Spring 5-8-2021

Women's Collegiate Lacrosse Team Cardiorespiratory Fitness and Muscular Strength

Kaylee Kaczvinsky
Coastal Carolina University

Women's Collegiate Lacrosse Team Cardiorespiratory Fitness and Muscular Strength

By

Kaylee Kaczvinsky

Exercise and Sport Science

Submitted in Partial Fulfillment of the
Requirements for the Degree of Bachelor of Science
In the HTC Honors College at
Coastal Carolina University

Spring 2021

Justin Guilkey

Louis E. Keiner
Director of Honors
HTC Honors College

Justin Guilkey, Ph.D.
Assistant Professor
Department of Kinesiology
Gupta College of Science

Abstract

The study is characterizing cardiorespiratory fitness and muscular strength in women's collegiate lacrosse players. It will examine maximal heart rate, maximal oxygen consumption and hamstring and quadriceps muscle strength and compare between positions. There are multiple athletes that each play a different position which will affect their cardiorespiratory fitness and muscular strength. For maximal heart rate and oxygen consumption, a cycle ergometer will increase in work rate until the point of fatigue. A Cosmed Quark metabolic cart will measure oxygen consumption and heart rate. The muscular strength test measures the athlete's quadriceps and hamstring ratio at two different isokinetic speeds. It is expected that positions require the athlete to be up and down the field the whole game will have greater aerobic fitness, while positions like the goalie will have lower aerobic fitness. Positions of power, like goalie, are going to have stronger hamstrings and quadriceps. The results of this study showed no differences between positions for the lacrosse players.

Introduction

Lacrosse is an outdoor team sport where individuals are constantly running on a lacrosse field. The goal of the game is to throw the lacrosse ball from player to player or run with the ball in a lacrosse stick to go score a goal. The different positions are important to know in lacrosse because some players only play half the field during the match, while other positions play the whole field. The players that play the whole field during the match should have a higher VO_2max than someone who does not play as intense or as much in a game because they are going to be running around the whole game and need to be conditioned so they do not get tired or fatigued quickly.

A lacrosse game is generally performed in the aerobic and anaerobic domains. Some intervals during the game are low-moderate intensity, while other intervals of the game are at a high-intensity level. Aerobic exercise is performed in lacrosse players every day (Taylor, 2017). Aerobic exercise is any exercise that requires oxygen. In this case, aerobic exercise contributes to walking/jogging/running on the field and biking on the electronically braked cycle ergometer. Positions were determined from Coastal Carolina University Women's Lacrosse Roster. There are 4 positions in lacrosse (Attack, Defense, Midfield, Goalie). Attack (offense) plays the whole field. Attack has a high intensity level during a match because they are running back and forth on the field the whole match. Midfield is light-moderate intensity position because they only play half the field. Defense is moderate-high intensity because they need to be stopping the other team when they have the ball (Taylor, 2017).

The hamstring-to-quadriceps ratio is tested in this study because the coach wanted to find out if his players were more likely to tear their ACL or not. The reason being is, there have

been studies done that have concluded that the higher your hamstring-quadricep ratio is, the less likely you are to tear your ACL and have an ACL injury (Alentorn-Geli et al, 2009).

Muscle strength is the amount of force you can put out or the amount of weight you can lift. This is important for lacrosse because strength is a key component of power (Cronkleton, 2019). The legs need to be strong and powerful (quadriceps & hamstrings) for sprinting speed. VO_2max is the maximum amount of oxygen a person can utilize during intense exercise. VO_2max is important for lacrosse. Players because you are running back and forth on the field almost the entire match, so they need be conditioned to be conditioned to be able to not get tired or fatigued quickly. Percent body fat (%. BF) is the total mass of fat an individual has vs. their total body mass. Fat free mass (lean body mass) is everything your body is made up of except fat. Muscle mass is the amount of muscle that makes up an individual's body. Thinking about lacrosse players and being on a collegiate team, they are going to have to be on a certain diet intake and training program. All of the players will have similar eating habits. Eating correctly and exercising is associated with better performance and decreased injury.

