shuttle Time	Pearson Coefficient (*r*)	-.589**	.047	-.827**

	P	.016	.861	.000

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

Table 3.2

Associations between Repeated Sprint Ability Test Performance and Catapult Metrics (n=15)

		Acceleration Count	Power Score	Power Play Count
Change in Speed (%)	Pearson Coefficient (*r*)	-.120	-.325	-.181
	P	.671	.237	.518

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

Figure 4

Level of Yo-Yo Test Scatterplot with Catapult Metrics (n=28)

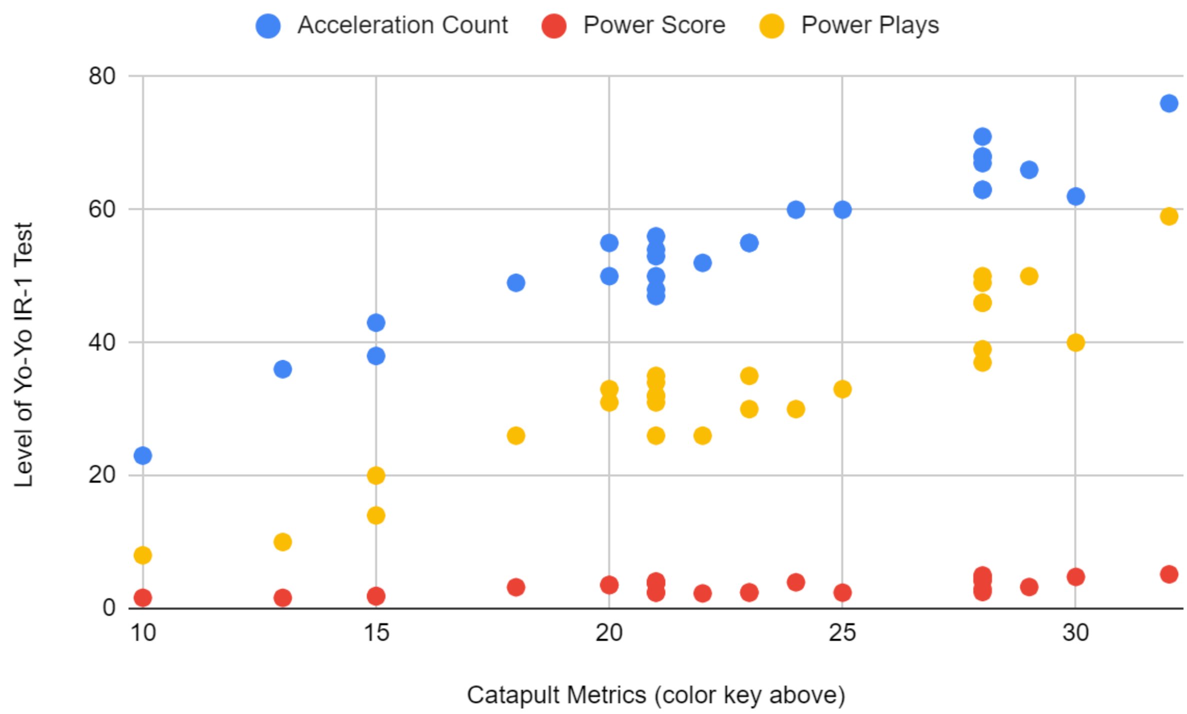


Figure 4.1

Average Time in 300-Yard Shuttle Test with Catapult Metrics (n=16)

