

ORIGINAL RESEARCH

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# EVALUATION OF ATHLETE LOAD AND RELATIONSHIP BETWEEN EQUATION VARIABLES IN DIVISION I WOMEN'S LACROSSE

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## ABSTRACT

Athlete monitoring companies have created an “all-in-one” variable to provide a composite score for external load, measured in arbitrary units (AU). This study aimed to evaluate the proprietary metric from VX Sport, Athlete Load (AL), for collegiate women's lacrosse across different positions, and compare training (T) to games (G). A secondary aim was to evaluate the relationship between AL, equation variables, and session rating perceived exertion. **METHODS:** Global positioning system units and heart rate monitors were worn by athletes (n = 22) during T and G. **RESULTS:** Analyses indicated no differences (p = 0.186) between T AL (48.0 ± 5.8 AU) and G AL (57.7 ± 32.8 AU), along with no positional differences (p = 0.913). Correlation analyses between equation variables indicated strong correlations during T and G for distance (T: r = 0.72; G: r = 0.99), HID (T: r = 0.78; G: r = 0.94), and sprints (T: r = 0.85; G: r = 0.81), all p < 0.001. Session ratings of perceived exertion was strongly correlated with G AL (r = 0.91, p < 0.001). **CONCLUSIONS:** The data suggest there was no difference between T and G, with AL more related to the intensity of the session rather than the duration.

**Keywords:** team sport, sports performance, athlete load

## INTRODUCTION

Sport microtechnology companies that measure variables through global positioning systems (GPS), accelerometry, and heart rate have created an “all-in-one” variable (AIM) to provide a composite score for external load. All are measured in arbitrary units (AU) but are calculated differently. Athlete Load (AL)

from VX Sport compares session outputs to predefined benchmarks in an equation combining the numbers into an aggregate score (1). Player Load (PL) from Catapult is calculated as the sum of accelerations across all axes that the tri-axial accelerometer detects during movement (2). Training Load (TL) from Polar Team Pro incorporates the intensity and duration of the session, personal

information, and aerobic and anaerobic thresholds (3). Although these metrics provide coaches with a simplified tool by which to manage training volume, comparison across these proprietary measures is difficult due to the varied calculations.

Existing literature has used the AIM as a means for quantifying an athlete's workload across various activities. Bredt et. al (4) reported that the AIM measures the magnitude of change in acceleration in all three axes (x, y, z), and the equations vary across studies (5–8) Similarly, previous studies have used AIM to analyze physical demands experienced by athletes in handball (9), cricket (10), soccer (6), and rugby during training and matches (11). PL was also found to have a strong association with session rating perceived exertion (sRPE) and heart rate (HR). Given the differences in calculation and usage of AIMS, two problems arise: 1) difficulty in understanding this variable as a descriptor for external or internal demand, and 2) difficulty comparing data sets between studies utilizing different measurement systems. In the existing literature using AIMS as a metric for quantifying load values, none were found using AL.

AIMs have been marketed as a “one number for all” variable, meaning that coaches will need to observe only that metric to know the demand players experience. The intended use of this metric highlights the need for a better understanding of what is being measured and which performance variables are most influential. The primary purpose of this study was to evaluate AL for collegiate women's lacrosse comparing training to games and across different positions. A secondary purpose was to evaluate the relationship between AL and the equation variables [duration total, total distance, high-intensity distance (HID), and total sprints] and sRPE. To

our knowledge there have been no studies that evaluated the equation variables or provided AIM data for collegiate women's lacrosse. Each variable was selected to align with previous literature in lacrosse (12–14) and previous literature evaluating AIMS (6,9–11)

## **METHOD**

### ***Study Design and Participants***

In this study a prospective observational study design was used. The team studied participated in 111 practices along with 15 competitions over a span of eight months. Practices observed were designed and supervised by the team's coaches with all activities performed included in the data analysis. Player warm-ups before each competition were also included in the analysis.

