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Analysis of the Effectiveness of a Preseason Strength and Conditioning Program for Collegiate Men's and Women's Lacrosse

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by

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A Dissertation submitted to the Education Faculty of Lindenwood University in partial fulfillment of the requirements for the degree of

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This dissertation has been approved in partial fulfillment of the requirements for the

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Declaration of Originality

I do hereby declare and attest to the fact that this is an original study based solely upon my own scholarly work here at Lindenwood University and that I have not submitted it for any other college or university course or degree here or elsewhere.

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Abstract

Lacrosse participation in recent years has experienced tremendous growth. Though lacrosse has been documented as the oldest team sport in North America, lack of research exists regarding appropriate strength and conditioning systems for the sport. Therefore, the purpose of this study was to investigate the effectiveness of two lacrosse-specific preseason strength and conditioning programs offered to NCAA DII men's and women's lacrosse players. This synthesizes literature covering lacrosse's past; lacrosse's current status; differences in play between men's and women's lacrosse; physiological profiles of male and female lacrosse athletes; injury prevalence in both genders; and the various strength training and conditioning programs offered to lacrosse players of both genders that have been published to date. Performance testing data was collected from the head strength coach at three different testing intervals, and these secondary data underwent a statistical analysis in order to determine whether or not the strength and conditioning programs increased lacrosse-specific performance abilities.

The results of this study indicate that each strength and conditioning program increased the performance of male and female lacrosse athletes as measured by a timed 40-yard dash, timed 5-10-5 agility drill, vertical jump measured in inches, 1 rep max bench press measured in pounds, and 1 rep max squat measured in pounds. The increases in performance were similar for both male and female athletes. The results are not broadly generalizable, as other performance testing parameters exist that are more specific to the game of lacrosse than those used by the strength coach in this study. Lastly, this study does not examine any effect that the strength and conditioning programs may have had on injury prevention.

Table of Contents

Abstract ii

List of Tables vi

List of Figures vii

Chapter 1: Introduction 1

SIGNIFIGANCE OF THE STUDY 3

RESEARCH PROBLEM 4

HYPOTHESES 5

LIMITATIONS 6

STUDY DEMOGRAPHICS 7

OPERATIONAL TERMS DEFINED 8

CONCLUSION 14

Chapter 2: Review of the Literature 16

OVERVIEW 16

LACROSSE, A HISTORICAL PERSPECTIVE 17

LACROSSE, A CURRENT PERSPECTIVE 25

PLAYING THE GAME 36

PHYSIOLOGICAL PROFILE OF LACROSSE ATHLETES 42

COMMON INJURIES SUSTAINED IN COLLEGIATE LACROSSE 48

Men's Lacrosse Injury Analysis 49

Women's Lacrosse Injury Analysis 52

Strength and Conditioning for Lacrosse: Testing and Performance Assessments 54

Strength and Conditioning for Lacrosse: Speed, Agility, Quickness, and Conditioning 57

Strength and Conditioning for Lacrosse: Resistance Training 64

Summary 73

Conclusion 73

Chapter 3: Methodology 75

Overview 75

Data Collection, Analysis, and Evaluation 76

Methodology of Services Being Analyzed 78

Time Frame 78

Participants 79

Test Selection and Administration 79

Exercise Selection 81

Periodization 85

Summary 86

Chapter 4: Results 88

Collected Men's Lacrosse Data Results 88

Summary 97

Chapter 5: Discussion 98

Overview 98

Summary of Findings 98

Suggested Testing Parameters for Future Studies and Coaches 100

Conclusion 101

References 104

Appendix A: Men's Lacrosse Speed, Agility, and Conditioning Program: January 2012-April 2012 113

Appendix B: Women's Speed, Agility, and Conditioning Program: January 2012-April 2012 114

Appendix C: Example Women's Lacrosse Strength Training Program 115

Appendix D: Example Women's Strength Training Program 122

Appendix E: Example Men's Lacrosse Strength Training Program 127

Appendix F: Example Men's Lacrosse Strength Training Program 131

Appendix G: Sample New Lacrosse-Specific Exercises and Instructions 135

Appendix H: Institutional Review Board Approval 195

Appendix I: Media Release Form 196

Vitae 197

List of Tables

Table 1: Lacrosse Participation 2010 2

Table 2: Lacrosse Historical Events 24

Table 3: Primary Energy Systems of Sports 45

Table 4: Injury Surveillance Survey Demographics 49

Table 5: Performance Measurements 77

Table 6: Summarized Men’s Lacrosse Performance Results 89

Table 7: Men’s Lacrosse z-Test Results 90

Table 8: Summarized Women’s Lacrosse Performance Results 93

Table 9: Women’s Lacrosse z-Test Results 94

List of Figures

Figure 1. US lacrosse participation survey results: NCAA and NFHSA 27

Figure 2. US lacrosse participation survey results: Youth growth from 2006 to 2010 28

Figure 3. 2010 US lacrosse participation survey results: High school 29

Figure 4. US lacrosse participation survey results: College and club growth from 2001 - 2010.. 30

Figure 5. US lacrosse participation survey results: NCAA men's five year growth......... 31

Figure 6. US lacrosse participation survey results: NCAA women's five year growth.... 32

Chapter 1: Introduction

Lacrosse is the oldest team sport in North America, with rich ties to the native populations of Canada and the Northeastern region of what is now the United States (Poulter, 2003). Throughout the majority of its lifetime, lacrosse experienced only a moderate rate of growth in participation; however, in recent years, participation at all levels has increased rapidly, more so than in any other sport (Burton & O'Reilly, 2010; Halley, 2008; Harris, 2008). As a result of its traditionally slow growth, lacrosse has received little attention from a strength and conditioning perspective regarding best practices for coaches and programs (Pistilli, Ginther, & Larsen, 2008; Plisk, 1992). Understanding the important physical and physiological components of a sport are essential when planning and progressing a strength and conditioning program (Baechle, Earle, & Wathen, 2008). Thus, further understanding the required physical and physiological components of lacrosse and documenting an effective preseason strength and conditioning program seems the next logical step in advancing lacrosse strength and conditioning research.

Strength and conditioning, while relatively new as a profession, is driven by research (Bompa & Haff, 2009). The field is governed primarily by the National Strength and Conditioning Association in Colorado Springs, Colorado, which publishes semi-annual research journals, administers certifications, and provides opportunities for professionals to continue their education throughout their careers (Ratamess, 2011). Strength and conditioning professionals have focused mainly on researching the more popular sports, such as football, baseball, basketball, soccer, wrestling, volleyball, tennis, golf, and rugby, as those tend to offer large populations of athletes to sample from and work with (Ratamess, 2011). Even though these sports remain more popular than lacrosse among American youth, high school, collegiate, and professional athletes, their rate of growth has slowed and in some cases declined as lacrosse's growth has continued to increase more rapidly than any other sport at each level (US Lacrosse, 2011; National Federation of State High School Associations, 2010). Thus, the need for further research is becoming increasingly critical. Table 1 graphically represents the growth in lacrosse participation by gender and level of play over the past decade.

Table 1

Lacrosse Participation 2010

	Boys	Girls	Total	1yr Increase
Youth	201,727	122,946	324,673	9.20%
High School	149,400	105,914	255,314	12.20%
College	19,326	13,105	32,431	2.60%
Professional	180	0	180	0.00%
Post-Collegiate	8,981	3,014	11,995	5.80%
Total	379,614	244,979	624,593	10.00%

(US Lacrosse, 2011, p. 3)

As of the date of this writing, the author is aware of only eight peer-reviewed articles published in regards to lacrosse strength and conditioning (Gutowski & Rosene, 2011; Enemark-Miller, Seegmiller, & Rana, 2009; Pistilli et al., 2008; Burger & Burger, 2006; Ballantyne, 2000; Plisk, 1992; Moore, 1985). As the number of participants continues to increase, the physical and physiological research arena of lacrosse should grow as well in order to provide coaches with the most up-to-date findings pertaining to the sport. This study helps to fill the gap in lacrosse strength and conditioning research and further contributes to the field by providing evidence-based research supporting the design, implementation, and progression of one collegiate men's lacrosse preseason strength and conditioing program and one preseason women's lacrosse strength and conditioning program. The programs implemented and investigated in this study were separate, but the testing and test administratioin remained the same for both groups. Chapter 3 includes more detail about the study methods.