Having an understanding of the physiological, physical and anthropometrical norms of division I female lacrosse players during preseason conditioning will help the training the player personally and also help the coaches get a sense of what needs to be done during training before the preseason and how these tests effect the overall team. The purpose of this study is to test NCAA Division I Women's Lacrosse Coastal Carolina players aerobic fitness, muscular strength and %BF to compare based on position (Attack, Midfield, and Defense). It was hypothesized that athletes who play Attack or Midfield will have a higher VO_2max then an athlete who plays Defense. Additionally, lower %BF and greater muscular strength should be

found in the athletes that will have a position that plays longer out on the field and more intense than a position that does not play as long or as intense.

METHODS

Subjects

The participants of this study are from the NCAA Division I Coastal Carolina University Women's Lacrosse team. All testing took place during the pre-season conditioning. Each athletes position was gathered from the lacrosse team roster on the official university website.

Anthropometrics

The Bod Pod test is being tested to measure body composition of each player. Anthropometric measurements were made by air displacement plethysmography. The individual sits in the Bod Pod and has the least amount of clothing on. They have their hair up and in a cap. They only have their sports bra and shorts on. The clothing should be tight. The participants were supposed to sit still and let the measurements be taken. The subjects will wear the exact same clothing for all testing. Thoracic gas volume is estimated for all subjects using a predictive equation integral to the Bod Pod® software. The calculated value for body density will use the Siri equation to estimate body composition. Data from the Bod Pod® will include body weight, percent body fat, fat free mass and fat mass.

Muscle Strength

Muscle strength of the knee extensors and flexors was measured on a Biodex isokinetic dynamometer. After a 5-min warm up on a cycle ergometer, participant will be fitted to the isokinetic dynamometer, according to manufacturer instructions. The individual sat in the chair and was strapped into the chair so the only force could be produced was from the kneed

extensors and flexors. The right legs was tested first. The participants, while strapped in, were to kick their right leg out as far as they could and pull it back in as fast as they could while taking measurements. Knee extensor and knee flexion strength was tested on each leg at two different speeds, which were 60 /sec and 30 / sec. There was one practice trial on each leg to get a feel for the speed of the machine. Then the next 2 trials were maximal contractions for the right leg. Then the same procedure was done for their left leg. For each speed (60 /sec and 300 / sec), the highest force created during any of the trials was considered peak force.

Aerobic Fitness

This test was performed on an electronically braked cycle ergometer and a Cosmed Quark PFT metabolic cart was used to test the VO_2max of the lacrosse player. Prior to exercise, the Borg rating of perceived exertion scale was explained using a standard set of instructions. After reading the instructions the subject will be asked a series of questions to his ensure understanding of the scale. Before each test the equipment will be calibrated via manufacturer's instructions.

The graded exercise test started with a low exercise intensity (20W) for four minutes. The intensity was then increased by 20W every minute until the athletes reached volitional fatigue. The VO_2max test should last between 10-15 minutes for each athlete. The participant wore a face mask with a breathing valve to measure oxygen consumptions and carbon dioxide production. Additionally, a HR monitor was used to measure heart rate. From this test, VO_2max, WR max, and HR max were considered the highest recorded oxygen consumption, heart rate and work rate during the test, respectively.

Statistical analysis

All statistical analyses were conducted on Sigmaplot 14 statistical software. All athletes were placed into groups based on their position. Goalies were excluded from the analysis because of the uniqueness of the position compared to the field positions. A one-way ANOVA was used to compare differences in aerobic fitness, muscular strength and body composition between groups. Subsequent pairwise post-hoc comparisons were made when necessary. Statistical significance was established if $p \leq 0.05$. All data are shown as mean ± standard deviation.

Results

Anthropometric and Body Composition

Anthropometric measurements by positions are shown in Table 1. There were no differences in height or weight the positions. The body composition analysis showed that there were no differences in percent body fat, fat mass, or fat-free mass between any of the positions.

Table 1. Anthropometric Measurements.