Participant criteria consisted of being on the varsity women's lacrosse team, being cleared to participate in training and competition by an athletic trainer, and 18 years of age or older. A total of 27 female team members were monitored over the course of one full training macrocycle (eight months). The final sample size included 22 athletes (8 attackers, 6 midfielders, 8 defenders), with five athletes excluded due to significant time missed. The athletes were aware of the monitoring process and were required to submit written and informed consent approved by the institutional review board. This study was conducted in alignment with the Declaration of Helsinki.

### ***Procedures***

The players were monitored using VX Sport microtechnology (Wellington, New Zealand). Each athlete was assigned a heart rate monitor and 10 Hz GPS unit for the duration of the training year, both of which were placed in a vest and positioned in the upper thoracic spine. Existing literature reports

VX Sport microtechnology and 10 Hz GPS trackers as valid and reliable (15,16)

Each unit was turned on outside approximately fifteen minutes before each training session to ensure satellite connections. Units were collected after each session and competition where data were uploaded to VX Sport software, trimmed to remove any downtime during the session, and split by drill.

VX Sport (Wellington, New Zealand) defines AL as a calculated metric that compares the session output to pre-defined benchmarks, which is then converted to a percentage and combined for an aggregate “load” score (1). The pre-defined benchmarks include distance (total distance covered during data collection), HID (distance covered at greater than 60% maximum sprint speed), duration (time in which data was collected), and total sprints (total amount of sprints falling under the sprint equation). Maximum sprint speed (MSS) for each athlete was determined at the beginning of each training macrocycle using three sprint bouts with a 20-m fly-in followed by a 30-m all-out sprint effort. Athletes recovered for approximately two minutes between bouts. The fastest speed obtained during these bouts was determined to be MSS for each athlete. This value was used to determine the threshold for HID at 60% MSS.

Athletes completed their session rating of perceived exertion (RPE) utilizing the VX Sport Cloud application at least thirty minutes after each session. Athletes rated the difficulty of the session using the Borg CR-10 scale (17). RPE values were multiplied by the duration of the training session to calculate sRPE (18).

### **Statistical Analysis**

The mean of each metric analyzed (AL, total distance, HID, duration, sprint

repetitions, and sRPE) for training and games was calculated for each athlete and used for analyses. A Shapiro-Wilks test was used to evaluate data normality. Results indicated that the data were normally distributed, thus parametric analyses were used. Data were analyzed using SPSS (version 27.0, Chicago, IL), and an alpha level of 0.05 was used to determine differences.

To address the primary purpose of this study, a repeated measures analysis of variance (RM-ANOVA) was used to evaluate differences between training and game AL by position. A Tukey post-hoc analysis was used to compare any specific difference in AL by position. Partial eta squared ( $\eta^2$ ) effect sizes were calculated and interpreted as small (0.01), medium (0.06), and large (0.14) (19).