Signifigance of the Study

There is a lack of empirical evidence regarding sport and gender-specific lacrosse strength and conditioning programs (Pistilli et al., 2008; Plisk, 1992). In order to effectively and continually increase the specific performance characteristics of a sport, the strength and conditioning program must be specific to that sport (Baechle et al., 2008). Thus, simply applying a general strength and conditioning program to an already intermediately trained group of college athletes will not elicit the appropriate performance increases (Zatsiorsky & Kraemer, 2006). This study provides documentation of one successful strength and conditioning preseason program for men's lacrosse and one successful strength and conditioning preseason program for women's lacrosse. Each program is specific to the sport of lacrosse and individualized for each gender. This study provides lacrosse athletes, coaches, parents of lacrosse athletes, and strength and conditioning coaches of lacrosse athletes valuable information regarding the specific biomechanical and physiological components necessary for successful play.

Additionally, it offers an in-depth understanding of how to design, implement, and progress gender-specific lacrosse strength and conditioning programs using lacrosse-specific strength and conditioning exercises. Lastly, the strength and conditioning community will gain the first set of empirically proven, effective preseason strength and conditioning program details for both female and male lacrosse NCAA DII teams. This first such set of program data will provide a pivotal starting point for coaches and researchers as the community plans further training and training-related research to complement lacrosse's continued growth.

Research Problem

The research problem addressed in this study is the lack of data pertaining to effective, lacrosse-specific strength and conditioning programs. This study is significant in that it provides documentation of a successful, effective program. Such documentation will help to combat the lack of research in this field. In this study, the research problem is broken down further into subgroups focusing on the lack of empirical data in regards to increasing the performance of lacrosse-specific strength, speed, power, and agility. Thus, in this study, the researcher aims to uncover whether or not the strength and conditioning program under investigation overcomes the human body's resistance to adaptation, thereby producing a positive gain in strength, speed, power, and agility. The research question is: Will the analyzed preseason strength and conditioning program for the men's lacrosse team as well as the analyzed preseason strength and conditioning program for the women's lacrosse team elicit an increase in performance of strength, speed, power, and agility? The results of this study indicate that the preseason strength and conditioning programs for both teams were proven to be effective at increasing strength, speed, power, and agility across each of the three testing dates during the preseason.

Hypotheses

The purpose of this study was to examine the effectiveness of the strength and conditioning program offered to a 30-person men's lacrosse team, as well as the strength and conditioning program offered to a 15-person women's lacrosse team, at a mid-sized university in the Midwest from the beginning of the 2011 school year through the preseason phase of training, August 2011 to February 2012. In addition to examining the effectiveness of services, this study adds documentation of empirical data to the body of literature on lacrosse strength and conditioning, which currently lacks significant evidence on specific training programs for the sport (Gutowski & Rosene, 2011; Pistilli et al., 2008; Burger & Burger, 2006). Quantitative measures were used to provide insight into the effectiveness of the programs administered to both teams. Quantitative data were collected in the form of performance testing parameters implemented on the following three occasions: 1) the beginning of the fall semester, the last week of August 2011, 2) the end of the fall semester, the week of November 21st, and 3) one week prior to the competitive season, the second week of February 2012. In addition, the collected data were compared to old coaching data provided by the head coach and the team of individuals who conducted strength and conditioning services prior to this study. Performance parameters essential for success in the sport of lacrosse were selected and are reflected in the research hypotheses.

Hypotheses 1a-e: There is a difference in athletic performance as measured by (a) a timed 40-yard dash, (b) timed 5-10-5 agility test, (c) 1 repetition maximum bench press measured in pounds, (d) 1 repetition maximum barbell back squat measured in pounds, and (e) vertical jump measured in inches, between the university's men's and women's lacrosse athletes at the August 2011 testing date as compared to the university's men's and women's lacrosse athletes at the November 2011 testing date.

Hypotheses 2a-e: There is a difference in athletic performance as measured by (a) a timed 40-yard dash and (b) timed 5-10-5 agility test, (c) 1 repetition maximum bench press measured in pounds, (d) 1 repetition maximum barbell back squat measured in pounds, and (e) vertical jump measured in inches, between the university's men's and women's lacrosse athletes at the November 2011 testing date as compared to the university's men's and women's lacrosse athletes at the February 2012 testing date.

Limitations

The motivation behind this study was to contribute additional empirical data to the field of research regarding lacrosse. Although the results of this study indicate a positive change in performance capabilities in the lacrosse athletes under investigation, several limitations remain, leaving room for additional research. The major limitation of this study exists in the selected performance tests. The chosen performance parameters represented a compromise between what the lacrosse coaches wanted and what the strength coach wanted. In the future, a study that more appropriately implements lacrosse-specific tests, such as a 40-yard dash, 5-10-5 agility drill, Illinois agility test, 100M dash, VO2Max, 300-yard shuttle, vertical jump, broad jump, 3RM bench press, 3RM back squat, and 3RM power clean, would yield a better understanding of how such training affects more lacrosse-specific skills. Additionally, this study did not investigate the effect of the strength and conditioning program on injury rates because these data had not been recorded accurately prior to the study. In order to better assess the overall effectiveness of a program, injury rates should be considered. Additional research linking plyometric training to lower body injury prevention would also be of use to strength coaches designing programs for lacrosse athletes.

Study Demographics

This study took place at a mid-sized, four-year, liberal arts institution of higher education in the Midwest offering undergraduate and graduate degree programs to approximately 10,000 students. This university had applied recently for National Collegiate Athletic Association Division II (NCAA DII) entry. During this study, all athletic teams were within an NCAA DII probationary period, meaning that all postseason play opportunities were restricted. The university was not accepted into the NCAA DII program until this study was being finalized. Part of the university's new NCAA DII athletic program consisted of separate male and female varsity lacrosse teams. At the time of this study, the study's author was employed by the university as the head strength and conditioning coach for both the men's and women's lacrosse teams.

While attempting to research and plan a strength and conditioning model for the 2011-2012 season, the author noticed a limited amount of empirical data representing strength and conditioning services that had been proven effective for lacrosse athletes (Ballantyne, 2000; Burger & Burger, 2006; Burton & O'Reilly, 2010; Carter, Westerman, Lincoln, & Hunting, 2010; Enemark-Miller, Seegmiller, & Rana, 2009; Gutowski & Rosene, 2011). Additionally, over the past decade, lacrosse has experienced exponential growth at the youth, high school, collegiate, and professional levels (Connoly, 2010; Dick, Lincoln, Agle, Carter, Marshall, & Hinton, 2007; Dick, Romani, Agle, Case, &

Marshall, 2007; Gutowski & Rosene, 2011; US Lacrosse, 2011). As a result of this lack of data and increasing popularity, the author decided to fulfill his dissertation requirements for his EdD program by studying the strength and conditioning program implemented for the men's and women's lacrosse teams under his direction. As the sport was continuing to grow at the university under investigation, the author hoped that his work would lay the groundwork for subsequent studies on the sport of lacrosse and lacrosse athletes. Additionally, as other colleges and universities may choose to implement a strength and conditioning department, this study may provide some insight regarding the potential structure of such a program. The following section provides an abbreviated look at how the athletic department was restructured to include strength and conditioning at the university where the author was employed, which led to the design and implementation of this study.

Operational Terms Defined

In this section, significant terms used throughout the study will be presented and defined. These terms are known and used widely within the exercise science and strength and conditioning field.

1. ***Absolute and Relative Strength:*** Absolute strength does not consider one's body weight, while relative strength measures the strength of a person compared to his/her body weight. Relative strength also is known as **strength-to-mass-ratio** (Bompa & Haff, 2009, p. 268; Ratamess, 2011, p. 10; Baechle et al., 2008; Stone, Stone, & Sands, 2007; Stoppani, 2006).
2. ***Aerobic:*** Aerobic processes are those that depend heavily on the use of the oxidative system, which is one of three energy systems always in use at differing

ratios depending on exertion. The oxidative system is used for low-intensity, at-rest activities; during low-intensity exercise, the oxidative system becomes the primary energy system utilized after three minutes (Baechle et al., 2008, p. 31-33).

3. ***Agility:*** An independent set of skills that converge for an individual, typically as a response to an external stimulus, allowing the individual to accelerate, decelerate, reaccelerate, or change direction (Sheppard & Young, 2006, p. 920; Bompa & Haff, 2009).
4. ***Anaerobic:*** Anaerobic processes are those that do not depend heavily on the oxidative energy system. The **phosphagen** and **glycolytic** systems are the two anaerobic energy systems that, along with the oxidative energy system, comprise the three main energy systems used by the body at all times at differing ratios depending on exertion. The phosphagen system produces the most force, power, and intensity, however, it can only be used fully between 0-15 seconds; after 15 seconds, the glycolytic system takes over the primary energy production responsibilities, producing submaximal force, power, and intensity and lasting up to three minutes, at which point the oxidative energy system takes over, and the force, power, and intensity decrease (Baechle et al., 2008, p. 22-37).
5. ***Concentric Muscle Action:*** A muscle action in which the muscle is shortened, resulting from the external force (resistance) being less than the internal force (muscular force) (Stoppani, 2006, p. 5).