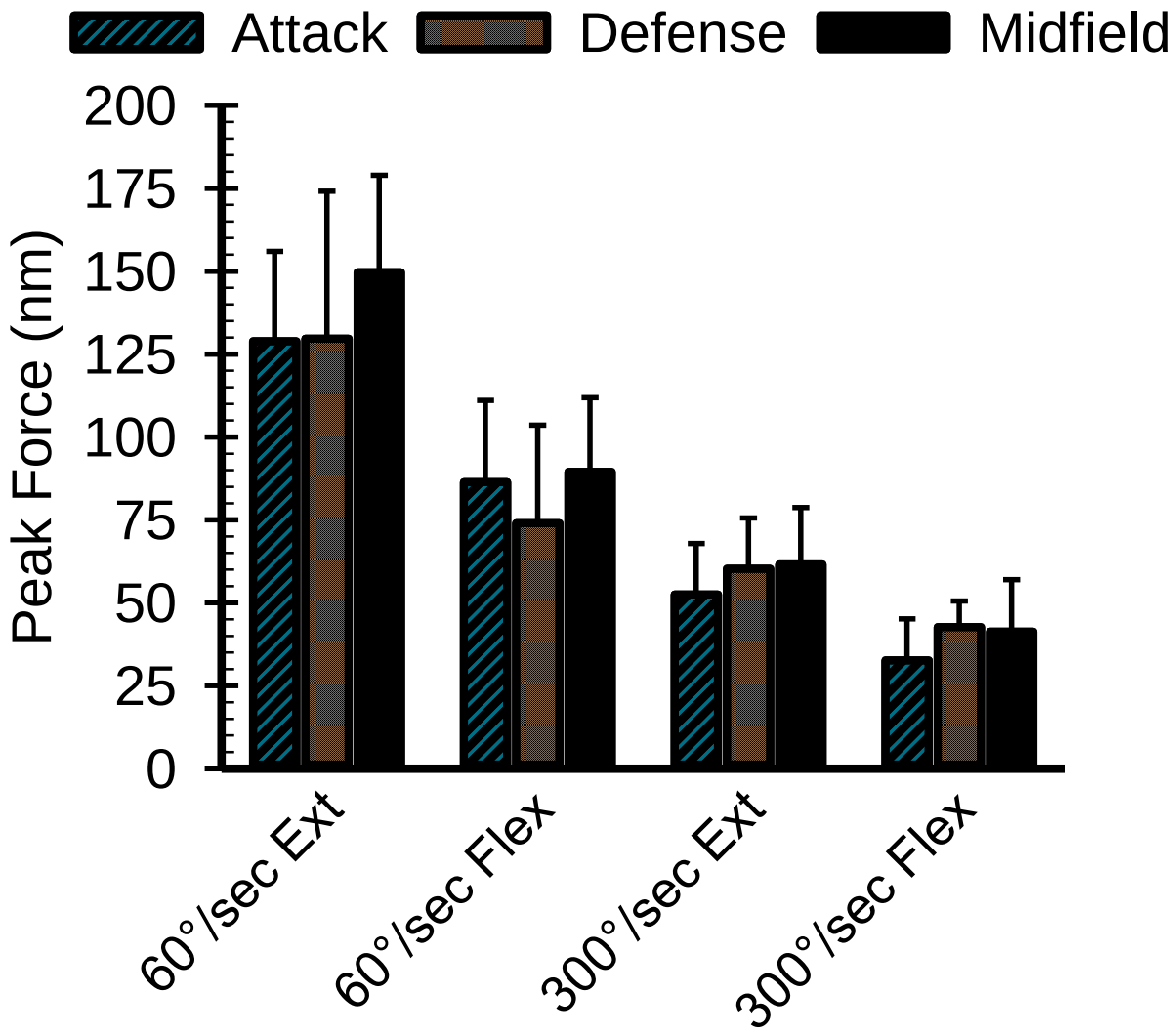
	Height (cm)	Weight (kg)	Body Fat (%)	Fat Mass (kg)	Fat-Free Mass (kg)
Attack	167.1 ± 18.7	69.2 ± 47.8	27.8 ± 5.6	18.7 ± 5.6	47.8 ± 3.3
Defense	163.8 ± 14.9	63.2 ± 48.3	22.9 ± 5.1	14.9 ± 5.1	48.3 ± 4.4
Midfield	166.8 ± 16.3	65.2 ± 48.9	24.8 ± 4.6	16.3 ± 4.6	48.9 ± 4.6

Values presented as means ± sd.

