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Comparison of In *vs.* Out of Conference Game Demands in Collegiate Division I Women's Lacrosse

Andrew Thornton[1], Bradley J Myers[1] and Jennifer A Bunn[2]*

[1]*Department of Physical Therapy, Campbell University, Buies Creek, NC, USA*

[2]*Department of Kinesiology, Sam Houston State University, Huntsville, TX,USA*

***Corresponding author:** Jennifer Bunn, 1900 Ave I, Box 2301, Huntsville, TX 77341, USA, Tel: +936-294-2393; E-mail: jab229@shsu.edu

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Abstract

Objective: The purpose of this study is to assess differences in physiological demands and different performance variables between In-Conference (IC) and Out-of-Conference (OC) games throughout a season for a Division I collegiate women's lacrosse team (n=13).

Methods: Performance variables were analyzed Per Minute Played (PT) and data were collected using micro technology units and Heart Rate(HR) monitors during 18 total games, 11 OC games and 7 IC games.

Results: Analyses indicated a higher workload for IC games than OC games for total distance (OC: 100.8 ± 8.0 m/min PT; IC: 145.5 ± 26.7 m/min PT), distance rate (OC: 0.85 m/min/min PT; IC: 1.15 m/min/min PT), High-Intensity (HI) distance (OC: 7.8 ± 2.8 m/min PT; IC: 10.9 ± 2.9 m/min PT), metabolic equivalent distance (OC: 155.4 ± 13.5 m/min PT; IC: 215.7 ± 32.6 m/min PT), accelerations (OC: 3.6 ± 0.3 reps/min PT; IC: 4.4 ± 0.5 reps/min PT), decelerations (OC: 0.7 ± 0.1 reps/min PT; IC: 1.0 ± 0.2 reps/min PT), and sprints in zone 5 (OC: 0.29 ± 0.0 reps/min PT; IC: 0.57 ± 0.2 reps/min PT), all $p<0.001$. Workload was also higher for HI sprints (OC: 0.09 ± 0.6 reps/min PT; IC: 0.12 ± 0.5 reps/min PT; $p=0.005$) and training impulse (OC: 7.0 ± 1.4 AU/min PT; IC: 11.6 ± 5.2 AU/min PT; $p=0.009$).

Conclusion: The data suggests the more physiologically demanding games are those where the opponent is more evenly matched. The more even the player-to-player matchups are the greater likelihood of competition being present throughout the duration of the game, forcing each athlete to sustain higher workloads for longer periods of time. Having a better understanding of game demands can help coaches and trainers to better strategize training sessions and recovery periods to be as competitive as possible.

Keywords: Athlete monitoring; Game schedule; Female athletes; Team sports; College

Introduction

Lacrosse, a combination of soccer, basketball, and hockey, is an extremely demanding sport placing high levels of physiological stress on the cardiovascular and musculoskeletal systems [1–3]. Coordination, swiftness, and agility are all required characteristics an athlete of the sport must have in order to be successful at the collegiate level. A typical game consists of high-intensity sprints alongside sudden starts and stops, with explosive multiple joint movements that utilize main muscle groups to pass, dodge, and shoot [2,4].

Division I collegiate play for women's lacrosse is highly competitive and teams experience countless challenges throughout a season while aiming for success. Per the National Collegiate Athletic Association (NCAA), training and competition for a women's lacrosse season occurs during a 132-day span with a team competing in no more than 17 games [5]. Exceptions to the 17 games limit include a conference championship tournament, NCAA championship tournament, NCAA championship tournament play-in competition. A typical season for a team in the NCAA Big South conference consists of six In-Conference (IC) games and [6-8] Out-of-Conference (OC) games. Team success is often assessed through IC play with conference standings most likely determining whether a team will have a postseason. Most conferences provide a conference tournament where the top teams compete for the conference championship title. The winner of the Big South Conference championship receives an automatic bid into the NCAA national championship tournament where they will compete against 28 other teams, consisting of 16 conference champions and 12 teams selected by an appointed committee [9]. The 12 teams are selected based on strength of their schedule, wins, losses, and strength of opposing teams for the wins and losses. The postseason formatting for a team receiving a NCAA championship tournament bid illustrates how crucial each game can be for a team, with emphasis placed on IC games as that is the most direct way to receive a tournament bid.

