

# Which performance markers have the greatest impact on lacrosse point production? A review

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## ABSTRACT

**Purpose:** The purpose of this literature review was to explore what performance markers have the greatest impact on lacrosse point production. **Method:** A literature search was performed using the Google Scholar database. All articles were accessed through a combination of the Lasell University Library and Indiana University Purdue University Indianapolis Library. Some journals that were included in this paper are Journal of Strength and Conditioning Research, The Journal of Sports Medicine and Physical Fitness, Journal of Athletic Enhancement, International Journal of Exercise Science and many others. The initial criteria for sources were set for peer reviewed articles within the last 10 years. Due to a void in research, older sources were included to help provide a bigger picture of the research. **Results:** Of the 32 studies, 12 looked at men's lacrosse, 16 looked at women's lacrosse, 2 studies collected data from both men's and women's teams, and lastly 1 included article looked at sports that were not lacrosse. Of the 32 studies, 24 of them explore performance markers, 2 studies explored exclusively point production variables, and 6 studies looked at the relationship between performance markers and point production. **Conclusion:** All studies included in this paper create a fundamental base of research for the sport of lacrosse. The base of suggestions from this article appears to be improvements should focus on decreasing body fat percentage, improving anaerobic training, and increasing muscular strength. All three of which could be linked together physiologically.

**Keywords:** Lacrosse, Men's lacrosse, Women's lacrosse, Team sport testing, Preseason testing, Speed, Power, Strength, Body composition, Minutes played, Starts, Aerobic fitness, Anaerobic fitness, Grip strength, Points scored, Lacrosse shooting.

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## INTRODUCTION

For a sport with roots that date back centuries, lacrosse continues to grow. Coaches continue to be presented with new issues. How can scientific review help coaches better develop the athletes they coach and the athletes' skill sets? With increased participation has come yet to elicit an increase in lacrosse specific published literature (Gutowski & Rosene, 2011). Lacrosse continues to grow in popularity; however, a lack of introduction to the game, lack of knowledge about the game, and a need for experienced practitioners continues to hamper to the development of the athletes that participate in lacrosse.

Lacrosse has grown tremendously (A Sport, 2021). US Lacrosse, the national governing body of lacrosse in the United States of America, reported in 2020 that youth participation had increased (A Sport, 2021). By US Lacrosse's account, they had experienced a combined growth of over 32% across all age groups from 2008 to 2018 (A Sport, 2021). Additionally, the National Collegiate Athletic Association (NCAA) reported that between 2003 and 2018, Division 1 (D1), the highest level of college sports in the United States, had seen increases in participation amongst their men's and women's programs (A Sport, 2021). The amount of NCAA D1 men's program that participated in men's lacrosse had increased by 61% over that 15-year time span (A Sport, 2021). Meanwhile, NCAA D1 women's program had increased by 97% over the same time span (A Sport, 2021).

With this rapid growth, has come a need for experienced coaches. Any level of rapid growth can leave gaps in a system or process that may have been missed in favour of progressing further. With a rapid influx of new players and programs, there is a void of coaches that are well versed in the game of lacrosse. This void ultimately leaves a sharp learning curve for many coaches. The coaches must not only learn the game of lacrosse but quickly figure out why the best players are the best. With time restrictions galore and an age of *time management* and *work-life balance*, can coaches draw from key performance indicators in the weight room to get a better idea of what to prioritize?