Knee Extensor and Knee Flexor Strength

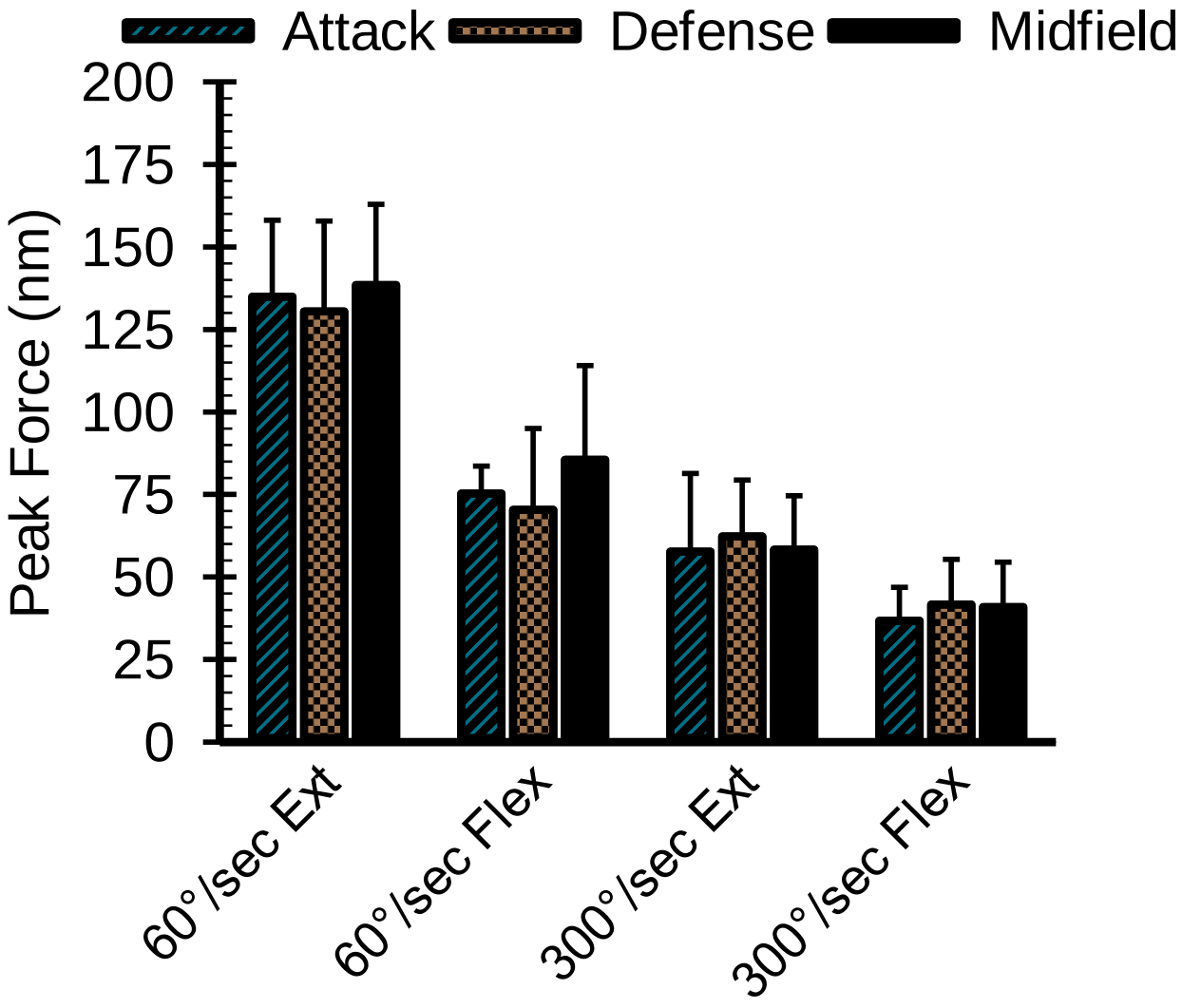
Knee extensor and knee flexor peak forces at 60 deg/sec and 300 deg/sec for the right leg and left leg are shown in figure 1 and figure 2, respectively. For the right leg, knee extensor and knee flexor peak force was not different between positions for 60 deg/sec or 300 deg/sec. However, there was a difference in peak force between 60 deg/sec and 300 deg/sec for knee extensor and knee flexor peak force in all positions. For the left leg, knee extensor and knee flexor peak force was not different between positions for 60 deg/sec or 300 deg/sec. However, there was a difference in peak force between 60 deg/sec and 300 deg/sec for knee extensor and knee flexor peak force in all positions.

Figure 1 Right Leg Knee Extensor and Knee Flexor Peak Force.



Values presented as means ± sd.

Figure 2. Left Leg Knee Extensor and Knee Flexor Peak Force.