Literature in the field of lacrosse is scarce with most studies centered on men's lacrosse with less knowledge around the women's game. Preceding research has investigated training load measures [10-11], classification of various drills [1], the impact of wellness on workload [12], external game loads [2,3], and positional differences for distance and speed [2-4]. Lacrosse entails a high physiological demand for an athlete to be successful, requiring high muscular strength and endurance in both the lower and upper body and high aerobic capacity scores that place in the 90th percentile [10]. Hauer et al. discussed the activity profile of women's international lacrosse match-play, finding that when compared to other invasion sports, lacrosse consists of similarly high or even higher physiological load on the athletes with the most amount of time spent in Heart Rate (HR) zones 4 and 5, but also having a high number of recovery phase [3]. Similarly, Devine et al. posed that compared to other major female sports, collegiate lacrosse athletes travel fewer total distances; however, they spend more time in high intensity running [2]. Both, Hauer et al. and Devine et al., discussed positional differences in match-load with midfielders covering more distance at moderate intensity as opposed to attackers and defenders covering less total distance at higher intensities [2-3]. Further, game demands may be different depending upon the opponent, team strategy, or the context of the game.

To evaluate the impact of game context, Bozzini et al. compared game demands in Division I collegiate women's soccer between IC and OC [11]. Female athletes (n=11) were monitored with micro technology throughout a competitive season. Players included in the analyses played for more than 45 minutes in more than 50% of the games. The data was analyzed as rate per minute of Playing Time (PT) with warm up, half time and bench time taken out of the analysis. Results showed that players endured a higher workload for OC games as measured by total distance covered, calories expended, and time spent in HR zone 5. No differences were found for number of sprints, HR zone 4, and distance covered in fastest speed zones; however, IC games favored differences in PT. Overall, Bozzini et al. found OC games were more physiologically demanding for the athletes, and that the OC opponents were of lower caliber teams as indicated by the Ratings Percentage Index (RPI).

The physically demanding nature of the collegiate lacrosse requires further research into which types of games—IC or OC—place the highest workload on athletes; allowing coaches and health care professionals to better determine how to prepare the team and individual athletes for certain games during a season. Determining which type of game, IC or OC, is more physiologically demanding is important in helping coaches and trainers develop practice plans to best prepare teams physically for upcoming competitions. The purpose of this study was to assess differences in physiological demands and performance variables between IC and OC games throughout a season for a NCAA Division I collegiate women's lacrosse team. To our knowledge this is the first study to compare game loads in collegiate women's lacrosse in this manner.

Methods

Study design and participants

This was an observational prospective study design. The team played in 17 games, 10 OC and 7 IC, during the 2019 season with one IC game going into overtime and one OC game going into triple overtime. The team played in 16 regular season games with game number 17 being a conference championship tournament game. The final mean RPI ranking for IC games was 79.6 and 54.8 for OC games, indicating that OC games were against higher quality opponents.

Participants were included if they were athletes on the varsity women's lacrosse team, 18 years of age or older, and cleared to play by an athletic trainer. Participants were excluded if they played in less than fifty percent of the games played during the 2019 season. There were 21 total female team members monitored during the season, but only 13 met the criteria of consistently playing throughout the season in both IC and OC games. These 13 players made up the final sample size. Written and informed consent was obtained from all participants before monitoring began. Research was approved by the University Institutional Review Board.

Procedures

Athletes were monitored during each game with VX Sport micro technology (Wellington, New Zealand). Each athlete wore a HR monitor (measuring at 2.4 GHz) and a unit consisting of a global positioning system (GPS, measuring at 10 Hz), 3-axis accelerometers (measuring at 104 Hz per channel), 3-axis magnetometers (measuring at 18 Hz), and 3-axis gyroscopes (measuring at 18 Hz). Previous literature has shown that 10 Hz GPS trackers and VX Sport micro technology were accurate and valid in tracking different metrics during athletic performance [12,13]. Each unit was specifically assigned to one athlete over the duration of the season. Units were turned on and distributed before each game then collected and turned off after completion of the game.

Workload variables analyzed included: total distance covered, distance rate, High-Intensity (HI) distance, number of HI sprints, Metabolic Equivalent Distance (MED), number of accelerations, number of decelerations, sprint repetitions in sprint zones four and five, and Training Impulse (TRIMP). VX Sport defines distance rate as distance traveled per unit of time, HID as distance covered at greater than 60% Maximum Sprint Speed (MSS), and HI sprints were counted when speed exceeded 80% MSS. Accelerations and decelerations were determined by a change in acceleration by more than ± 3 $m*s^{-2}$. MED is a VX Sport proprietary calculation determined by converting the extra energy cost due to accelerations and decelerations to meters. TRIMP is determined from the athlete's HR and duration of the session. These variables were selected to align with previous literature in lacrosse [2,8,9] and literature in women's collegiate soccer making similar comparisons between IC and OC games [11].