The goal of this paper is to explore the following question. Which performance markers have the greatest impact on lacrosse point production? Performance markers can include any measurable physical, or physiological, trait. Performance markers can be categorized by fitness tests that measure muscular strength, muscular power, muscular endurance, anaerobic cardiovascular ability, aerobic cardiovascular ability, and body composition. Each of those seven qualities can be tested in a variety of ways. Jumps and certain weighted movements, like the Olympic lifts and their deviations, can be used to measure muscular power. Muscular strength is often measured in one repetition maxes (1RMs). Anaerobic qualities could be linear in the form of sprints or multidirectional in the form of agility tests. Those are a few examples how each category can be further broken down for testing purposes. Alas, there is a scarcity of research directed at linearly following athletes and their performances outside, and inside, the field of play. This scarcity of individual athlete data may be due to a fear of losing a competitive advantage by coaches or researchers. The best comparative study was between starters and non-starters (Sell et al., 2018). This research found that starters were faster and possessed better change of direction qualities, as seen with faster 20- and 40-meter sprint times and three cone drill times. The starters also had greater vertical jump measurements. Sell et al. (2018) also suggested the notion that speed, change of direction, and muscular power abilities are drivers of players seeing the field. Additionally, body fat percentage and speed and agility performances were found to be inversely related (Collins et al., 2014). As body fat percentage increased, performance of speed and agility-based tests decreased (Collins et al., 2014). This would suggest the leaner the athlete, the faster they are. In a sport dominated by high-speed runs, a faster player will ultimately have more opportunities going towards the face of the goal (Hamlet et al., 2021).

Point production can be broken down to a combination of goals scored and assists. Further variables that may influence point production are the number of games started and total minutes played. Lacrosse is a sport based around scoring points through ball movement and placing the ball past a goalie into a goal. This means points produced could be a good indicator of success for an athlete. Points produced is the combination of goals and assists a player has. Factors that may influence point production is the number of starts a player has and subsequently, the total number of minutes played. The longer a player is on the field, the more opportunities to score will arise. Although the research is sparse for lacrosse, there is a study that examines ice time and scoring chances in NCAA D1 men's ice hockey. The results of this study from 2006 shows the mean playing time as 611 minutes of ice time and the mean of 2.5 scoring opportunities (Green et al, 2006). The top 5 teams with the highest average goals per game in men's ice hockey for the 2020-2021 season scored between 3.50 - 4.25 goals per game; however, the NCAA men's lacrosse teams that fit the same criteria scored between 11.50 – 15.25 goals per game (NCAA, 2021). Meanwhile, the NCAA women's lacrosse top 5 teams in goals per game averaged between 16.76 – 20.12 goals per game. This finding would suggest that a lacrosse player would have more chances to score in a similar amount of time on the field as compared to their ice hockey counterparts. From 1987-1991, NCAA D1 men's lacrosse Final Four game were analysed to find key statistics that may hint at winning probability (Plisk, 1994). The primary statistics contributing to winning games included *Goals* and *Save %* (Plisk, 1994). These statistics had very common variance rates (Plisk, 1994). This means that as goals went up, the other teams save % would go down. These variables were directly related to the outcome of each other and could influence that outcome of a game. All these findings could suggest at players that are on the field more often, are more likely to score, thus they have the chance to improve the chance of winning the game.

## METHODS

All research gathered for this paper came from the Google Scholar database. The Google Scholar database houses articles, theses, books, abstracts, and court opinions. Google Scholar sources all material from academic publishers, professional societies, online repositories, universities, and other various virtual sources. By using Google Scholar, the research came from a wide variety of sources. All articles were accessed through a combination of the Lasell University Library and Indiana University Purdue University Indianapolis Library. Some journals that were included in this paper are *Journal of Strength and Conditioning Research*, *The Journal of Sports Medicine and Physical Fitness*, *Journal of Athletic Enhancement*, *International Journal of Exercise Science* and many others. The initial criteria for sources were set for peer reviewed articles within the last 10 years. Due to a void in research, older sources were included to help provide a bigger picture of the research. The key article more than 10 years old include in this research is Plisk (1994). Keywords included in the initial search included the terms: lacrosse, men's lacrosse, women's lacrosse, team sport testing, preseason testing, speed, power, strength, and body composition. That list was later expanded to include the keywords: minutes played, starts, aerobic fitness, anaerobic fitness, grip strength, points scored, and lacrosse shooting. These keywords returned a total of 32 studies that were included in this paper.