6. ***Eccentric Muscle Action:*** A muscle action in which the muscle is lengthened, resulting from the external force (resistance) being greater than the internal force (muscular force) (Stoppani, 2006, p. 5).
7. ***General Strength:*** The strength of the entire the neuromuscular / musculoskeletal system, which is the whole person. Foundational strength is needed before other, more specific types of strength can be developed (Bompa & Haff, 2009, p. 268; Baechle et al., 2008; Stone et al., 2007; Stoppani, 2006).
8. ***Hypertrophy:*** Muscular growth in the human body characterized by an increase in the cross-sectional area of the muscle tissue. Hypertrophy is a common adaptation to anaerobic training, especially resistance training, resulting from the increase in the size of muscle fibers (Schoenfeld, 2010; Ratamess, 2011; Cormie, McCuigan, & Newton, 2011; Krieger, 2010).
9. ***Intensity:*** The percentage of one's best performance; in weightlifting, this is typically quantified by one's 1RM, 3RM, 10RM, or Multiple Repetition Maximum (MRM). In activities not involving weight lifting, intensities may be quantified by the time taken to complete a task (40-yard dash, 100M sprint, 1-mile run) or distance traveled (vertical jump, broad jump, shot put throw, discuss throw); intensity is a measure of one's effort or quality of work performed (Baechle et al., 2008, p. 393; Baker & Nance, 1999; Bompa & Haff, 2009; Carson, Popple, Verschueren, & Riek, 2010; Clark, Stearne, Walts, & Miller, 2010; Cormie et al., 2011).

10. ***Isometric Muscle Action:*** A muscle action in which the length of the muscle does not change, and the external force (resistance) is equal to the internal force (muscular force) (Stoppani, 2006, p. 5).
11. ***Maximum Strength:*** The highest force a muscle or group of muscles can generate. In weight training, a 1 Rep Maximum (1RM) typically is used to assess the maximum strength; this 1RM represents the highest load a muscle or group of muscles can lift one time; 3RMs also are widely used (Bompa & Haff, 2009, p. 268; Baechle et al., 2008; Stone et al., 2007; Stoppani, 2006).
12. ***Muscular Endurance:*** The ability of the neuromuscular / musculoskeletal system to produce force repetitively for an extended period of time (Bompa & Haff, 2009, p. 268; Baechle et al., 2008; Stone et al., 2007; Stoppani, 2006).
13. ***Parametric and Nonparametric Strength:*** Parametric strength refers to the production of force against external resistance (e.g., shot-put, disc, Olympic weightlifting). While performing parametric strength activities, the production of force is governed by the external resistance; if the external resistance increases, so does force production. However, when force production increases as a result of an increase in the external resistance, **the velocity** at which the force can be produced decreases. Nonparametric strength refers to the production of force without external resistance (e.g., sprinting, jumping, running). While performing a non-parametric activity, the production of force is governed by internal processes (e.g., bioenergetics, neuromuscular system, musculoskeletal system), and when force production increases, so does velocity (Zatsiorsky & Kraemer, 2006, p. 17-46).

14. ***Plyometrics:*** A Greek word meaning *more length*, plyometrics are a type of exercise that enables a muscle to reach its maximum force generation capacity through quick, powerful movements utilizing a **stretch-shortening cycle**, otherwise known as prestretching or countermoving, in order to maximize the power development of the subsequent movement (Baechle et al., 2008, p. 414). An example would be a squat jump (Baechle et al., 2008, p. 428).
15. ***Power:*** Mathematically, power equals work (force x distance) divided by time; power also can be expressed as force multiplied by velocity. In sports, power represents one's ability to react quickly and with strength against moderate to high forces (Stone et al., 2007, p. 57; Stoppani, 2006; Baechle et al., 2008; Bompa & Haff, 2009).
16. ***Resistance Training:*** A form of exercise that uses some form of external resistance, such as gravity or weighted or elastic implements, that has been proven to increase strength, power, muscle mass, speed, and endurance (Evans, Vance, & Brown, 2010; Carson et al., 2010; Spreuwenberg et al., 2006).
17. ***Series Elastic Component (SEC):*** A mechanical process that results from the elastic nature of muscle and tendons (Baechle et al., 2008, p. 414). When muscle and tendons are stretched or lengthened (ECC muscle action), energy is stored. If the ECC muscle action is followed immediately by a CON muscle action, the stored energy will be released through the CON muscle action (Baechle et al., 2008, p. 414). The SEC contributes approximately 70% to the SCC (Ratamess, 2011, p. 24)

18. ***Specific Strength:*** strength that is specific toward the movement and motor patterns used in sport or activity (Bompa & Haff, 2009, p. 268; Baechle et al., 2008; Stone et al., 2007; Stoppani, 2006).
19. ***Speed Strength:*** Force or strength that is developed rapidly and at high speeds, for example, spiriting (Bompa & Haff, 2009, p. 268; Baechle et al., 2008; Stone et al., 2007; Stoppani, 2006).
20. ***Speed:*** One's ability to cover a distance quickly, which consists of acceleration, attainment, and maintenance (Bompa & Haff, 2009, p. 315).
21. ***Strength and Conditioning****:* A term adapted to include several modalities of exercise, such as resistance training, plyometrics, sprint and agility training, anaerobic and aerobic conditioning, flexibility, and recovery acceleration (Ratamess, 2011, p. 3).
22. **Strength:** The maximum force that a muscle or group of muscles can generate at a specific speed and in a specific direction (Baechle et al., 2008, p. 74).
23. ***Stretch Reflex:*** A neuromuscular process that results from the body's involuntary response to the stretching of the muscle (Baechle et al., 2008, p. 415). Muscle spindles are the proprioceptive organs that sense the degree and magnitude of each stretch and determine the degree and magnitude of the counter stretch based on that information (Baechle et al., 2008, p. 415). The countermovement then is initiated by the Golgi Tendon Organs (GTO); thus, muscle spindles sense the stretch, and the GTOs inhibit further stretching by initiating a counter stretch (Ratamess, 2011; Baechle et al., 2008; Bompa & Haff, 2009).

24. ***Stretch-shortening cycle (SSC):*** The result of an eccentric (ECC) muscle action preceding a concentric (CON) muscle action, which enables the subsequent CON to be more forceful than if not preceded by an ECC (Ratamess, 2011, p. 24). The SSC is made possible through two mechanisms: 1) the elastic nature of the muscle known as the **series elastic component**, which acts like a spring when stretched, and 2) the **stretch reflex**, which is initiated by a sensory receptor known as a **muscle spindle** (Ratamess, 2011, p. 24).
25. ***Volume:*** Volume is the representation of the quantity of work one performs; it may be characterized by the number of sets, reps, or exercises, or the distance, time, or duration of an event (Baechle et al., 2008; Bompa & Haff, 2009; Ratamess, 2011; Stone et al., 2007; Stoppani, 2006).

Conclusion

There is a lack of empirical evidence and documentation in the lacrosse strength and conditioning community regarding successful sport and gender-specific lacrosse strength and conditioning programs (Plisk, 1992). This study provides documentation of one successful strength and conditioning preseason program for men's lacrosse as well as one successful strength and conditioning preseason program for women's lacrosse. Lacrosse athletes, coaches, parents of lacrosse athletes, and strength and conditioning coaches of lacrosse athletes stand to gain valuable information in regards to the specific biomechanical and physiological components necessary for successful play. Additionally, these groups of individuals will gain an in-depth understanding of how to design, implement, and progress gender-specific lacrosse strength and conditioning programs using lacrosse-specific strength and conditioning exercises. Lastly, the strength and conditioning community will gain the first set of empirically proven, effective preseason strength and conditioning preseason program details.

Success in this study is quantified by an increase in performance from the first test date to the second test date and to the third test date. This study looks only at increases in performance and does not make any hypothesis in regards to varying rates of increase between genders or performance parameters. A positive increase in performance across and entire group of intermediately trained athletes will not be induced by adding a general strength and conditioning program; thus, assumptions should not be made in regards to increases in performance being possible regardless of the type of program and type of progression (Bompa & Haff, 2009). Additionally, as athletes progress in their training, the rate of performance gains decreases, and the more specific, progressive, and varied a program must be in order to induce positive increases in performance; thus, a general strength program would not elicit continual increases in performance across a series of tests (Bompa & Haff, 2009). The strength and conditioning programs analyzed in this study were specifically designed to progressively overload and vary volume and intensity over the preseason in order to continually elicit performance gains across all three tests, resulting in the athletes achieving their highest performance capabilities during the competitive phase of the year.