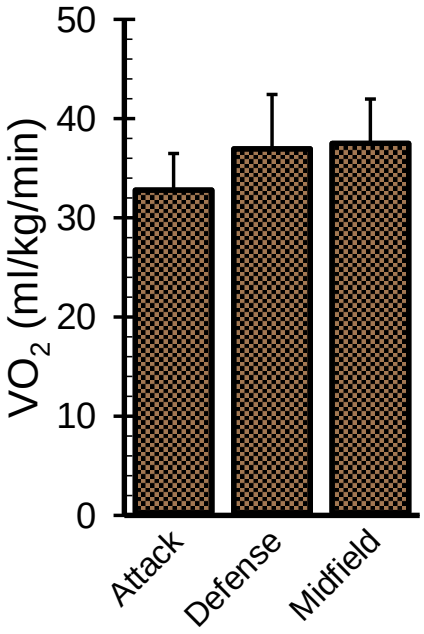


Values presented as means ± sd.

Aerobic Fitness

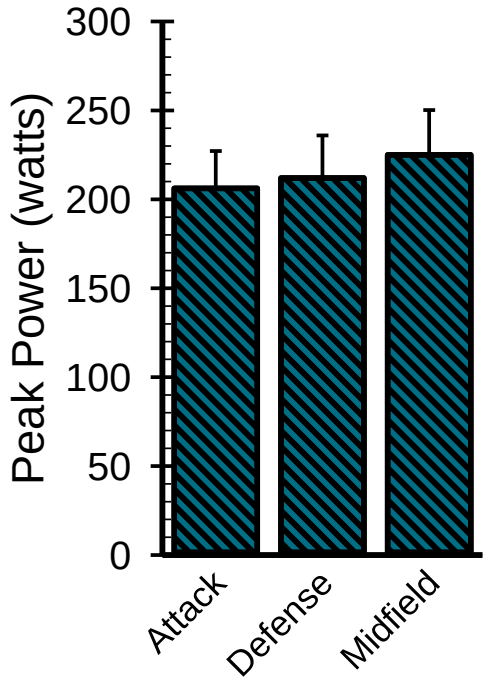
VO2peak, WRpeak and HRpeak are shown in figures 3, 4, and 5, respectively. There were no differences in any of the aerobic fitness measurements between positions.

Figure 3. Maximal Oxygen Consumption



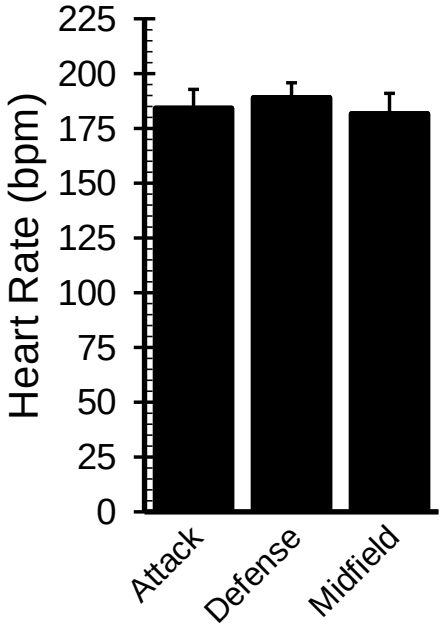
Values presented as means ± sd.

Figure 4. Peak Power



Values presented as means ± sd.

Figure 5. Peak Heart Rate



Values presented as means ± sd.

Conclusion and Practical Application

The purpose of this study is to test NCAA Division I Women's Lacrosse Coastal Carolina player's aerobic fitness, muscular strength, and % BF to compare based on position (Attack, Midfield, and Defense). Based off of this study, we concluded that the results were not significantly different between positions. There was no significant difference between body composition, muscle strength or aerobic fitness, regardless of the lacrosse player's position. While there

were no statistical differences, there were a few numerical differences in the data. Looking at the anthropometrics graph, the data shows that defense has the lowest %BF (22.9) and fat mass (14.9) and has the highest fat-free mass (48.3). Attack has the greatest %BF (27.8) and fat mass (18.7) and a lower fat-free mass (47.8) than defense. When each lacrosse player did the Biodex isokinetic dynamometer test, the results were pretty close together for the overall average peak force for the left and right leg. Midfield has the overall highest average for the right and left leg. Attack and Defense had very close overall average results between the left and right leg. The electronically-brake cycle ergometer test was measuring peak power, VO_2 and heart rate. Overall, attack had the lowest numbers for peak power, VO_2max, and heart rate max. Defense and Midfield were both close in results once again.