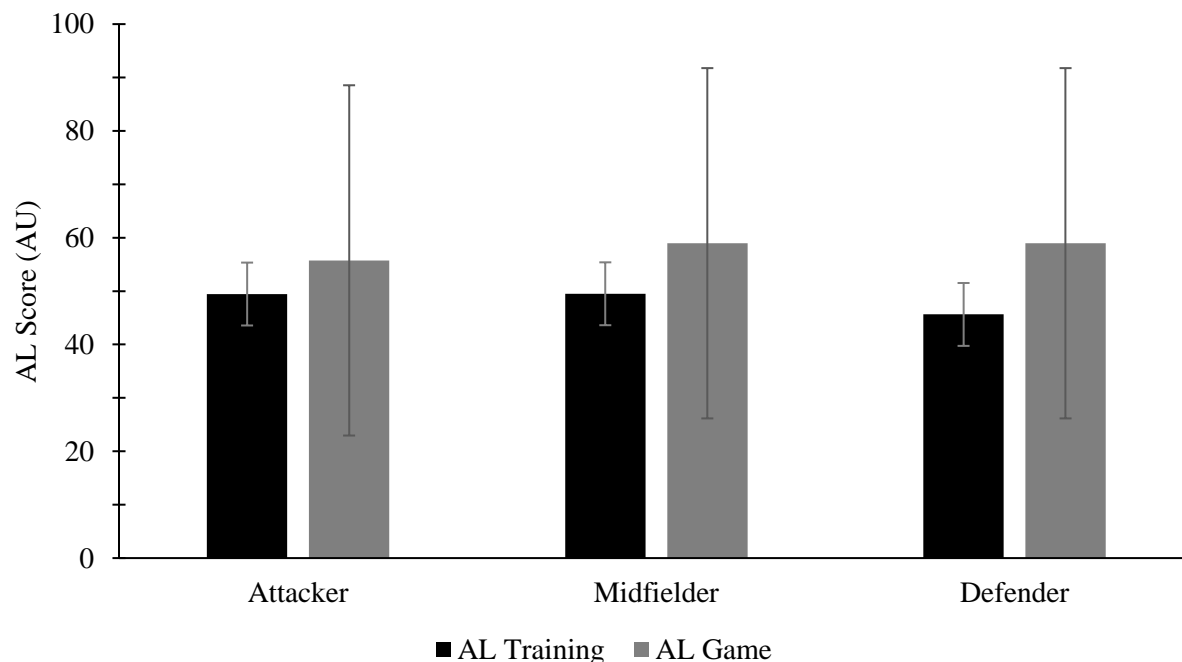
To address the secondary purpose of the study, Pearson correlation analyses were calculated between AL and training/game volume metrics (duration total, total distance, HID, total sprints, and sRPE) for both training and games.

## **RESULTS**

Figure 1 shows the means and standard deviations of AL by position for training and games. The overall mean AL score for all athletes in training ( $48.1 \pm 5.9$  AU) and games ( $57.8 \pm 32.8$  AU) were not different from one another ( $Lambda(1,19)=1.88$ ),  $p = 0.186$ ,  $\eta^2 = 0.09$ ). There was also no difference in training and games AL by position ( $Lambda(2,19)=0.09$ ,  $p = 0.913$ ,  $\eta^2 = 0.01$ ). The effect size for AL training to game is interpreted as moderate, while the effect size for AL by position is interpreted as small. Figure 1 shows the positional differences in means for AL training and game. Although there was no difference between training and games, AL during games was slightly higher

than during training, but with much larger variance.

Results from the correlation analyses are reported in Table 1. Distance, HID, and sprints were all found to be strongly positively correlated with training AL, while distance, HID, sprints, and sRPE presented a strong positive correlation with game AL. The relationship for all these variables indicates that an increase in one tends to increase the AL score for that session. A weak negative correlation was found between duration and sRPE with training AL and duration for game AL, however these did not achieve statistical significance.



**Figure 1:** Means for AL by position for training and games are as follows. Training: attacker 49.5 (± 5.7 AU); midfielder 49.5 (± 7.4 AU); defender 45.6 (± 4.7 AU). Games: attacker 55.8 (± 37.1 AU); midfielder 58.9 (± 33.2 AU); defender 58.9 (± 32.5 AU).

**Table 1:** Correlation analysis of training and game AL. Data are shown as r-value with the p-value shown in parentheses. \* indicates  $p < 0.05$ .

	<u>Distance</u>	<u>HID</u>	<u>Sprints</u>	<u>Duration</u>	<u>sRPE</u>
<u>Training</u>	<u>0.72 (&lt;0.001)*</u>	<u>0.78 (&lt;0.001)*</u>	<u>0.85 (&lt;0.001)*</u>	<u>-0.07 (0.076)</u>	<u>-0.03 (0.906)</u>
<u>Game</u>	<u>0.99 (&lt;0.001)*</u>	<u>0.94 (&lt;0.001)*</u>	<u>0.81 (&lt;0.001)*</u>	<u>-0.23 (0.303)</u>	<u>0.91 (&lt;0.001)*</u>

## DISCUSSION

The primary purpose of this study was to evaluate AL from VX Sport for collegiate women's lacrosse across different positions and compare training to games. A secondary purpose was to evaluate the relationship between AL and the equation variables and sRPE. The main findings of this study consisted of no positional differences between AL for training and games. Additional findings include strong correlations to training AL for distance, HID, and sprints with strong correlations to game AL for distance, HID, sprints, and sRPE.