Chapter 2: Review of the Literature

Overview

The purpose of this study is to provide coaches and other strength and conditioning professionals with empirical evidence supporting an appropriate and effective strength and conditioning program for the sport of lacrosse for both men and women at the NCAA DII level. A literature review will be presented in this chapter to help readers fully understand the nature of the sport, recent trends, and current strength and conditioning perspectives. The literature review will cover such areas as lacrosse's historical perspective; growth trends and issues over the years; current perspectives and state of lacrosse; current game play and gender differences that influence rule and play differences; physiological profiles of male and female collegiate lacrosse athletes; prevalence of injuries for each gender; conditioning programs offered by other professionals; and strength programs offered by other professionals. Following the literature review, Chapter 3 will outline the methods and rationale for the design of the strength and conditioning program during the analysis portion of this study. In addition, Chapter 3 will provide examples of author-suggested strength and conditioning programs for the non-tested portions beyond the scope of this study. Next, Chapter 4 will outline the results of the tests described in Chapter 3, and lastly, Chapter 5 will present a discussion of the results and weaknesses of the study, as well as areas that offer opportunities for further research and those in which improvement is needed within this particular annual strength and conditioning program. The literature review begins with the historical perspective of the sport of lacrosse, which identifies its origin, growth, and popularity through history.

Lacrosse, a Historical Perspective

Lacrosse, also known as *baggataway*, meaning "they bump hips" in Algonquian, *tewaarathon*, meaning "little brother of war" in Iroquois, and *teiontsikwaeks*, also from the Iroquois, meaning "our National Game," is a ball and stick game played either outdoors or indoors (box lacrosse), traditionally by the native North American tribes located in Canada and the northeastern part of what is today the United States (Diamond & Gale, 2001; Hinkson & Lombardi, 2010; Korba, 1976; Lacrosse, 2011; Mitchell, 2008; Poulter, 2003; Robidoux, 2002). Originally, the game had several variations of play between the various Native American tribes throughout the different regions of North America. Regardless, the essentials of the game remained quite constant, with the object being to, with a wooden stick and somewhat of a half fishnet encapsulate attached to the end, get the ball past certain markers that are protected by what is now called a goalie (Lacrosse, 2011; McCulloch & Bernard, 2007; Mitchell, 2008; Otago, Adamcewicz, Eime, & Maher, 2007). Lacrosse has been well documented as the first North American team sport ever to have been played (Coulter, 2001; Kerrigan, 2007; McCulloch & Bernard, 2007).

Lacrosse combines soccer-like finesse with a basketball strategy of offense and defense played with the intensity and physicality of ice hockey and American football (Ballard & Morill, 2004; Economist, 1994; Kerrigan, 2007). The game originated among native North American tribes as an exercise or spiritual ritual for "acknowledging the Creator's life forces and honoring the Elders and their Nations" (Mitchell, 2008, p. 6). The Native Americans believed that lacrosse was a gift given from the Creator to the Haudenousaunee Tribe and the entire native population (Mitchell, 2008). Mitchell

(2008) compared the Creator's giving of this gift to a parent giving a child a toy out of love and kindness, so when the child (people) play with this toy (lacrosse), it recreates and honors the love that flows between the parent (Creator) and the child (people) (p. 8). Given the belief in this connection, playing the game was a chance to physically and emotionally express true affection, appreciation, and love to the Creator (Mitchell, 2008; Poulter, 2003; Robidoux, 2002; Korba, 1976). Furthermore, some historians have suggested that lacrosse was played among the tribes of North America not only as a spiritual ritual, but as a way for the tribes to practice war-specific skills and tactics, in addition to settling disputes between tribes, all of which had been done for many years before European settlers came to the land (Connoly, 2010; Korba, 1976; Lacrosse, 2011; Mitchell, 2008).

This warring aspect appeared in an early documentation of a game played in 1763 between two indigenous First Nations tribes at Fort Michilimackinac, located in the Great Lakes of North America (Robidoux, 2002). Robidoux (2002) described this game as a staging act formulated by the two tribes in order to execute a surprise attack on the once French, now British, fort during the Pontiac Revolution/Rebellion (p. 214). The two tribes played lacrosse right outside the fort in order to capture the unassuming attention of those inside; as an intentional loose ball flew out of the field of play and crossed the borders of the fort, the tribes chased after, not to follow the ball, as it first appeared, but to execute the surprise attack, which indeed ended in chaos and fatality for the fort's people (Robidoux, 2002). In a sense, lacrosse has remained somewhat pure and true to its origins as an extremely fast-paced, violent game that truly tests one's abilities in agility, endurance, power, physicality, quickness, speed, tactical knowledge, and technical skill (Connoly, 2010; Eddington, 2000; Gutowski & Rosene, 2011; Harris, 2006; Schmidt, Gray, & Tyler, 1981). Throughout the evolution of lacrosse, a few key moments have influenced the sport's initial and current growth.

Originally known by the native tribes as *baggataway* or *tewaarathon,* the game was renamed *lacrosse* by early French-Canadian settlers as a reference to the likeness between the hickory sticks used to throw and catch the ball and a bishop's *crosier* (Diamond & Gale, 2001; Economist, 1994; Korba, 1976). Some texts have reported that the ball came from "an ancient rubber obtained during trade with the Mayas and Aztecs" (Mitchell, 2008, p. 22). However, most balls were made of bone, clay, or wood (Kohl, 2006). The significance of lacrosse to the native people, which emanated from its legendary status, origin, and spiritual significance, struck a deep chord of affection with the early European settlers (Poulter, 2003). These settlers began to respect the game in much the same way as it became increasingly popular in the northeastern part of North America (Lacrosse, 2011). They began to emulate the First Nation males, and eventually the natives and settlers sought refuge and common ground within lacrosse, which led to the sharing of cultural practices and a stronger connection between the two groups (Robidoux, 2002). During the 1800s, lacrosse's growth and popularity in Canada resulted in the loose organization of town-based teams that competed against surrounding towns to promote local pride and superiority (Mitchell, 2008). This trend continued, resulting in the formation of the Montreal Lacrosse Club in 1856; in 1860, the rules of the game became standardized (Lacrosse, 2011; Mitchell, 2008; Poulter, 2003; Robidoux, 2002; McCluney, 1974). On the shoulders of these events, in 1867, the Canadian

Parliament adopted lacrosse as Canada's national game. There is value in understanding how this adoption was made possible.

During the mid-to-late 19th century, sport in general became a construct of national pride for many prominent countries around the globe (Poulter, 2003; Robidoux, 2002). For example, *cricket* had become known as the British national game, baseball the American pastime, and *turnen,* a combination of dance and gymnastics, a source of national pride for Germany (Vaught, 2011; Poulter, 2003; Lindsey, 1892; Dunton, 1886). As a result, one of Canada's early prominent nationalistic pioneers, William George Beers, an avid sportsman and member of the Montreal Lacrosse Club, sought to further the promotion of national pride among Canadians through sport, particularly through the game of lacrosse (Poulter, 2003; Robidoux, 2002; Mitchell, 2008). Beers promoted lacrosse over ice hockey, even though both were widely popular in Canada at the time and both eventually became recognized as a national sport (Farber, 2010). Ice hockey had been imported from Britain and was played initially by early British soldiers who settled in Canada during the mid-to-late 19th century (Poulter, 2003; Robidoux, 2002). Beers preferred to promote lacrosse, touting it as a sport that was truly Canadian in origin and had the ability to put Canadians in a spiritual place that remained true to the native people of the land (Poulter, 2003; Mitchell, 2008; Robidoux, 2002). Poulter (2003) explained, "Playing lacrosse was an appropriate secularization of a significant aboriginal ritual" (p. 304). Lacrosse was also a truly rugged and brutal sport, representing what it meant to be a Canadian settler at that time (Robidoux, 2002). Beers took much pride and honor in the traditional ties to the land, and it was his promotion of lacrosse, by way of implanting his nationalist agenda, that led to much of the standardization of the official rules and Canada's adoption of lacrosse as its national sport (Robidoux, 2002). Beers knew that in order to garner support and achieve growth within the sport, lacrosse needed to be standardized and regulated; therefore, in 1867, he published the first set of standardized rules for men's lacrosse in the *Montreal Gazette* under the title "Goal-Keeper," which was Beers' position when he played (Robidoux, 2002). Apart from Beers' great efforts, additional credit for the promotion of lacrosse must be given to its nature as a true presentation of masculinity and superiority, which consistently attracted Canadian men more so than did the more dignified and refined British games, such as cricket and ice hockey (Lindsey, 1892).