## RESULTS

Of the 32 studies, 12 looked at men's lacrosse, 16 looked at women's lacrosse, 2 studies collected data from both men's and women's teams, and lastly 1 included article looked at sports that were not lacrosse. These results are highlighted in Table 1. Of the 32 studies, 24 of them explore performance markers, 2 studies explored exclusively point production variables, and 6 studies looked at the relationship between performance markers and point production. These results are further highlighted in Table 2.

Table 1. Sport in review.

Citation	Sport
Akiyama & Yamamoto, 2019	Men's Lacrosse
Akiyama et al., 2022	Men's Lacrosse
Bunn et al., 2022	Women's Lacrosse
Bynum et al., 2022	Women's Lacrosse
Collins et al., 2014	Men's Lacrosse
Comfort, 2014	Men's Lacrosse
Enemark-Miller et al., 2009	Women's Lacrosse
Gordon et al., 2013	Women's Lacrosse
Green et al., 2006	Other: Ice Hockey (Men's)
Greene et al., 2019	Both
Gutowski & Rosene, 2011	Men's Lacrosse
Hamlet et al., 2021	Women's Lacrosse
Hauer & Tschan, 2017	Men's Lacrosse
Hauer et al., 2021	Women's Lacrosse
Lockie et al., 2018	Women's Lacrosse
Kaczvinsky, 2021	Women's Lacrosse
Kipp et al., 2018	Men's Lacrosse
Kulakowski et al., 2020	Women's Lacrosse
Medina et al., 2017	Men's Lacrosse
Millard & Mercer, 2014	Women's Lacrosse
Morrill, 1980	Both
Parker et al., 2022	Women's Lacrosse
Plisk, 1994	Men's Lacrosse
Rosenberg et al., 2021	Women's Lacrosse
Schott, 2020	Men's Lacrosse
Sell et al., 2018	Men's Lacrosse
Swanson, 2018	Women's Lacrosse
Talpey et al., 2019	Men's Lacrosse
Vescovi et al., 2007	Women's Lacrosse
Vincent et al., 2015	Men's Lacrosse
Zabriskie et al., 2019	Women's Lacrosse

### **Performance markers**

Most research that focuses on lacrosse as the primary sport has an emphasis on measuring the physical characteristics of the athletes that play the game. Over a quarter, 7 out of 26, of the articles that focus on performance markers were related to internal or external loads or physiological profiling. This could suggest that practitioners are very interested in finding out more about the lacrosse athlete. Additionally, practitioners may be interested in profiling lacrosse athletes to help better understand how it relates to other more commonly studied sports. Five studies in this set focus on the lower extremities. The research looks at different lengths of time and different physical and muscular characteristics of the lower extremity. Three studies focus on the collection of preseason testing metrics. Two studies focus mainly on body composition. Additionally, two more studies focus on how trunk strength and stability may have a relation to balance and performance of a lacrosse athlete.

Table 2. Variable in review.