When assessing positional differences, AL demonstrated scores between  $45.6 \pm 4.7$  AU and  $58.9 \pm 33.2$  AU for training and games, respectively. These numbers differ from existing literature, with McLaren et. al reporting PL scores between  $520 \pm 89$  AU and  $550 \pm 81$  AU (11). In handball, PL/min was calculated and reported for first ( $12.6 \pm 2.4$  AU) and second ( $12.9 \pm 3.4$  AU) halves (9), while in soccer mean PL was reported to be  $789.2 \pm 224.9$  AU (6). Although different sports were evaluated, there is clearly a difference in the way these AIM variables are calculated, making it extremely difficult to compare scores. This could be a result of different pre-determined benchmarks and differing equations.

Analyses indicated no significant differences in training and game AL by position, which is likely the result of appropriate training that mimicked the demands of competitions. In the present study, midfielders were tied for the highest AL score for both training and games, while attackers were found to have the lowest game AL with defenders having the lowest training AL. Similarly, Devine et. al reported midfielders had higher external load values (distance

traveled, MSS, and HID) followed by attackers, with defenders exhibiting the lowest for game competition (12). When analyzing sprints during games, Rosenberg et. al found midfielders reached higher MSS than attackers and defenders; however, attackers presented higher values for sprint zones 2 and 3 along with distance in zone 2 (20). These similarities with existing literature surrounding women's lacrosse provide evidence for coaching staff and researchers to utilize the AL metric as a tool in monitoring athletes.

The four metrics encompassing the AL equation, according to VX Sport, include total distance, HID, number of sprints, and total duration. Pearson correlation analyses indicated strong positive correlations for HID, distance, and sprints during training. Additionally, the same three metrics showed strong positive correlation for games. Notably, total duration presented no correlation to AL for training or games, indicating AL appears more affected by the intensity and volume of the session rather than the duration. Interestingly, sRPE exhibited weak negative correlation during training but strong positive correlation during games. As the other variables are more objective in nature, this difference may be due to the subjective basis of the sRPE variable and its relationship to training versus game environments experienced by players. Casamichana et. al reported sRPE having a large association ( $r = 0.76$ ) with PL from Catapult sports, although only training sessions were used in their analysis (6). Subsequent research may yield more insight in this area.

While this was the first study to examine AL as a training indicator for collegiate women's lacrosse, there are general limitations to acknowledge. First, inconsistencies of how AIMs are calculated by differing athlete monitoring companies make it

difficult to compare these “load” scores across studies. Second, game and training data were analyzed as group means rather than individually, which may offer further insight.

The current study presents the basis for future investigation of these metrics, including analysis of trends for AL between or within individual games, across or within seasons, or against selected competitors. These studies could aid coaches in managing workloads for athletes across different positions.

## CONCLUSIONS

A1M variables purport to offer value to coaches in assessing and managing athlete workload, however their proprietary nature makes it difficult for coaches and researchers to compare these measures to each other and to traditional variables. These data provide the foundational groundwork to understand VX Sport’s A1M, so this score can be implemented most appropriately. The data provide context for using AL by position within both competitive and training frameworks. Coaches could use AL in conjunction with sRPE as a simplified method to gauge objective and subjective volume. Examining variation of AL in response to different types of training (e.g., tactical, technical) and assessing changes in AL with acute to chronic workload ratios may be beneficial. Future analysis of AL could provide more insight of the value of utilizing this “load” score as an A1M.

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