International Journal of EXERCISE SCIENCE

Original Research

Assessment of Relationships Between External Load Metrics and Game Performance in Women's Lacrosse

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ABSTRACT

International Journal of Exercise Science 15(6): 488-497, 2022. The purpose of this study was to analyse the relationship between external load metrics with game performance for Division I collegiate female lacrosse. Data were collected using microtechnology during 26 games with 13 athletes (attackers n = 5, midfielders n = 8). External load variables included: total distance (TD), distance rate (DR), high-intensity (HI) distance, speed, HI sprints, accelerations, decelerations, metabolic equivalent distance (MED), and sprints. For attackers, goals, points, shots, and shots on goal (SOG) had low, positive associations with TD (r = 0.32 to 0.42) and MED (r = 0.39 to 0.45). For midfielders, goals, shots, and draw controls had low, positive relationships with TD (r = 0.34 to 0.41), DR (r = 0.33 to 0.45), and decelerations (r = 0.30 to 0.35). Points and SOG had low associations with TD (r = 0.35), DR (r = 0.33), accelerations (r = 0.31), and decelerations (r = 0.32 to 0.35). Turnovers demonstrated low, positive relationships with HI distance (r = 0.31) and HI sprints (r = 0.41). Though the correlations were low, they still revealed insights into workload metrics and offensive game statistics in the sport of lacrosse. Training for attackers should focus on agility and a training base for TD. Training for midfielders should focus on HI endurance and sprinting.

KEY WORDS: Athlete monitoring; microtechnology; performance; team sports

INTRODUCTION

Workload metrics measure biological and mechanical stressors placed on an athlete, as well as the work achieved by the athlete during activity. The recent growth in technology has allowed an increase in accessibility to external workload metrics (e.g., distance, speed, sprints, accelerations) through microtechnology systems that include global positioning systems (GPS), accelerometers, magnetometers, and gyroscopes. The use of microtechnology to assess athletes has become common in various sports including football, rugby, and field hockey (11, 19, 23). Monitoring external load metrics have been used within sport to optimize training sessions

while reducing the risk of injuries via managing training progression, overtraining, and reductions in fitness (3, 12, 24).

Evaluation of workload metrics in women's lacrosse is a recent addition to the sports science literature, with most studies focusing on analysis of game loads and fitness metrics (3, 8, 15). This research has explored areas pertaining to injury rates (3, 8), energy expenditure and body composition of lacrosse athletes (25), assessment of wellness in relation to performance (7) and fatigue (10), and evaluation of game and training workloads (1, 8, 15). These studies revealed the physical stressors placed on athletes during performances and games, differences in positional loads (15), and the loads that may lead to injury (8). Ultimately, the usage of microtechnology has aimed to help athletes, athletic trainers, and coaches become more aware of physiological and mechanical stressors placed on athletes' bodies. This information can be used to help create training regimens that will be the most beneficial for lacrosse athletes in preparation for practices and games. More researched preparation for positions, opponents, or styles of play may help athletes have better personal and team success rates throughout the lacrosse season (21).

Success in a game can be viewed through the broad lens of team success (e.g., wins versus losses) or individual success that includes the assessment of individual game statistics that subsequently contribute to team success. Studies have revealed that examining and managing external training workloads can help prepare athletes and improve game performance (19). This improved game performance is shown by an increase in overall game statistics and team success (21). However, no research has analysed the correlation between athletic loads and game statistics on a position-specific basis in lacrosse. Position-specific analysis have given coaches a large amount of player insight in other sports such as rugby which has shown positional differences in high-intensity (HI) efforts (13). Evaluating metrics specific to position, skillset, and individual physiological capability may have high value for individual game success.

The purpose of this study was to evaluate the relationship between external workload metrics and game performance by position in women's collegiate lacrosse. It was hypothesized that sprints, accelerations, and decelerations would be the most important metrics for attackers, and that total distance and HI distance would be the most important metrics for midfielders. To the authors' knowledge, there is no known research pertaining to the prediction of game performance in women's collegiate lacrosse athletes based on workload measures. This information may prove to be useful in assisting coaches and athletic trainers design training and practices to include exercises, drills, or movements that will best prepare women's collegiate lacrosse athletes for games on a position-specific basis.