Citation	Variable Focus	Study Emphasis
Akiyama & Yamamoto, 2019	Both	Physical characteristics and shot speed
Akiyama et al., 2022	Both	Physical qualities and game activity profiles
Bunn et al., 2022	Performance Marker	Internal and external workloads
Bynum et al., 2022	Performance Markers	External workload and game performance
Collins et al., 2014	Performance Markers	Body composition and preseason tests
Comfort, 2014	Performance Markers	Changes in sprint, change of direction and jump performance over the course of a season
Enemark-Miller et al., 2009	Performance Markers	Physiological profiling
Gordon et al., 2013	Performance Markers	Trunk strength in relation to balance
Green et al., 2006	Both	On-ice performance and physiological profiles
Greene et al., 2019	Performance Markers	Core stability in relation to performance
Gutowski & Rosene, 2011	Performance Markers	Preseason testing
Hamlet et al., 2021	Performance Markers	High-Speed running density
Hauer & Tschan, 2017	Performance Markers	Physiological profiling
Hauer et al., 2021	Performance Markers	Activity profiling
Lockie et al., 2018	Both	Effects of carrying a stick for field-based testing
Kaczvinsky, 2021	Performance Markers	Cardiovascular endurance and muscular strength
Kipp et al., 2018	Performance Markers	Mechanical demands of power clean and jump shrug
Kulakowski et al., 2020	Performance Markers	Lower body power relation to sprint and change of direction
Medina et al., 2017	Both	Grip strength and shot speed
Millard & Mercer, 2014	Performance Markers	Lower extremity muscle activity during a shot
Morrill, 1980	Performance Markers	An early resource on weight training for lacrosse
Parker et al., 2022	Performance Markers	Physical capabilities and psychological skills in relation to performance
Plisk, 1994	Point Production	Regression analysis of Final 4 games
Rosenberg et al., 2021	Performance Markers	Sprint distance and zones by position
Schott, 2020	Performance Markers	Metric differences between games and practices
Sell et al., 2018	Performance Markers	Starters vs Non-Starters for testing
Swanson, 2018	Point Production	Draw control
Talpey et al., 2019	Performance Markers	Lower body muscle performance across a season
Vescovi et al., 2007	Performance Markers	Descriptive characteristic
Vincent et al., 2015	Both	Shooting Motion
Zabriskie et al., 2019	Performance Markers	Energy status and body composition

### **Point production**

The largest void in research for lacrosse seems to stem around how points are scored in lacrosse and what factors influence point production the most. The most significant study is Plisk (1994). The additional study in this series explores of draw controls influence the outcome of games.

### **Both performance markers and point production**

The remaining 6 studies looked to bridge the gap between performance markers and point production. Half the studies, three total, looked at the shooting motion. This was done either from a biomechanical standpoint or measured in terms of speed of the shot. Two of the remaining three articles looked at how physical capabilities impacted game performance. One study looked at lacrosse directly while the other was ice

hockey. The last article looked at how carrying a stick, a critical aspect of lacrosse, may influence performance testing metrics.

## DISCUSSION

Lacrosse athletes have been documented to exhibit similar fitness characteristics to basketball, soccer, and track athletes (Enemark-Miller et al., 2019). However, as lacrosse continues to grow, coaches may be unaware of the needs of a lacrosse athlete. Very early research hinted practitioners should train lacrosse athletes to increase maximal strength in the fewest number of sessions and the least amount of total time (Morill, 1980). The thought behind this logic was that lacrosse players needed the extra time to work on stick skills, such as, passing, catching, cradling, and shooting (Morill, 1980). As research has progressed, studies have found that attributes like speed, agility, and muscular power may have a greater effect on the performance of a lacrosse athlete (Gutowski & Rosene, 2011; Sell et al., 2018). Additional research suggests that physiological profiling of lacrosse athletes show homogeneity in results when separated by position (Vescovi et al., 2007). The researchers suggested the homogeneity may arise from relatively minimal playing experience when compared to other sports (Vescovi et al., 2007).

Recent profiling studies have shown different needs for each position (Akiyama et al., 2022; Hauer et al., 2021). A study of 13 games revealed that midfielders had greater quantities of time at top speed and larger total sprint distances (Akiyama et al., 2022). An additional study showed that defenders covered the greatest total distance per game (Hauer et al., 2021). Although the total distance covered may be a combination of aerobic and anaerobic abilities, research suggests that aerobic ability may not play as large of a role in success as initially believed (Sell et al., 2018). Additionally, Kaczyinsky (2021) noted no positional difference regarding aerobic fitness. Bynum et al. (2022) suggests that training for attackers should focus on agility while midfielders should focus on high intensity endurance and sprinting. This research would suggest that practitioners should shift training emphasis to anaerobic training methods (Akiyama et al., 2022; Bynum et al., 2022; Hauer et al., 2021; Kaczyinsky, 2021).