The Canadian Lacrosse Association was established as the governing body of the sport after the Parliament of Canada adopted lacrosse as the country's national game in 1867 (Lacrosse, 2011). Lacrosse has attracted a wide amateur following since that time. Between 1920-1932, it was played professionally in Canada by 12-man teams (Lacrosse, 2011). After its introduction into the United States in the 1870s, New York University hosted the nation's first collegiate team, followed in 1882 with the first high school teams at Phillip Academy in Andover Massachusetts, Phillip Exeter Academy in New Hampshire, and Lawrenceville School in New Jersey (Wolff & Morrill, 2005). As for women's lacrosse, the first official team in the United States was formed at Bryn Mawr School in Baltimore by Miss Rosabelle Sinclair (US Lacrosse, 2010; Kohl, 2006; Wolff & Morrill, 2005). From the 1930s to the 1950s, men's lacrosse evolved with the addition of more finite guidelines, which afterwards remained relatively constant (Wolff & Morrill, 2005). On the other hand, women's lacrosse, outside of limiting body and stick contact from the time it originated, remained relatively unchanged until approximately the year 2000, when it began to undergo drastic regulation and rule changes (National Collegiate Athletic Association, 2011; Hinkson & Lombardi, 2010; Vescovi, Brown, & Murray, 2007; Vescovi & McGuigan, 2008; Wolff & Morrill, 2005). For example, in 2011, the field dimensions were changed from 120 yards by 70 yards, to 120 yards by 65 yards (National Collegiate Athletic Association, 2011).

For both men's and women's lacrosse, it was not until the 1990s that the sport began to see an unprecedented increase in participation (US Lacrosse, 2011; US Lacrosse, 2010; Boston Herald, 2008; Burton & O'Reilly, 2010; Chezzi, 2001; Connoly, 2010; Coulter, 2001; Devoe, 2006; Dick, Lincoln, et al., 2007; Dick, Romani et al., 2007). During the 1990s, lacrosse gained major recognition as ESPN began live coverage of the NCAA DI men's championship game (Ballard & Morill, 2004). The 2004 NCAA Division I men's championship drew a record-breaking crowd of 43.898 (Wolff & Morrill, 2005). In April 2005, *Sports Illustrated* published a nine-page dedication to the sport and its recent growth. Then, the 2005 NCAA championship game broke a new record of 44,920 spectators. This record was broken each year until 2010, when the championship game brought a crowd of over 50,000 spectators (US Lacrosse, 2011; Kohl, 2006). Lacrosse participation has continued to grow at all levels, and this one-time niche sport is now pulling in record numbers of participants as athletes have begun to drop from other sports programs in pursuit of success playing what some have called the fastest team sport on two feet (US Lacrosse, 2010; Kohl, 2006; Wolff & Morrill, 2005). Table 2 provides an additional look at some of the key moments in lacrosse's history. Although its growth has been slow and gradual for the majority of the 20th century, several significant variables have contributed in recent years to what some people are now calling ‘the lacrosse explosion’ (Wolff & Morrill, 2005). The next section in this literature review will outline those variables that have contributed to the rapid growth of participation in lacrosse and provide a look into the current state of the game.

Table 2

Lacrosse Historical Events

Date	Event	Institution/People
Up to 1600	Native Americans played the sport as "The Creator's Game"	Native Americans in the Northeastern US and Southeastern Canada
1636	Lacrosse was first documented to have been played by at least 48 native tribes in a Huron Contest in southeast Ontario	Jean de Brebeuf: Jesuit Missionary
1650 – 1800	French missionaries began playing the game and renamed it after a bishop's crosier.	French Pioneers and Missionaries to Canada
1850	Lacrosse was standardized with field dimensions and set number of players	George W. Beers: Canada
1867	Lacrosse named Canada's national sport	Canadian Parliament
1877	First American lacrosse team at a university	New York University
1882	First high school teams	Phillip Academy, Andover Mass. Phillip Exeter Academy, New Hampshire. Lawrenceville School, New Jersey
1890	First women's lacrosse game was played.	St. Leonard School: Scotland
1900	First established women's lacrosse team in the United States	Rosabelle Sinclair: Bryn Mawr School, Baltimore
1950	Noted differences between women's lacrosse and men's lacrosse. Women's lacrosse rules limit stick and body contact while men allow it to some extent.	
1990s	ESPN began live coverage of NCAA Division I national championship games	NCAA and ESPN
1998	Founding of lacrosse's governing body in the USA	US Lacrosse
1998	From-behind-the-net Air Gait slam dunk for Syracuse during the 1988 NCAA tournament remains the most famous shot in lacrosse.	Gary Gait
2005	April: Sports Illustrated dedicated nine pages to lacrosse's growth	Sports Illustrated
2005	Record crowd of 44,920 spectators	NCAA DI Championship
2005	NBC, USA; Score, Canada; televised the National Lacrosse League championship game	NBC and Score
2005	Largest women's lacrosse crowd ever in US	IFWLA World Cup: USA versus Australia
2006	Lacrosse TV: First 24/7 broadcast network dedicated to lacrosse	National Lacrosse League and Interactive Television Networks
2010	US Lacrosse Membership grows to 334,033	US Lacrosse
2010	US Lacrosse hosts 63 regional chapters across the nation	
2010	Highest recorded number of organized United States lacrosse players in history at 624,952	US Lacrosse

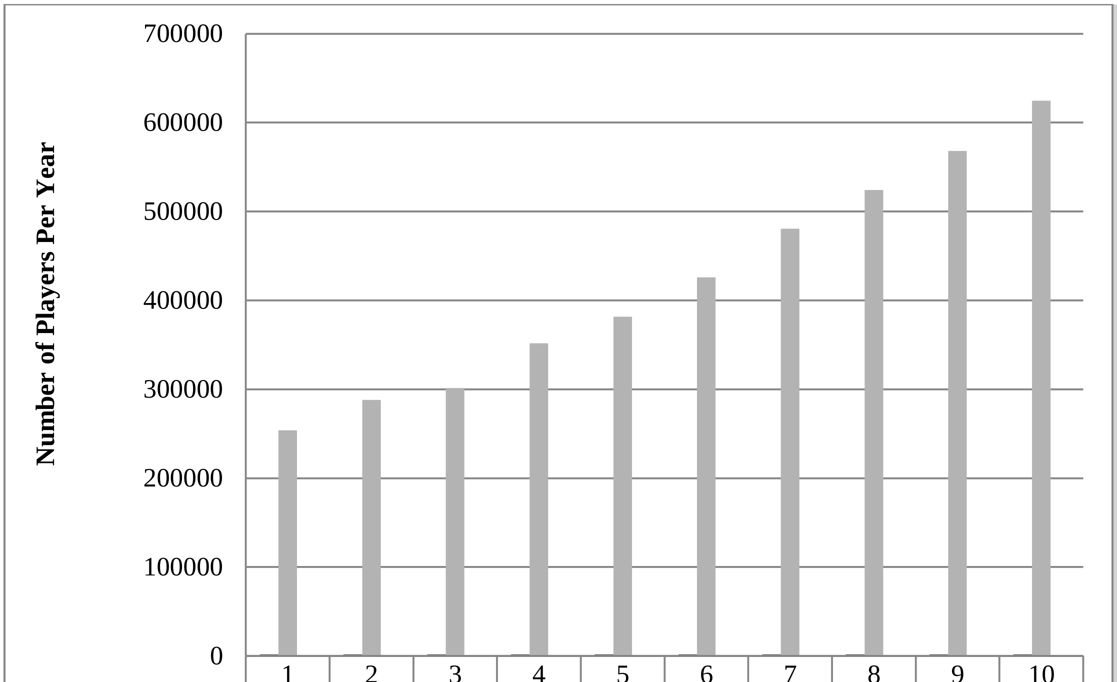
(US Lacrosse, 2010; Kohl, 2006; Wolff & Morrill, 2005)

Lacrosse, a Current Perspective

Lacrosse, under its original name baggataway, has been well documented as the first North American team sport ever to have been played (Coulter, 2001; Kerrigan, 2007; McCulloch & Bernard, 2007). During the past two decades, lacrosse also has been documented as the fastest growing sport in North America (Randolph, 2012; US Lacrosse, 2010; Ballard & Morill, 2004; Boston Herald, 2008; Chezzi, 2001; Connoly, 2010; Coulter, 2001; Diamond & Gale, 2001; Economist, 1994; Harris, 2008; Kerrigan, 2007; Kohl, 2006; McCulloch & Bernard, 2007; Mees, 2005; Wolff & Morrill, 2005). Revealing the exponential growth of the sport, US Lacrosse (the governing body of lacrosse in the United States) began issuing the *US Lacrosse Participation Survey* in 2001 as an annual monitoring survey system set to measure participation in youth, high school, college, college club, professional, post-college club, and internationally organized lacrosse teams (US Lacrosse, 2010; Ballard & Morill, 2004; Boston Herald, 2008; Chezzi, 2001; Connoly, 2010; Coulter, 2001; Diamond & Gale, 2001; Economist, 1994; Harris, 2008; Kerrigan, 2007; Kohl, 2006; McCulloch & Bernard, 2007; Mees, 2005; Wolff & Morrill, 2005).