METHODS

Experimental Approach to the Problem: The current study was a longitudinal observational design that occurred over a two-year period. Dependent variables included individual game statistics and independent variables included external load metrics. Data were collected over two competitive collegiate lacrosse seasons and analysed by position for attackers and midfielders.

All procedures were approved by the institutional review board and conducted in accordance with the Declaration of Helsinki. Written informed consent was received from all participants with the opportunity to meet with the researchers and ask questions prior to data collection. This research was carried out fully in accordance with the ethical standards of the *International Journal of Exercise Science* (20).

Participants

Division I athletes (n = 35) from the women's lacrosse program agreed to participate in this study. The inclusion criteria were athletes that were 18 years of age or older, current member of the varsity lacrosse team, and clearance to participate by the university's athletic trainers and team physician. Individuals were excluded if they were removed from the team or voluntarily chose to discontinue participation. Participants were also excluded if they did not participate in games where data were collected and played less than 50% of the game or if they played the position of defender. Lacrosse game statistics are more inclusive of offensive efforts than defensive efforts, thus defenders were excluded from analyses. With these criteria, a total of 13 participants (attackers n = 5, midfielders n = 8) were analysed for this study.

Protocol

Workload metrics were collected using microtechnology over a two-year period, encompassing 26 games—17 games from the 2019 season and 9 games from the 2020 season. The load metrics were collected using VX Sport microtechnology units (Wellington, New Zealand) with a GPS unit (collecting at 10 Hz), 3-axis accelerometer (collecting at 104 Hz per channel), and a HR monitor (collecting at 2.4 GHz). VX Sport units have been previously validated for accuracy in speed and distance metrics (2, 18). Each athlete wore the same unit during each game with the unit placed inside the vest on the thoracic spine in-between the shoulders. The chest strap for the HR monitor was embedded in the vest with the dongle situated on the thoracic spine.

Approximately six weeks before each season, athletes' maximum sprint speed (MSS) was tested using a 20-m fly-in followed by a 30-m full effort sprint. Athletes completed this sprint three times with two minutes of rest between bouts. The fastest speed attained during a sprint was used for the individual athlete's MSS. This MSS benchmark was used to determine the relative speed thresholds for the sprint workload variables (e.g., high-intensity distance, high-intensity sprints).

After each game, performance metrics were uploaded into the VX Sport Training Tool software program. Using the time and raw GPS output, data were split into three sections including warm-up, first half, and second half. Data from the first and second halves, excluding warm-up, were used for this study. Workload variables retrieved from the VX Sport Training Tool were play time (min), total distance (m), distance rate ($m \cdot min^{-1}$), high-intensity (HI) distance (m), HI sprints (number of efforts), accelerations (number of efforts), decelerations (number of efforts), and metabolic equivalent distance (MED; m). HI distance was measured as the total distance covered at > 60% MSS; whereas, sprint efforts > 80% MSS were categorized as HI sprints. Accelerations and decelerations were counted when there was a change in acceleration more than ± 3 $m \cdot s^{-2}$. MED is a proprietary calculation from VX Sport that estimates and converts the

extra energy cost of accelerations and decelerations into meters and combines the distance estimate with total distance. Play time was determined by analysing the GPS data from each individual player for each game. Accumulated play time was tracked by adding the total time that corresponded with GPS spikes to indicate movement during the game. After all the spikes had been recorded, an overall playing time was calculated for each player, and this excluded half time, breaks, and timeouts.