Anaerobic training methods are commonly referred to as sprint training (Reuter, 2012). It has been shown that physical fitness and speed are correlated with total game success (Parker et al., 2022). Bunn et al. (2022) and Rosenberg et al. (2021) found that average speeds in practice were much lower than those observed in game. An additional study found that not only was the average speed lower as suggested by Bunn et al. (2022) and Rosenberger et al. (2021) but the density of high-speed running did not align between practice and games (Hamlet et al., 2021). The finding from Hamlet et al. (2021) makes sense in the theory that if a similar or greater total distance is covered at a slower speed, as suggested by Bunn et al. (2022) and Rosenberg et al. (2021), then the density of high-speed running would be different as well. This would suggest that practitioners would be wise in their implication of speed-based training to help meet the demand of top speed found in game (Bunn et al., 2022; Hamlet et al., 2021; Parker et al., 2022; Rosenberg et al., 2021). The additional training of speed can take place throughout the year. Sprint speed can be improved across a 24 week in-season training block that with proper periodization (Comfort, 2014). The balance of speed training and sport schedule needs to be well thought as a study showed that when an athlete presents feeling like they have more energy, they cover further total distances during games (Crouch et al., 2021). The ability to continue to improve speed through the season, as mentioned by Comfort (2014), could play a large role in playing time. It was found that players that start games had faster 20-yard and 40-yard sprint times (Sell et al., 2018). The 20-meter, 50-meter, and Pro Agility tests were also found to be significantly correlated with the top speed of any lacrosse player (Akiyama et al., 2022). When programming sprinting practitioners can base their training around the principle of being able to produce large amounts of force through a short period

of time (Haff & Triplett, 2016). Additional consideration for practitioners is the need to focus on developing sound running mechanics instead of prioritizing running with a lacrosse stick. It was found that carrying a lacrosse stick does not generally affect linear speed or agility (Lockie et al., 2018). One way to prescribe sprinting intensity is through using a percent max heart rate or beats per minute of the athlete. The average heart rate for a total game was found to be  $158.4 \pm 42.6$  beats per minute (Bunn et al., 2022). Research additionally shows that an average heart rate of female Australian national player was  $75.3\% \pm 5\%$  of max heart rate (Hauer et al., 2021). Meanwhile, for a high school boy, the average heart rate was  $84.56\% \pm 5.15\%$  of max heart rate (Schott, 2020). Those articles give practitioners a reasonable guideline to follow when prescribing speed-based work in terms of maximal heart rate (Bunn et al., 2022; Hauer et al., 2021; Schott, 2020).

Another way to measure large forces during a short period of time is through muscular power testing. It was found that relative lower body power was significantly related to speed and change of direction ability in NCAA Division 2 female lacrosse athletes (Kulakowski et al., 2020). Additionally, it was found that starters had significantly higher vertical jumps than non-starters (Sell et al., 2018). As mentioned early in this paper, starters are often faster as well. This could start to suggest a strong relationship between lower body power and lacrosse performance. An additional study found when compared to their Austrian counterparts, male United States college lacrosse players had greater vertical jumps (Hauer & Tschan, 2017). This is important to note when working with athletes from outside the United States. The speed of an athletes shot has also been correlated to the athlete's ability to perform a vertical jump out of a crouch position (Akiyama & Yamamoto, 2019). The same study was able to correlate the distance an athlete throws a medicine ball to their vertical jump height (Akiyama & Yamamoto, 2019). The practical application for this finding is for practitioners that may not have access to a feasible way to measure vertical jump but possess the materials needed to measure medicine ball throws. From a periodization standpoint, exercise selection for developing muscular power may be biased depending on the exact adaptation along the force-velocity curve that is trying to be influenced (Kipp et al., 2018). Kipp et al. (2018) mentions the differences in programming a hang power clean and jump squat and how each exercise may fit a training stimulus differently due to mechanical loading patterns of the movement. Unlike sprinting though, relative peak force, reactive strength index, and squat jump measures all drastically decline through the season (Comfort, 2014; Tapley et al., 2019). Knowing that these qualities diminish quickly in-season, the practical application would be to look for ways to maximize the preseason baseline measure. This would allow for a greater quality after the initial value had diminished.