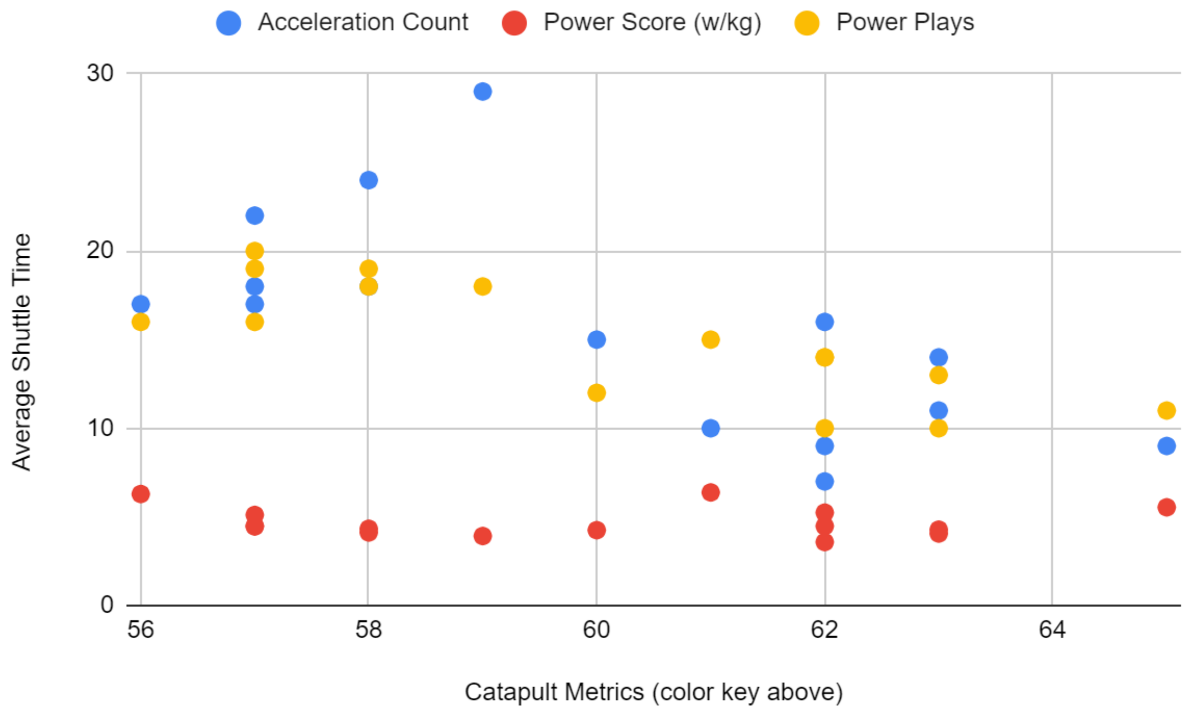
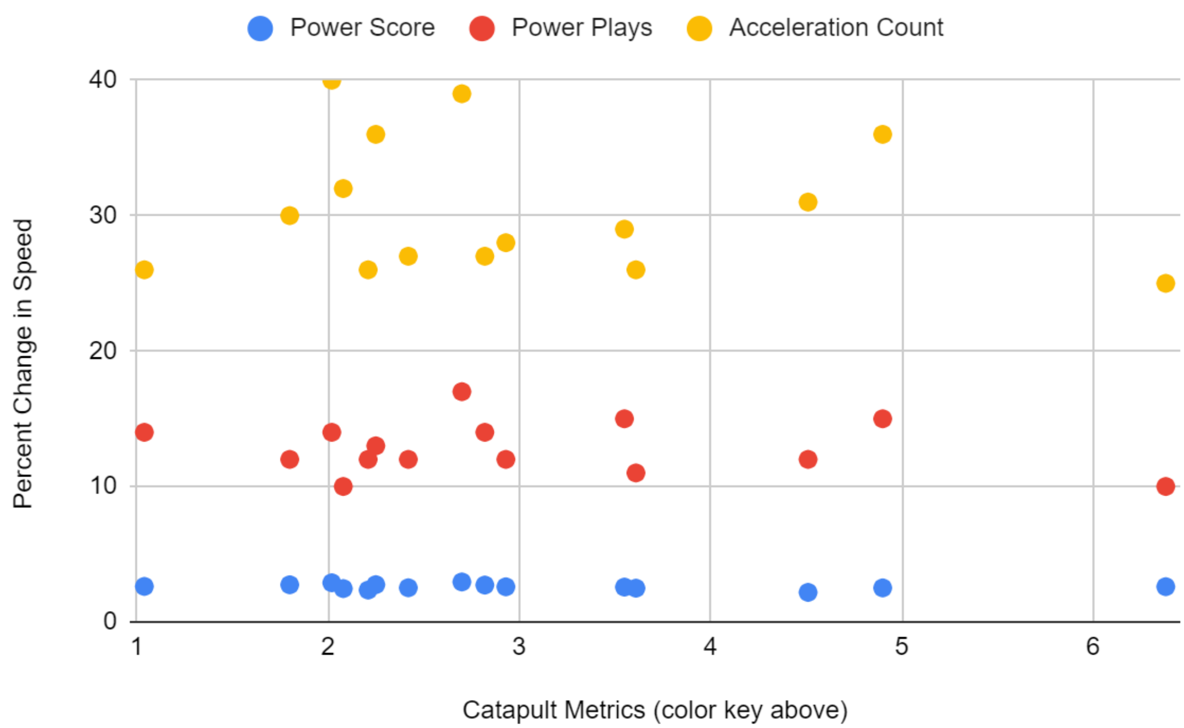