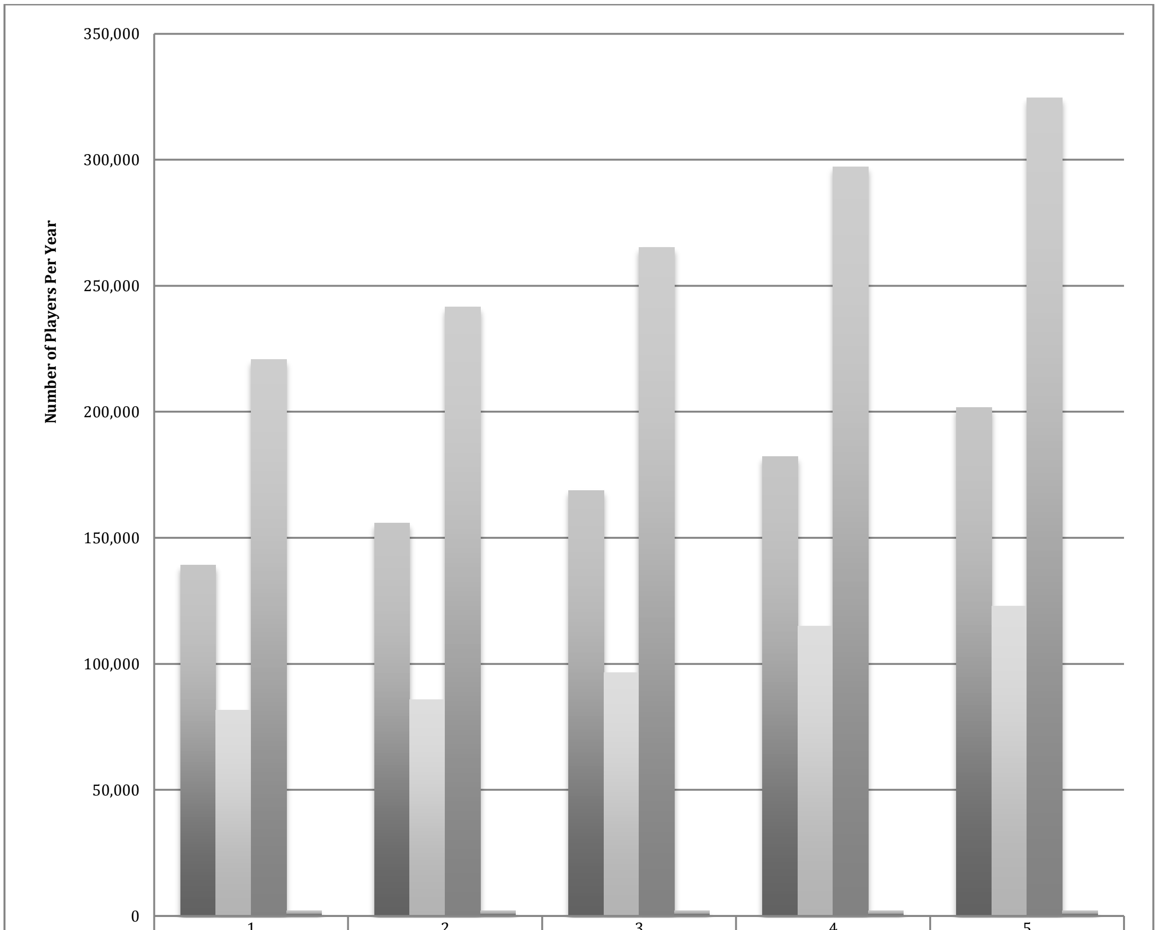
The 2010 survey results positioned youth-organized participation as the fastest-growing subgroup of participants, with 30,000 additional teams added across the country that year (US Lacrosse, 2010). Also as of 2010, high school lacrosse was sanctioned in 21 states, and as of 2011, NCAA Division I lacrosse was sanctioned by 61 colleges and universities (US Lacrosse, 2010). At the time the current study was being written, lacrosse could be viewed on a number of primary television networks and followed in a handful of sports magazines and internet-based publications (Wolff & Morrill, 2005; US

Lacrosse, 2010). The 2010-2011 US Lacrosse participation survey indicated that “US Lacrosse chapters have been established in 42 states and nearly 625,000 people played on organized teams in 2010 compared to just over 250,000 in 2001. The sport is growing at almost every level of the game” (US Lacrosse, 2010, p. 3). Figures 1 through 6 offer an additional depiction of the increase in lacrosse participation among different subgroups. These figures have been adapted from the 2010-2011 US Lacrosse Participation Survey.



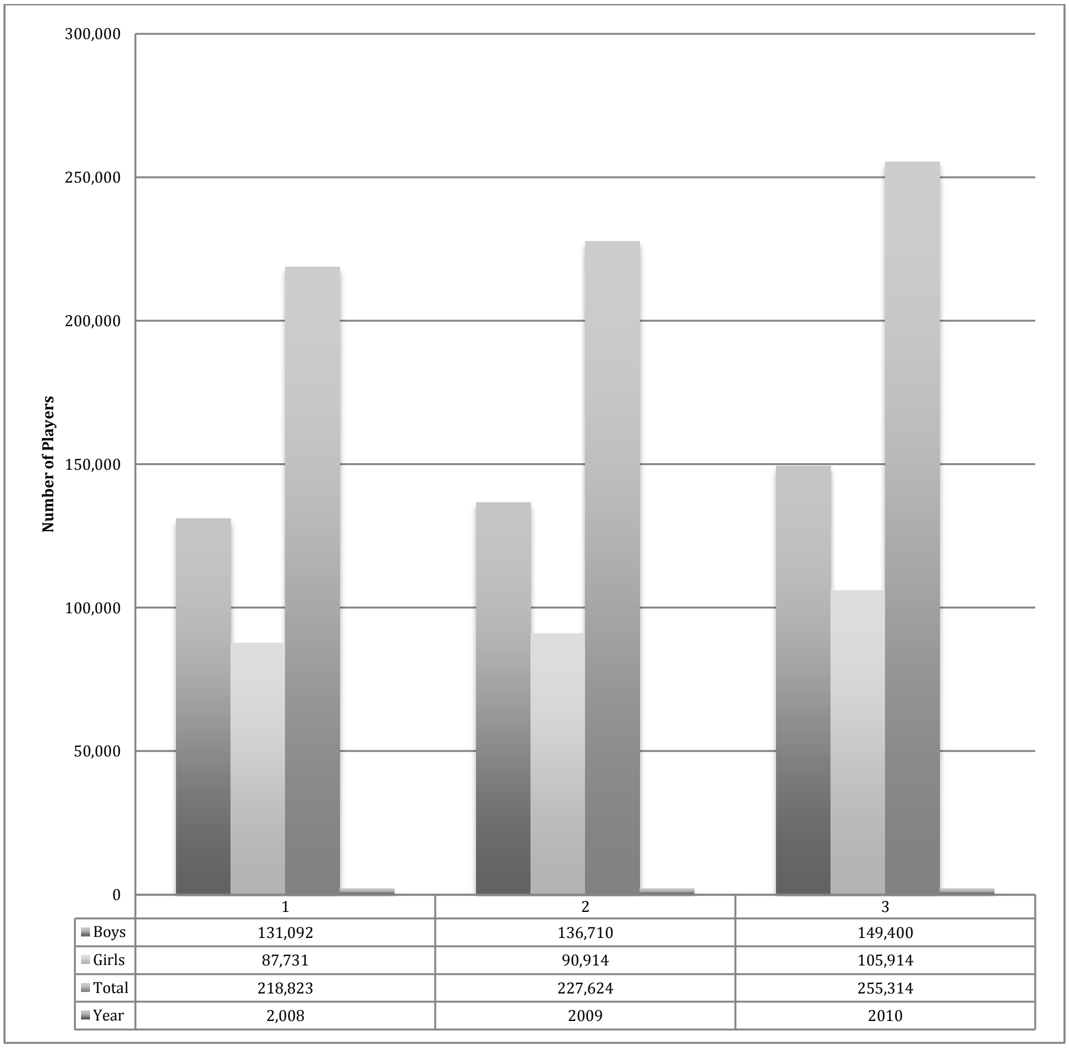
	1	2	3	4	5	6	7	8	9	10
Year	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Players	253,93	288,10	301,56	351,85	381,56	426,02	480,62	524,23	568,02	624,59
% 1-yr Growth	0	13.5	4.7	16.7	8.4	11.7	12.8	9.1	8.4	10

Figure 1. US lacrosse participation survey results: NCAA and NFHSA (US Lacrosse, 2010). Figure represents a total of all sanctioned NCAA play and all sanctioned high school play.