Being an athlete, it is important that you have more fat-free mass and a low %BF. You are going to be running on the field and wanting to be able to move quickly. The leaner you are, the quicker you will be. The excess fat is not good. Looking at fat mass compared to fat-free mass for a player is comparing how much fat is on someone vs. how much of everything is made up of someone except fat. This study found that body composition between positions were very similar. With the different positions you would think that the goalie and midfield positions might have a higher %BF and Fat mass than the defense and attacks. However, this study was only done in the pre-season, so all results were based on off-season voluntary training (Vescovi et al, 2007). I did not expect the results to be so close together between positions. Before this study was done, I interpreted that the less active players are going to be the ones with the greater body composition and the more fit players are not going to have as high of a body composition. Other studies seem to have a little bit more range in body composition between

positions than this study, and the averages were lower compared to our study looking at the data tables (Sell et al, 2018). For training/ performance, the coach is probably coaching his players to all train the same way that way they can all perform at the same level regardless of height or weight or position. A practical application for the coaches specifically with body composition could be that they have certain positions eat on one diet and a different position eat a different kind of diet because some players need to be more lean and quicker, while some need to be stronger, but are not moving as much.

The importance of muscle strength in athletes/ lacrosse players is that these players have strong leg muscles to hold them up and have a greater range of mobility and quickness out on the field. The stronger the leg muscles are, the less likely of an injury occurring. The muscle strength test was done at two different speeds. The legs need to be strong and powerful for sprinting speed. Overall, the hamstring to quad ratio should be pretty similar. The closer the numbers are, the less likely you are to tear your ACL (Alentorn-Geli et al, 2009). Lacrosse players should have strong quadriceps and hamstring muscles because they are running around on the field, twisting, pivoting, and making different movements with their bodies to throw the ball. The strong leg muscles will help them be able to last longer out on the field and not fatigue as quickly. The results in this study shows that the quadricep to hamstring ratio overall average was very similar and there was not really a difference based off of position. Muscle strength was very similar in the results in this study. It was surprising because based off of different leg sizes and different weight and height of each of the player, the overall average for the team had very close results even though a goalie player had a lot larger quadricep and hamstring muscles compared to a midfielder player's leg. For training and

performance for muscle strength, the stronger the quadricep and hamstring muscles are, the quicker the player's sprinting speed will be. Out on the field, you want to have quick legs and be able to be fast on the field.

I did not expect the muscle strength results to be as close as they were, solely because of looking at the size of each player and their position and assuming that the bigger leg muscles would have more strength than someone with smaller leg muscles. Other studies had results that were different and the results were not as close (Sell et al, 2018, Hoffman et al, 2009, Vescovi et al 2006, Vescovi et al 2007). I think these studies had had different results because men's division I lacrosse team was being tested instead of women's and although the men tested at pre-season, they conducted their tests at the end of pre-season when all scrimmages and practice games had been completed. Their testing time was scheduled from 6:30-8:30 AM, while this study, all the women were scheduled from 3:00-5:00 PM (Sell et al, 2018). Another study had 24 women participate and this study had 36 women participate (Enemark-Miller et al, 2009).

There was a force/velocity relationship, as well as muscle power (force x speed). The slower speed will give us a better idea of their overall strength, and the faster speed is closer to the speed they are contracting during a match. A practical application for the coaches specifically with muscle strength would be working in the weight room with the players and having the positions that need to have greater sprinting speeds out on the field, work on the leg press and quadricep/hamstring exercises and increasing the load to have greater leg strength than the positions that are not moving as much.

The importance of measuring VO_2max and HRmax in athletes/lacrosse players is going to measure the maximum amount of oxygen uptake. When athletes are out on the field it is important that they are conditioned and able to be out on the field for longer periods of time. If you are someone who does not have a high VO_2max, then you are more likely to get fatigued sooner than someone who has a high VO_2max. The lacrosse players practice and have games every week during the season. They train in the pre-season to get ready for the lacrosse season. It is important that everyone is doing what they are supposed to do that way they can perform well. In this study, the results show that everyone is pretty similar no matter their position. The coaches could possibly be training in a way to make the team all be around the same fitness level. This might be a good thing for when they are playing in games. Goalie and Midfield players do not run around the field as much as the Attack and Defense players. Seeing that there are really no difference in VO_2max and HRmax could mean that everyone does have the same or very close VO_2max and HRmax. The height, weight, and position of the player might not make a difference in the results. What makes a difference, is the training program and how each player trains every day in the weight room and out on the field. The different drills are the same for each position. If you want to see a difference in results, maybe change up the drills and do specific drills for that specific position. Do not give a goalie drill to a midfielder position because they are not doing the same type of movements and running out on the field. For training/performance the similar results for VO_2max and HRmax between positions show that the team most likely is training the same. This means that out on the field, no matter what position you are, the coach could likely play you in a different position if needed. If every teammate has around the same fitness level, then they should be able to run around the whole