Acceleration Count
Power Score (w/kg)
Power Plays
30
20
10
0
Average Shuttle Time
56
58
60
62
64
Catapult Metrics (color key above)

Figure 4.2

Percent Change in Speed Scatterplot with Catapult Metrics (n=15)



CHAPTER V

DISCUSSION

The purpose of this study was to better understand the utility of GPS tracking in the assessment and monitoring of collegiate women's soccer players' athletic performance by determining the association between Catapult metrics (accelerations, power score, power plays) and common assessments of soccer fitness (Yo-Yo intermittent recovery test level 1, 300-yard shuttle test, repeated sprint test). It was hypothesized that power plays and power scores would have large positive correlations with Yo-Yo IR-1 test performance. Power plays and power score would have large positive associations with the repeated sprint ability test. The major findings of this study were that Catapult metrics were largely associated with field-based soccer tests. All Catapult metrics showed significant associations with Yo-Yo IR-1 Test. Power plays and power score were largely associated with the 300-yard shuttle test. The repeated sprint ability test showed no significant associations with any Catapult metrics. Power play showed the strongest correlations for the 300-yard shuttle test and the Yo-Yo IR-1 test. The results of this study mostly reflected the hypotheses proposed apart from the repeated sprint ability test.

Professional or higher skilled players participate in a greater volume of high-intensity running and sprints throughout a match (Mohr et al., 2003). When comparing female collegiate players of a division 1 program (n=21) to the sample population in this study, it was found that total distance covered in the Yo-Yo IR-1 test was very similar between the groups (1,200 ± 473m to 920 ± 593 m) Lockie et al., 2017). However, as players increase in skill level, the amount of anaerobic or soccer-specific actions increases (Evangelos et al., 2016). When comparing the sample population to players of the professional level, the distance covered in the Yo-Yo IR-1 test is much higher (2,231± 294 m) (Rampinini et al., 2010). This is shown in the results (See Table 4 and 4.1) as players who completed the repetitions faster or got further on the test than other players, had more accelerations, power plays, and a higher power score on the Yo-Yo IR-1 and 300-yard shuttle test. Aerobically, when looking at collegiate Division 1 women's soccer players, the $VO_{2\ max}$ is largely indistinguishable (Miller et al., 2007). Miller et. al investigated changes in $VO_{2\ max}$ over the course of a single season. Players' $VO_{2\ max}$ were tested before (49.24 ± 4.4 ml/kg/min) and after (44.87 ± 4.6 ml/kg/min) the competitive season,$VO_{2\ max}$ significantly decreased; however, $VO_{2\ max}$ among players was still largely indistinguishable (Miller et al., 2007). These results show that anaerobic actions are the main discriminating factor in soccer-specific fitness. This reinforces the Catapult metrics that were selected were successful in indicating soccer-specific fitness in the Yo-Yo IR-1 and 300-yard shuttle test.