	1	2	3	4	5
Boys	139,188	155,866	168,768	182,249	201,727
Girls	81,609	85,715	96,446	115,022	122,946
Total	220,797	241,581	265,214	297,271	324,673
Year	2006	2007	2008	2009	2010

Figure 2. US lacrosse participation survey results: Youth growth from 2006 to 2010 (US Lacrosse, 2010). Youth consist of participants younger than high school aged involved in sanctioned play.



	1	2	3
Boys	131,092	136,710	149,400
Girls	87,731	90,914	105,914
Total	218,823	227,624	255,314
Year	2,008	2009	2010

Figure 3. 2010 US lacrosse participation survey results: High school (US Lacrosse, 2010). Figure represents all sanctioned high school play.

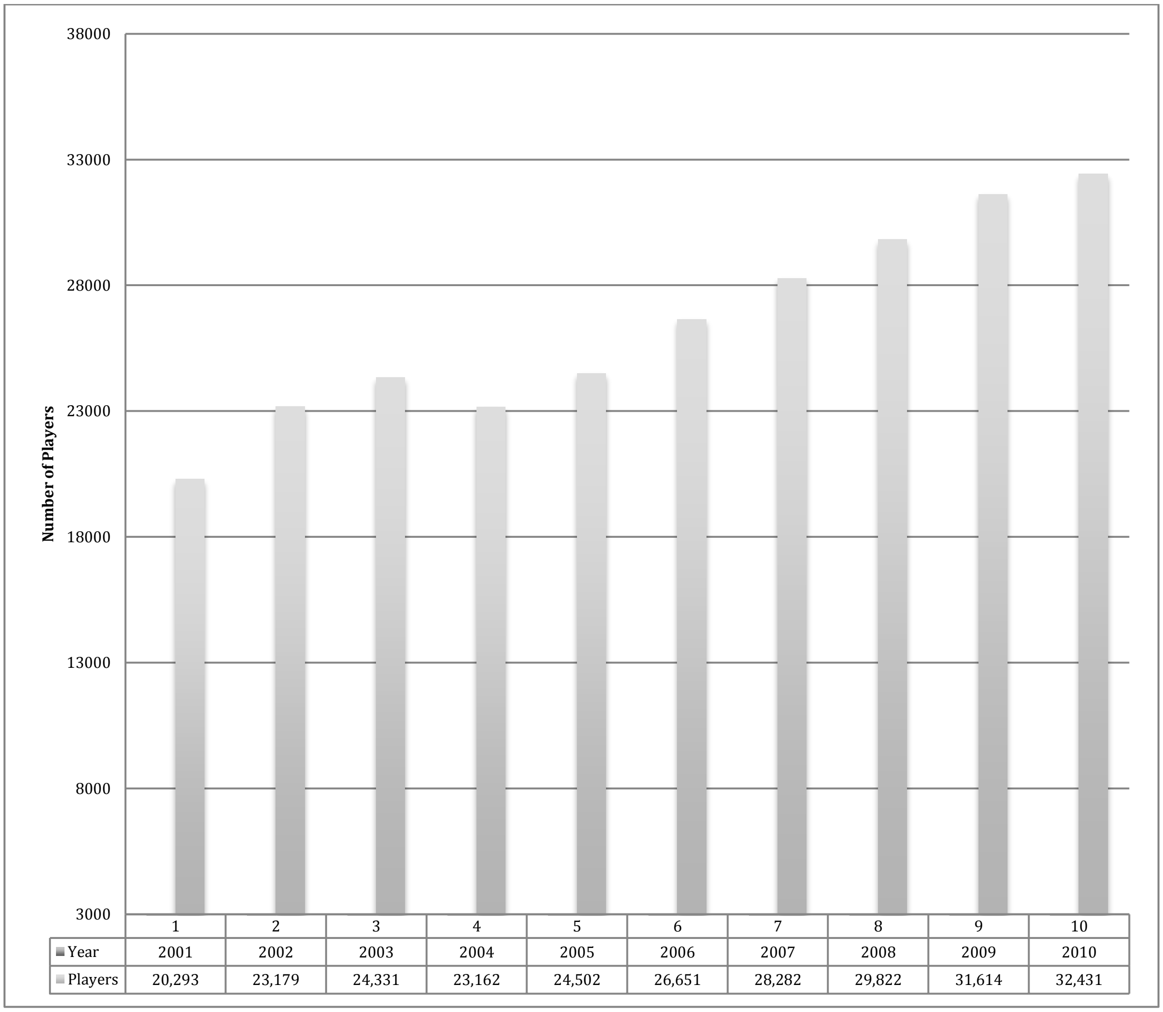


Figure 4. US lacrosse participation survey results: College and club growth from 2001 - 2010 (US Lacrosse, 2011). Figure represents all collegiate-level sanctioned play regardless of division or association.

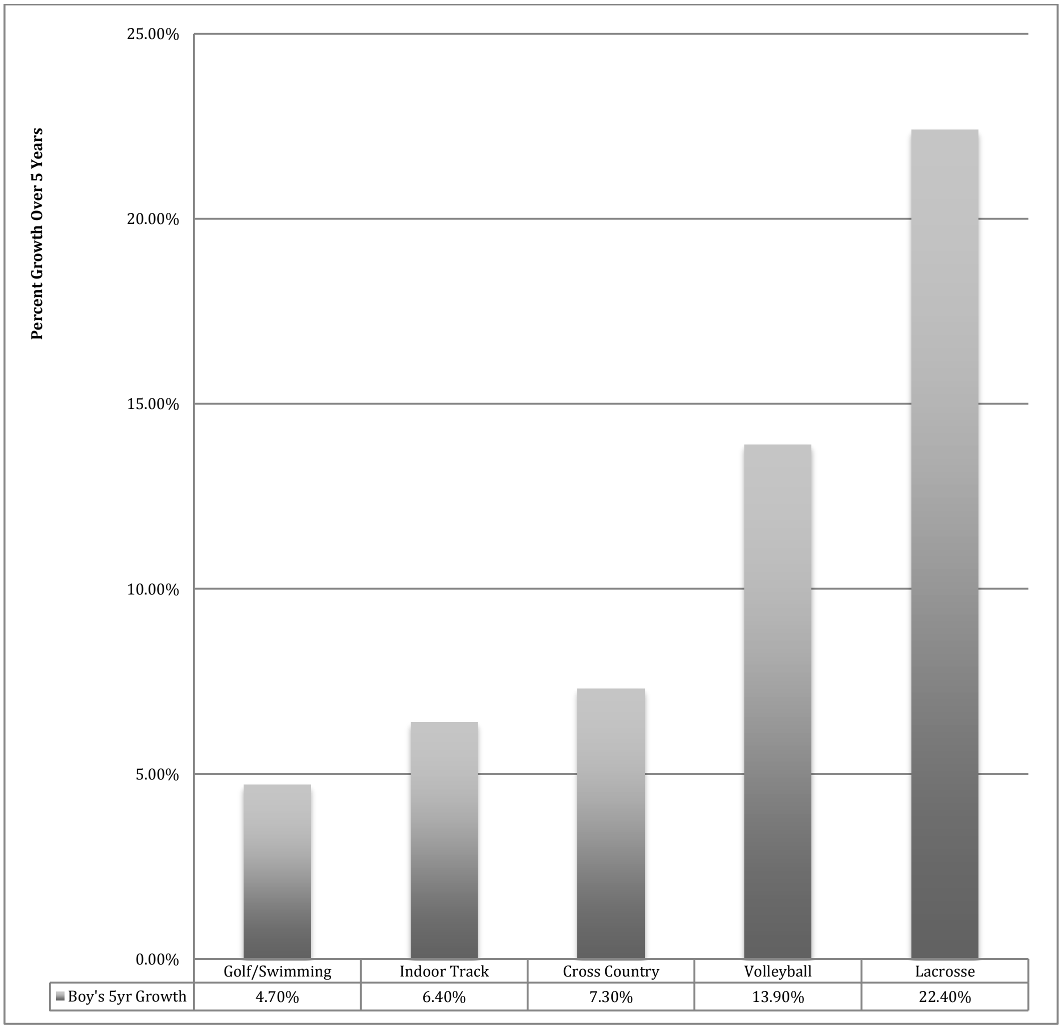


Figure 5. US lacrosse participation survey results: NCAA men's five year growth (US Lacrosse, 2011). NCAA growth rates based on number of teams from annual survey.