All of the game statistics including goals, assists, points, shots, shots on goal (SOG), ground balls (GB), turnovers (TO), caused turnovers (CT) and draw controls (DC) analysed for this study were collected from public game records (26). Goals were calculated by counting how many times a player shot the ball into the opposing team's net. Assists are credited to the player that passed the ball to a player who scored a goal. Points were calculated by combining a player's total number of goals and assists. Shots were calculated by totalling the number of times the player threw the ball attempting to score a goal, while SOG were the total number of times a player's shot was projected to go in the goal. GB were calculated by counting the number of times a player picked a loose ball up from the ground. TO were calculated by totalling the number of times a player gained possession of the ball from the other team, while CT refer to the number of times that a player gained possession of the ball through an aggressive manner by initiating the change in possession. Lastly, DC were calculated by counting the number of times the player gained possession of the ball after a draw. These statistics were recorded by the game scorekeeper who followed all National Collegiate Athletic Association (NCAA) lacrosse rules and guidelines (22).

Statistical Analysis

All data was analysed using SPSS (version 27.0, IBM Corp, Somers, NY). Repeated measures correlation analyses were used to calculate the association, along with 95% confidence intervals, between external load variables and game performance measures. Inter-item correlation estimates for fixed effects (i.e., independent variables) were determined via two-way random effects (i.e., athlete and game) model with an absolute agreement type. Bootstrapping, utilizing random sampling with replacement at 100 iterations per sample, was used to calculate the 95% confidence intervals and estimation bias. The external workload variables, for both attackers and midfielders, were classified as minutes played per game, total distance, distance rate, HI distance, HI sprints, accelerations, decelerations, and MED. For the attackers, dependent game performance measures were goals, points, shots, SOG, and DC; while midfielder dependent variables were similar to the attackers with the addition of GB, TO, and CT. For all correlation coefficients (r), an absolute value of 0.00 to < 0.30 indicated a negligible association, 0.30 to < 0.50 was low, 0.50 to < 0.7 was moderate, 0.70 to < 0.90 was high, and > 0.90 was very high (16). These values also serve as effect sizes (ES), with an r of 0.1 determined as low ES, 0.3 is medium ES, and 0.5 is large ES (6).

RESULTS

Table 1 shows the means and standard deviations for all workload metrics and game statistics for attackers and midfielders. Workload was comparable between the two positions except for

attackers having higher MED than midfielders during games. Attackers also had more goals, assists, points, shots, and SOG than midfielders. Notably, the attackers logged higher workload and game statistics, but they also had approximately 10 more minutes of play time than the midfielders.

Table 1. Mean and standard deviation for workload metrics and game statistics for collegiate female lacrosse attackers and midfielders.

		Attacker	Midfielder
Workload Metrics	Distance (m)	6952 ± 1329	6099 ± 1591
	HI Distance (m)	578 ± 255	569 ± 222
	Accelerations (reps)	204 ± 81	210 ± 103
	Decelerations (reps)	82 ± 121	128 ± 151
	Distance rate ($m \cdot min^{-1}$)	72.8 ± 27.9	80.8 ± 39.5
	MED (m)	9982 ± 2384	8114 ± 2143
	HI Sprints (reps)	4.9 ± 2.8	5.0 ± 3.1
	Play time (min)	67.7 ± 19.5	57.9 ± 26.5
Game Stats	Goals	1.5 ± 1.1	0.8 ± 1.1
	Assists	0.89 ± 1.23	0.26 ± 0.60
	Points	2.4 ± 1.9	1.0 ± 1.4
	Shots	3.4 ± 2.2	2.1 ± 2.5
	SOG	2.8 ± 1.9	1.7 ± 2.0
	SOG %	0.54 ± 0.28	0.43 ± 0.35
	GB	0.85 ± 0.93	0.78 ± 0.99
	TO	1.6 ± 1.3	0.9 ± 1.0
	CT	0.29 ± 0.60	0.38 ± 0.63
	DC	1.7 ± 3.0	0.7 ± 1.6

Notes: high-intensity (HI), metabolic equivalent distance (MED), shots on goal (SOG), ground balls (GB), turnovers (TO), caused turnovers (CT), draw controls (DC)

All correlation coefficient values and confidence intervals, demonstrating the associations between external workload variables and game performance outcomes, are displayed in Figures 1 and 2 for attackers and midfielders, respectively. For the attackers, results indicated that the amount of goals scored, total points, shots, and SOG all had low, positive associations with both total distance (r = 0.32, r = 0.42, r = 0.38, r = 0.39, respectively) and MED (r = 0.41, r = 0.39, r = 0.45, r = 0.42, respectively). However, DC demonstrated a low, negative relationship with HI distance (r = -0.42). All of these show medium ES. All other associations for the attackers were deemed negligible with small ES. The results disagree with the hypothesis that sprints, accelerations, and decelerations would be the most important metric for attackers.