Statistics from each game were obtained from the university athletics website. Game stats included goals, shots, and shots on goal. These stats were taken during games in real-time by a university sports information director in accordance with the NCAA lacrosse statistician's manual [14].

Substitutions are made freely in lacrosse, so play time is not tracked. Instead, each athlete's Playing Time (PT) was obtained from the VX Sport software with warm-up, half time, and bench times taken out of the analysis. PT was determined from adding up the total time from each individual shift that corresponded to a spike in GPS tracking data. The added total time of each individual shift for a player during a game was the final number used. This was completed for every individual athlete with data during each game. Data were all analyzed per minute of time played to negate any discrepancies between game lengths or athlete play time. An athlete's total score for each metric within a game was divided by the number of minutes played in that game. There was poor reception from the HR monitor for 11 out of 216 instances, thus those 11 files were removed from analyses.

Data analysis

Player's averages for game metrics per minute of time played within IC and OC games were calculated. A repeated measures multivariate analyses of variance (RM-MANOVA) was used to evaluate differences in IC and OC for workload metrics (play time, total distance, distance rate, HI distance, number of HI sprints, MED, accelerations, decelerations, and TRIMP). A second RM-MANOVA was calculated to evaluate game performance (points, shots, and shots on goal) differences between IC and OC games. Subsequent univariate analyses were conducted with both RM-MANOVAs to assess which variables were different. Partial eta squared ($\eta 2$) effect sizes were calculated and interpreted as small (0.01), moderate (0.06), and large (0.14) (0.15). All data were analyzed using SPSS version 25 (IBM, Chicago, IL), with the alpha level set at (0.05).

Results

Table 1 shows the comparison between the average workload for IC ad OC games. There was a main effect difference by game type (Lambda(11,2)=290, p<0.001, η2=0.999). Univariate analyses indicated a higher workload for OC games than IC games for PT, total distance, distance rate, HI distance, MED, accelerations, and decelerations (all p<.001). Workload was also higher for HI sprints (p=0.005) and TRIMP (p=0.009). All η2 effect sizes are considered large.

	IC	OC	Effect Size
PT (min)	49.94 (12.2)*	67.42 (7.8)	0.653
Total distance (m/min PT)	145.54 (26.7)*	100.78 (8.0)	0.713
Distance rate (m/min/min PT)	1.15 (0.2)*	0.85 (0.1)	0.701
HI distance (m/min PT)	10.85 (2.9)*	7.82 (2.8)	0.803
HI sprints (num/min PT)	0.12 (0.5)*	0.09 (0.6)	0.495
MED (m/min PT)	215.69 (32.6)*	155.38 (13.5)	0.731
Accelerations (num/min PT)	4.41 (0.5)*	3.57 (0.3)	0.829
Decelerations (num/min PT)	1.01 (0.2)*	0.74 (0.1)	0.833
TRIMP (AU/min PT)	11.60 (5.2)*	6.96 (1.4)	0.445

Table 1: Comparison of workload rates between IC and OC games. Notes: In-Conference (IC), Out-Of-Conference (OC), Play Time (PT), High-Intensity (HI), Metabolic Equivalent Distance (MED), Training Impulse (TRIMP), Arbitrary Units (AU).

The main effect analyses for game performance indicated no difference between IC and OC games (Lambda(3,13)=1.693, p=.218, η2=.218). Data are shown in Table 2, and univariate analyses also indicated no difference for points (p=0.066), shots (p=0.354), and shots on goal (p=0.529). Effect sizes for points and shots are considered large and moderate respectively, while the effect size for shots on goal is considered small.

	IC	OC	Effect Size
Points	19.86 (8.4)	12.10 (7.7)	0.207
Shots	0.407 (0.1)	0.357 (0.1)	0.058
Shots on goal	0.827 (0.1)	0.807 (0.1)	0.027

Table 2: Comparison of in-game stats between IC and OC Games. Notes: In-Conference (IC), Out-Of-Conference (OC).

Discussion

Although there are no significant differences indicated for game performance, IC games had a higher workload per minute played, but OC games tended to require more PT per player. IC games showed higher demand placed on the athlete indicating that despite the lower PT, athletes spent more time playing at higher intensity as opposed to OC. This could possibly explain the lower PT for IC games as the more intense play was, the quicker athletes became fatigued and needed a recovery period. With OC games typically played during the beginning of the season and IC games played toward the latter, this could have an impact on PT results. Having better conditioned players later in the season, despite possible fatigue, could explain why players were able to sustain higher outputs creating greater overall workload for IC games. Even though it is important for players to be at their highest level during the end of the season for postseason success, this may emphasize the importance of designing offseason training programs which can be difficult.