Some research exists for muscular strength (Gordon et al., 2013; Medina et al., 2017). Gordon et al. (2013) found that there was no correlation between hip external rotator strength, the bent knee lowering test, and lower extremity balance. This finding does seem odd considering Akiyama & Yamamoto (2019) concluded that strength and conditioning professionals should focus on trunk rotational strength to help improve shooting speed. Additional research has also stated that core stability may not directly impact performance variables in lacrosse athletes (Greene et al., 2019). An additional note on muscular strength, there is evidence to suggest that training with a wider bar may produce similar performance improvements with less total training volume in lacrosse athletes (Medina et al., 2017). No further research could be found to support or negate the claim.

The last major physiological quality that has been addressed by research is body composition. Research results have indicated that increased body fat percentage might be a detriment to the repetitive anaerobic performance and aerobic capacity vital to on-field lacrosse performance (Collins et al. 2014). A player carrying more body fat may not be able to compete at their highest level due to any restrictions placed by the increased total mass. There has been a mention of a significant correlation between body composition and

performance results for vertical jump, linear sprint, and 1.6km tests (Hauer & Tschan, 2017). The lower an athlete's body fat percentage, the better their scoring on fitness tests (Hauer & Tschan, 2017). Additionally, starters were noted to possibly have lower body fat percentages (Sell et al., 2018). It has been observed that body composition changes throughout the course of a lacrosse season (Zabriskie et al., 2019). As practitioners there should be an awareness of how body composition plays a role in performance; however, the appropriate guidance should be given by a licensed professional. This means nutritional guidance should be handled by licensed dietitians when applicable.

Statistically, lacrosse has many stats that are like other sports and a few that are different. A Plisk (1994) study took 15 consecutive games from NCAA men's lacrosse Final Fours and completed a regression analysis of select statistics. Plisk (1994) found the primary statistics contributing to winning games included *Goals* and *Save Percentage*. These statistics had very common variance rates (Plisk, 1994). This means that as goals went up, the other teams save percentage would go down. They were directly related to the outcome of each other. The next metric in the hierarchy was *Assists* (Plisk, 1994). It was suggested the assist may be used as a key indicator for offensive and defensive efficiency (Plisk, 1994). When a team can complete many passes, they have a higher offensive efficiency. When a team defensively does not allow many assists, it would show greater defensive efficiency. The tertiary, or in this case bottom, metrics in the hierarchy of game success include *Percent of Ground Balls*, *Percentage of Score*, and *Shots on Goal* (Plisk, 1994). Percentage of ground balls is the ability a team must pick up a loose ball and initiate a transitional play from defence to offense, or vice versa. Percentage of goals would mean the percent of shots that result in a goal. Lastly, shots on goal would be the total number of shots that are either saved or result in a goal. Occasionally, shots in lacrosse will go wide and miss the goal frame, much like an air ball in basketball. These three statistics play a large role in predicting goals and assist (Plisk, 1994). Diving deeper into the primary indicators of success, the primary indicator of *Goals* was found be *assists* (Plisk, 1994). The primary indicator of *Save Percentage* was, indeed, the number of *Saves* made (Plisk, 1994). The application of this data may be taken lightly due to the relatively low *n* value of games at 15 but future studies could continue to farther the understanding of how a box score can help the practitioner dictate training.