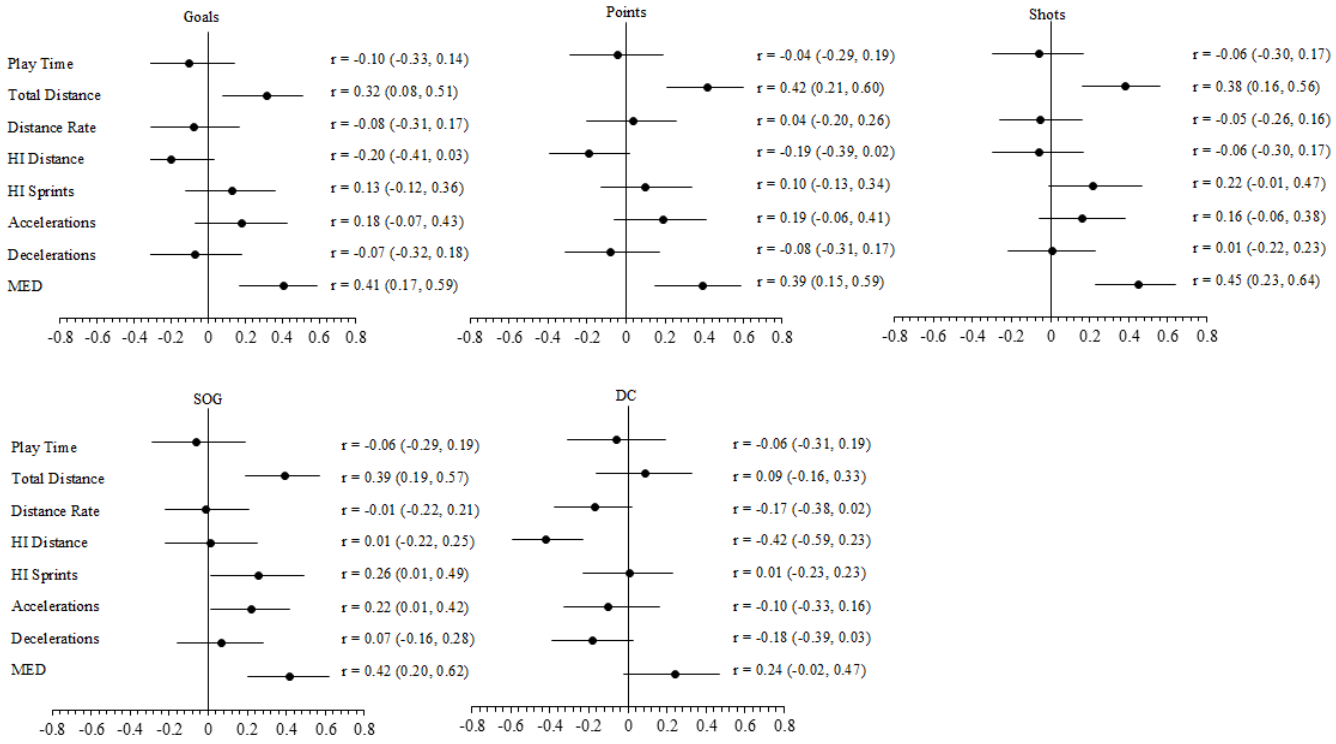

Figure 1. Correlation coefficients, with 95% confidence interval, of game performance variables for collegiate female lacrosse attackers. Notes: High-intensity (HI), metabolic equivalent distance (MED), shots on goal (SOG), draw controls (DC)