Higher total workloads for IC games contrasts the results Bozzini et al. found in women's collegiate soccer, but the collective results are likely a result of a match-ups with opponents [11]. Playing against athletes with similar skill level requires a greater physiological workload to get open to receive a pass, create a shooting lane, or defend an opposing player. OC opponents had significantly better RPI rankings which could result in greater output being given in the initial stages, which was not sustainable for the game entirety, resulting in fatigue and a decline in workload per minute played. This was the opposite of Bozzini et al. in that IC featured better opponents that could have had a more "cautious" strategy whereas OC games included opponents that elevated their game causing a greater workload. However, Bozzini et al. and the present study both showed that in cases where teams were more evenly matched—OC games for Bozzini et al. and IC games for the present study—workload was higher per minute of PT[11]. These data support that the quality of the opponent matters a great deal in determining player workload.

Understanding how two teams match up during a game is highly important when comparing varying game demands. Better matchups for IC play may not have only been created by skill level, but by a team's postseason hopes relying heavily on IC play, resulting in both teams sustaining high intensity play to increase their chances at a postseason. Bozzini et al. discussed how player readiness may have an impact on PT with starters tending to play more [11]. On the contrary, player readiness and order of games could be a reason as to why the present study showed significantly higher PT for OC games. OC games were scheduled earlier in the season than IC games in the present study. As the season progressed, athletes tend to have a greater risk of becoming injured or needing to manage workload, which may reduce PT in IC games. Player readiness speaks to both fitness and game experience. For younger athletes, their readiness improves as the season progresses and they gain more game experience. Player readiness is not seen as a limitation to this study as it is something every team experiences because it takes time for players to develop and be able to perform at the collegiate level.

Previous research has examined external match load for women's collegiate lacrosse analyzing team physiological demands and breaking down further by positions [2]. Comparable to this study, Devine et al. analyzed distance, speed, and frequency measures as unit per game instead of unit per minute PT. Variables for all players included total distance (4,732 m), HI distance (656 m), HI sprint count (6 reps), accelerations (51 reps) and decelerations (38 reps). The results of this study, when converted to whole game by multiplying IC and PT for each variable, show: distance total of 7,268 m, HI distance of 541 m, 6 HI sprints, 220 accelerations, and 50 decelerations. HI variables are similar between the two studies, but the athletes in the

present study moved a much higher total distance and completed more accelerations and decelerations. It is acknowledged that the methods conducted for this comparison is a limitation and for a most accurate comparison the variables should be evaluated in the same manner. Based off Devine et al, it is also indicated that the game data from this study line up with comparisons to other female sports[2]. Female lacrosse players exhibit greater time spent in high intensity per game, but travel less overall distance, with these differences emphasizing the relevance of research in female lacrosse. Devine et al. divided the season into thirds to compare fluctuations in game workloads throughout the season, showing higher workloads in the final third of the season which included IC play and playoff games. Collectively these two studies support the notion that IC and playoff game workloads are higher than OC workload. Further investigations could attempt to go deeper by examining positional differences such as Devine et al did, finding that midfielders experienced greater overall totals and high intensity totals followed by attackers and then defenders [2]. Breaking down positional differences would increase the knowledge base on comparison of IC and OC games helping coaches and clinicians make decisions.

One limitation of this study was the way we assessed athlete playing time through shifts corresponding to spikes in GPS movement. All movement was tracked from these units, so any sudden increase in movement by an athlete was tracked and may not have pertained to actual playing time; however, attempts were made to differentiate between a random movement and actual time on the field. Another limitation was that the team evaluated had a higher RPI rating (meaning not as competitive nationally) and this could be a determining factor in why the results were different from Bozzini et al. [11]. Lastly, the data were collected for one team and further studies should be conducted to determine if the findings are universal.

Conclusion

These data can be used to help improve the knowledge of coaches and trainers for in-game coaching decisions as well as in season/ offseason training programs. Previous knowledge of game demands to date is limited to game averages with no specifics on game types. Analyzing demands by per minute of PT allows for a deeper understanding that can be taken further assessing each half and individual positions. This will enable coaches and trainers to design more specific training programs taking into consideration past and upcoming games to create a better work recovery cycle for the athletes. Improving training loads and recovery periods will help to prevent overtraining and undertraining in response to in season demands, keeping the athletes optimized for varying game loads while trying to sustain a high level of play over the course of the season. Training loads can be modified to the coaches' and trainer's preference utilizing the information gained from this study.

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