The action of shooting is the movement initiated by the athlete to score a goal. With *Goals* being one of two statistics that dictate the outcome of a lacrosse more than others (Plisk, 1994). An athlete's ability to shoot becomes vital. With shooting being the primary means of goal scoring, shooting directly impacts over half of an athlete's ability to produce points. Point production is simply the sum of goals and assists. Studies have looked at muscles and bony structures of both the upper and lower extremities (Millard & Mercer, 2014; Vincent et al., 2015). The results from analysing the shot from the ground up is as follows. When an athlete is shooting at game speed, as opposed to practice, there is greater activation of the rectus femoris, biceps femoris, and gastrocnemius (Millard & Mercer, 2014). It was found professional players have greater range of motion regarding trunk rotation (Vincent et al., 2015). Professional players also had the greatest amount of transverse shoulder rotation range of motion in both their dominant and non-dominant sides (Vincent et al., 2015). The combination of increased ranges of motion allows for professional players to have faster shooting speeds (Vincent et al., 2015). These findings would suggest an emphasis on improving flexibility in the traverse plane in the shoulders and trunk while improving muscular strength in the lower extremity to improve shot speed (Millard & Mercer, 2014; Vincent et al., 2015).

Often faceoffs, for the men, and draw control, for the women, are seen as key moments within a game. A study shows that when a team wins in women's lacrosse, 86.1% of the time they won the draw (Swanson, 2018). There is no study on this for the men's game and the faceoff that occurs at start of quarters and after goals. This topic is of interest because faceoffs and draw controls can be seen as controlled groundball



situations. *Percent of Groundballs* was mentioned as a statistic that plays a role in teams winning games (Plisk, 1994). Research on the success of faceoff and draw controls with their impact on game outcomes could be a topic for further research.

## CONCLUSION

As lacrosse grows, coaches are continually faced with the need to coach more players and this only spreads resources thinner. The ability to pinpoint key attributes that may influence the outcome of games becomes vital to save the resource of time. The rapid expansion of lacrosse that has been seen from youth to college has brought challenges to the lacrosse coaching community (*A Sport*, 2021). Many practitioners may be unfamiliar with the sport. The rapid boom of participation has not brought a proportional level of research (Gutowski & Rosene, 2011). That lack of knowledge and research may leave practitioners misguided. The goal of this paper is to help provide greater insight into factors that influence the outcome of a lacrosse game. The hope of this goal is to further the development of lacrosse by providing greater insight into the sport of lacrosse to new or unfamiliar practitioners. Overall, there is a need for continued research in relation to key performance indicators, meaningful statistics, and other factors that may influence the quality of lacrosse play.

The current research that is available is overall very well executed. All studies included in this paper create a fundamental base of research for the sport of lacrosse. The base of suggestions from this article appears to be improvements should focus on decreasing body fat percentage, improving anaerobic training, and increasing muscular strength. All three of which could be linked together physiologically. As speed is built off the ability to produce powerful muscle contraction and muscular power is built off the ability to produce a force quickly, the less mass there is to move with a force the greater the impact of the force.

Moving forward, the need is for more research focused around both men's and women's lacrosse. A continued increase of research about performance markers in lacrosse could be necessary in growing more of a database to pull from. Continued research on topics like aerobic performance and muscular strength should be continued to be added as comparisons to current literature. More specific topics like grip strength, the role of the forearm muscles, and trunk movements should be added to get an even more detailed picture into lacrosse. Literature involving variables that factor into point production should be the primary focus of future research. The current literature looking at player statistics and game outcomes are almost non-existent. This an area of literature that can be improved upon. Specific topics that need addressed is how total minutes played impact scoring chances and how the skill-based components of lacrosse factor into the ability to score. Current literature on minutes played and scoring chances currently exist for other sports. The skill needed to use a lacrosse stick can hamper the ability of athletes to understand how to use it efficiently, which could impact any future research looking at inexperienced athletes.

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## DISCLOSURE STATEMENT

No potential conflict of interest was reported by the author.

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