For midfielders, goals, shots, and DC had low, positive relationships with total distance ($r = 0.34$, $r = 0.34$, $r = 0.41$, respectively), distance rate ($r = 0.33$, $r = 0.34$, $r = 0.45$, respectively), and decelerations ($r = 0.30$, $r = 0.35$, $r = 0.30$, respectively). Additionally, points and SOG had low, positive associations with total distance ($r = 0.35$ for both), distance rate ($r = 0.33$ for both), accelerations ($r = 0.31$ for both), and decelerations ($r = 0.32$, $r = 0.35$, respectively); while TO demonstrated low, positive relationships with HI distance ($r = 0.31$) and HI sprints ($r = 0.41$). The results regarding total distance align with the hypothesis for midfielders, but HI distance did not prove to be as important as hypothesized. All of these are medium ES. There were no relationships for GB or CT that were not deemed more than negligible. Furthermore, all other associations for game performance measures were considered negligible for midfielders with low ES.

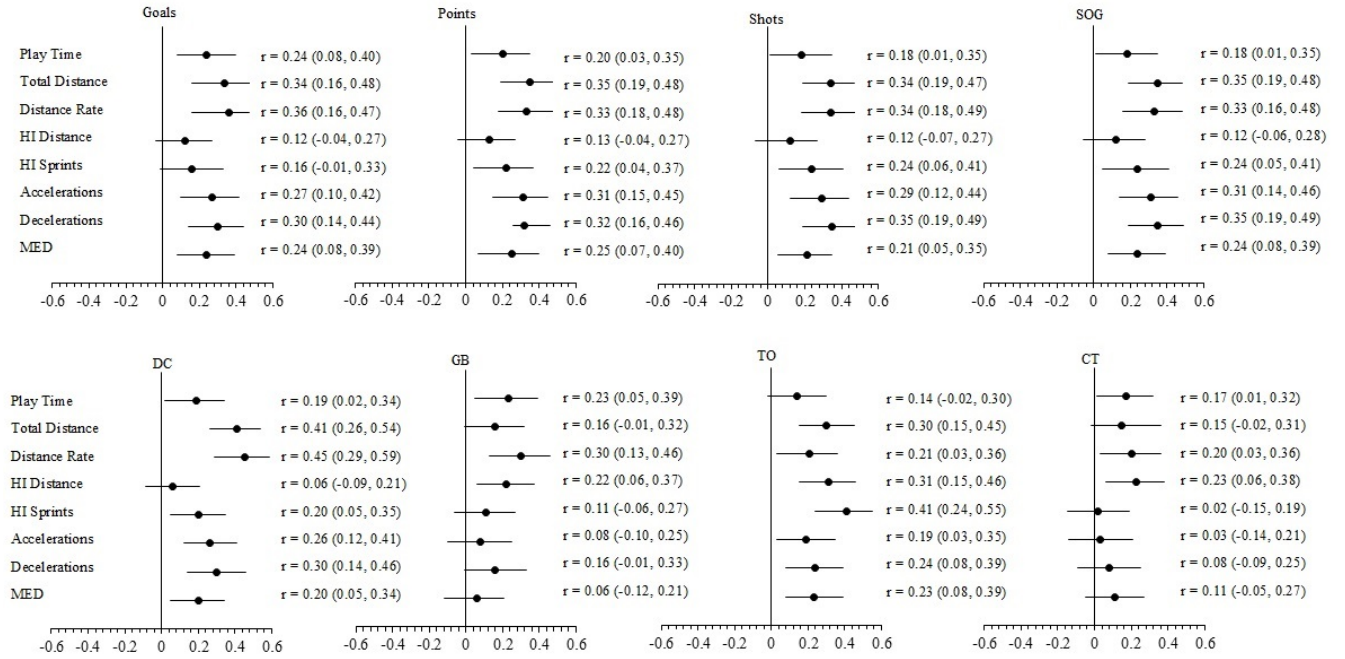

Figure 2. Correlation coefficients, with 95% confidence interval, of game performance variables for collegiate female lacrosse midfielders. Notes: High-intensity (HI), metabolic equivalent distance (MED), shots on goal (SOG), ground balls (GB), turnovers (TO), caused turnovers (CT), draw controls (DC)