field or half field depending on where they are needed. Performance is going to be good out on the field and training is going to be the same patterns. Before doing this study, I expected to see differences in aerobic fitness between positions. The reason being is because when you are defense or attack, you are going to be playing the whole field during the game. If your position is midfield, then that player only has to cover half of the field when they are out there. A goalie's job is to defend the goal, which is the least amount of surface area covered. Most of the time the goalie will be standing around or moving at a light intensity until the ball is on their side of the field. A practical application for the coaches specifically with VO_2max and HRmax. A practical application specifically for the VO_2max and HRmax would be when the players are using their HR monitors during practice and looking at each position and how hard they are working compared to another position player. The more fit you are, the higher VO_2max you will have. The coaches could look at the statistics of this study and do a post-season study and see if any of the player's aerobic fitness numbers changed or not. The players have heart rate monitors during practice and can get more individualized training intensities.

A limitation to this study could possibly have better results if the players did post-season testing. In the future, a good study would be to test the girls in their pre-season and also test them in the post-season right after they finish the season. The next study will compare the pre-season results like we have in this study and by testing them in the post-season we want to know the difference in each of the three tests again. The study will want to see if the goalies and midfield player's numbers really change because they are not going to be training like they were all together doing the same exact training as a whole team. Once the games start, the goalies and defensive players are not going to be as active as the attack and midfield players. Is

the coach purposely training the team all to train the exact same? Could we see better results if they training for each specific position instead?

This study concludes that the results were not significantly different between positions. There was no difference between body composition, muscle strength or aerobic fitness regardless of the lacrosse player's position. The lacrosse coaches can take this information and train their athletes the way they have been or change up the training. Currently the training appears to have the same impact on all athletes. Future training could be made more specific towards position and the specific demands of each position.

References

1. Alentorn-Geli E, Myer GD, Silvers HJ, Samitier G, Romero D, Lázaro-Haro C, Cugat R. Prevention of non-contact anterior cruciate ligament injuries in soccer players. Part 1: Mechanisms of injury and underlying risk factors. Knee Surg Sports Traumatol Arthrosc. 2009 Jul;17(7):705-29.
2. Cronkleton E. What is Muscular Strength, and What Are Some Exercises You Can 2019 Oct.
3. Enemark-Miller EA, Seegmiller JG, Rana SR. Physiological Profile of Women's Lacrosse Players. Journal of Strength and Conditioning Research. 2009 Jan; 23(1): 39-42.
4. Hoffman JR, Ratamess NA, Neese KL, Ross RE, Kang J, Magrelli JF, Faigenbaum AD. Physical Performance Characteristics in National Collegiate Athletic Association Division III Champion Female Lacrosse Athletes. Journal of Strength and Conditioning Research. 2009 Aug; 23(5): 1524-28.
5. Sell KM, Prendergast JM, Ghigiarelli JJ, Gonzalez AM, Biscardi LM, Jajtner AR, Rothstein AS. Comparison of Physical Fitness Parameters For Starters vs. Nonstarters in an NCAA Division I Men's Lacrosse Team. Journal of Strength and Conditioning Research. 2018 Nov; 32(11): 3160-66.
6. Taylor JB, Wright AA, Dischiavi SL, Townsend MA, Marmon AR. Activity Demands During Multi-Directional Team Sports: A Systematic Review. Sports Med. 2017 Dec;47(12):2533-2551.
7. Vescovi JD, Brown TD, Murray TM. Descriptive characteristics of NCAA Division I women lacrosse players. J Sci Med Sport. 2007 Oct;10(5):334-40

8. Vescovi JD, Brown TD, Murray TM. Positional characteristics of physical performance in Division I college female soccer players. J Sports Med Phys Fitness. 2006 Jun;46(2):221-6.