All GPS metrics were largely associated with Yo-Yo IR-1($p = 0.00$). Power plays should be the focused metric when analyzing Yo-Yo IR-1 performance. Acceleration count is useful but cannot be the only variable to gauge match fitness. Accelerations would be more efficient to analyze in an open field setting like a full soccer match. This is because a match is unstructured in movement so a player is able to freely accelerate depending on game situations and their fitness. Power Plays and Power scores are superior in this aspect in that they are formulated with multiple variables like recovery and sprinting characteristics, while accelerations only focus on simple count after one reaches the threshold. A player who covers more sprint distance or reaches a higher level will have more power plays and accelerations as well as a higher power score as the ability to recover and consistently perform high-intensity movements for the Yo-Yo

IR-1. A large association (*r* =.959*, p = .000)* was established with acceleration count and the level of the Yo-Yo test. This result means that players who achieved a higher level in the Yo-Yo test were able to recovery quicker and perform accelerations more efficiently than a player who scored lower.

The Repeated Sprint Ability test showed that across acceleration count, power score, and power play count there was no association among them. Every Catapult One metric, when correlated to the RSA protocol, showed a statistically nonsignificant p value ($p > 0.05$). This test has been proven to be reliable and valid to gauge soccer-specific fitness as well as the ability to recover (Gabbett, 2010). A possible reasons for having no correlation with any Catapult Metric as there needs to be more participants and the test does not administer as many repetitions as it should for the best possible data. Fifteen participants in this test could cause outliers on the upper or lower range to skew the correlation values. With the test being only 10 repetitions, there is not a lot of data in terms of sprinting characteristics that could be useful to interpret.

The 300-yard shuttle test showed power plays and acceleration count had large negative correlations with this fitness test. For the 300-yard shuttle test, the lower time a player received, the better they did as the test was scored based on the average of the 3 repetitions each player completed. This is the reason why there is a negative correlation because a player that had a lower overall average time, had more significant actions than players who had a higher average time for this fitness test. While these metrics showed significance and large correlations, it was found that the power score had no correlation with the 300-yard shuttle test. Acceleration count was largely associated with average shuttle time based on the protocol of the test. Players were instructed to maximally sprint at the start and throughout the repetition. As players fatigued throughout the repetition, some were not able to exceed or meet the 3 m/s/s threshold for at least one second. Power plays work better for this test as it counts any significant actions that are player has performed in a test, not only accelerations.

Players of a professional level complete 150-250 significant actions (jumping, change of direction, sprinting, etc.) during a match (Bangsbo et al., 2007). These significant actions directly represent actions that would trigger the 20 w/kg threshold of a power play. The Yo-Yo test combines actions like recovery, acceleration, change of direction, etc. that provide many possibilities for players to trigger a power play. While acceleration had a large association with the level of the Yo-Yo test, the power play better represents the soccer-specific actions in the test. The same reasoning applies to the 300-yard shuttle test. Power plays should be the metric to look at when performing the Yo-Yo IR-1 test and 300-yard shuttle test.

There are some notable limitations to this study. The sample size that was recruited decreased for each fitness test. A smaller sample size could lead to skewed data specifically in the Pearson correlation coefficients. The data itself could be utilized for other purposes in optimal soccer performance. Catapult itself offers many ways to analyze the metrics rather than just looking at associations to field tests. The data from this study should be combined with the technical and tactical aspects of soccer to achieve optimal performance. This study does not compare the data collected to other programs of women's player or to women's teams of different skill levels. In the future, research should focus on how the Catapult metrics examined change based on time and the time period of a season. Focusing on the repeated sprint ability test, the sample size had decreased multiple times due illness, injury, and players not following the proper protocol which disqualified their data from the correlation. This created a sample size that was significantly lowered from the original size. There was a lack of research in GPS tracking systems, regardless of Catapult Sports, on female populations in soccer. More research in the future would be beneficial in establishing associations with different field-based fitness tests and high-level women's soccer players. Future research should include changes in soccer-specific fitness across the full competitive season. Future research should include team data and their comparisons with similar programs.

Overall, Catapult Sports GPS metrics were associated with soccer field test performance in Division I women's soccer players. Power plays demonstrated the strongest relationship when examining fitness in women's soccer. The results a suggest that soccer-specific fitness can be tracked with the power play metric in the Catapult Sports GPS tracking system.

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