DISCUSSION

The purpose of this investigation was to assess the association between external workload metrics and game performance metrics in Division I NCAA women's collegiate lacrosse. These data were analysed on a position-specific basis and revealed low strength correlations regarding offensive production in games in relation to total distance, distance rate, MED, accelerations, and decelerations. Collectively, these results suggest that specific components of external workload (e.g., MED and total distance) are related to game success. Data from the present study, in conjunction with previous work related to lacrosse training (4) provide evidence for more focused positional training. The results of this study also suggest that individual game success is multi-factorial, which aligns with previous literature suggesting that factors such as fitness, external workload, coachability, skill, and mental toughness should all be considered (21). To the authors' knowledge, this is the first study to determine associations between external workload metrics with game performance measures on a position-specific basis in women's collegiate lacrosse.

MED and total distance were related to game statistics in areas such as goals, points, shots, and SOG. This indicates that distance metrics, both total and MED, are important aspects of the game of lacrosse to consider when training attackers. This finding coincides with previous studies that analysed the importance of position-specific evaluations of sports and training (5, 9). The correlations seen with MED, specifically, indicate that a players' ability to change direction is related to shots taken and goals. This may be that changing directions helped a player create the space needed from a defender to take a shot. With this information, coaches can create specific

agility drills that require a player to perform specific footwork patterns to create space from a defender prior to taking a shot.

Midfielders normally cover the largest surface area and are expected to be the most conditioned and trained athletes on the field (8, 15). Total distance, distance rate, and decelerations were related to goals, points, shots, SOG, and DC. These findings reiterate the importance of training midfielders to run long distances in order to prepare them to cover both offensive and defensive sides of the field (9, 17). The findings from the present study also provide more specific context, suggesting that distance rate, accelerations, and decelerations are also important metrics to evaluate and train for offensive production. Midfielders are expected to have stamina allowing them to cover a lot of ground, but the number of decelerations also correlate to the game statistics that they can produce. The most successful midfielders in this study performed more decelerations than the other midfielders on the team. Coaches should consider training aerobic speed for midfielders, as well as footwork drills for quick stops and changes in direction.

Strengths of this study include consistent data collection over two competitive seasons within the same team. A limitation of this study is the reduction of the number of potential correlates to only include external workload data with game statistics. Game performance is multifactorial as it relates to mentality, strategy, skill, and workload, and this study evaluated only one of these aspects. There was no clear way to test the strategy, toughness, coachability, or feelings of each athlete. These various factors would have most likely given more insight and revealed more correlations between external workload metrics and game statistics. More analysis of each individual athlete's skills, prior to the study, would have been helpful for this research. This was a limitation because athletes were evaluated as though they experienced similar external workload metrics, which studies have shown is not always true among the different positions in the game of lacrosse (9, 14, 17). Further, this study only evaluated the offensive side of the game. Most lacrosse game statistics tracked are offensively focused, thus we decided to exclude defenders from analysis.

Overall, lacrosse athletes, coaches, and trainers have known that training and practice greatly contribute to overall game success on the field. External workload metrics are assumed to correlate with intended performance abilities of lacrosse athletes, but to date, no statistical procedures have been used to justify this assumption. The results from the present study show that there were low strength, positive correlations between external workload metrics and statistical game success. This study also revealed that workload does not provide a whole explanation for game performance. Many athletes who were the most successful did not have the highest external workload metrics. Future research should include analysis of the "whole" athlete including evaluating the roles of workload, recovery, nutrition, and mental capacity on game success. It would also be of benefit to further evaluate the non-traditional metric of MED to further understand its role in game play. Additionally, it would be beneficial to conduct similar analyses across other levels of play in women's lacrosse to understand which metrics are important among high school, differing collegiate levels, and international levels of play. These data can greatly contribute to the evaluation of athletes in the sport of lacrosse, but other mental

analysis must be performed and analysed when evaluating the aspects that contribute to overall game success in Division I women's collegiate lacrosse.

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