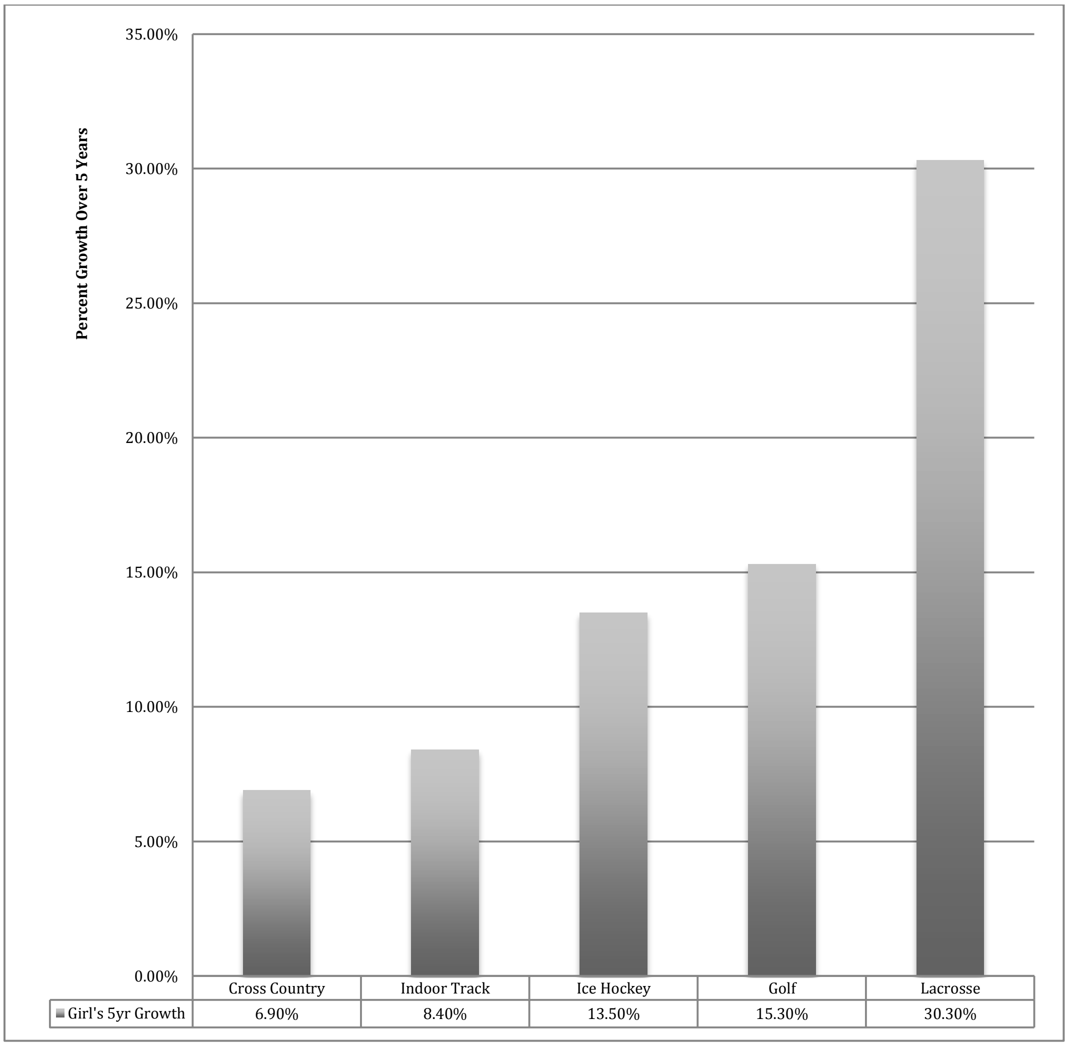


Figure 6. US lacrosse participation survey results: NCAA women's five year growth (US Lacrosse, 2011). NCAA growth rates based on number of teams from annual survey.

Interestingly, although lacrosse is the oldest team sport in North America, it has become popular only recently (Hinkson & Lombardi, 2010; Harris, 2008; Kerrigan, 2007; Wolff & Morrill, 2005). The literature suggests that explanations for the sport's recent rise in popularity might include recent television contracts and broadcasts; the formation of US Lacrosse and Canada Lacrosse; new technology that makes lacrosse sticks easier to use; the diverse, extreme, and niched nature of the sport; and the geographical spread of passionate players over the years caused by their gradual relocation (Boston Herald, 2008; Chezzi, 2001; Connoly, 2010; Coulter, 2001; Economist, 1994; Harris, 2008; Hinkson & Lombardi, 2010; Kerrigan, 2007; Kohl, 2006; Mees, 2005; US Lacrosse, 2010; Wolff & Morrill, 2005). A brief look at each of these areas, starting with new technology, will clarify these hypothesized catalysts for growth.

Until the 1970s and 1980s, the production of lacrosse equipment was limited at best; heavy, hand-made, wooden sticks were used most often, making it very difficult for a younger or female athlete to gain the necessary stick skills necessary to begin playing (Parker, 2010). Today, lacrosse sticks and stick heads are synthetically mass-produced from plastic and metal alloy composite, making them lighter, more easily accessible, and easier for younger and female athletes to use. These changes helped to influence growth specifically in the women's lacrosse sector as their game restricts contact more than men's and therefore requires more accuracy with stick-skills, passing, and shooting (Hinkson & Lombardi, 2010; Kohl, 2006). Lacrosse's growth also can be linked directly to the additional news and media attention given in the 1990s through primary television networks such as ESPNU, ESPN2, CSTV, and CBS College Sports. The sport also has received further exposure through a handful of sports magazines and internet-based publications such as *Lacrosse Magazine* (www.laxmagazine.com) and www.uslacrosse.org (Wolff & Morrill, 2005; US Lacrosse, 2010). These publications, advertisements, and promotional sources have made lacrosse a household term and have enhanced access to lacrosse resources, making them available to every individual with a TV, mobile phone, newspaper, or Internet. Lacrosse also received major recognition on a global scale as millions of viewers witnessed Chris Klein's character, Chris 'Oz' Ostreicher, playing the sport in the film *American Pie* (Moore, Perry, Weitz, Zide, & Weitz, 1999).

The formation of lacrosse's governing body in the United States in 1998 contributed to additional growth (Wolff & Morrill, 2005; US Lacrosse, 2011). Until that time, lacrosse spread primarily when players from the northeastern coast relocated across the country, establishing small local clubs for either themselves or their children (Kohl, 2006). This form of growth has been termed the *Johnny Appleseed* effect, a slow and gradual process whose effects have begun to materialize only recently (Wolff & Morrill, 2005). US Lacrosse now has 62 chapters in 42 states, and its memberships have grown from 43,696 in 1998 to over 334,033 in 2010 (US Lacrosse, 2010). As the governing body, US Lacrosse's mission has been to give "responsive and effective leadership" to the lacrosse community and to "provide programs and services to inspire participation while protecting the integrity of the sport" (US Lacrosse, 2011, p. 2). US

Lacrosse has taken a proactive stance toward remaining true to the origin of the game by using grants to fund programs and initiatives such as the Positive Coaching Alliance.

The 2012 US Lacrosse website provides a description of the Positive Coaching Alliance as being designed to help organizations educate their coaches, officials, athletes, and fans on how to honor the game. The website states that "The Double-Goal Coach 'Coaching for Winning and Life Lessons' workshop is one requirement for the Level 1 Coaching certification, which is part of the US Lacrosse Coaching Education Program." An example of this type of positive coaching style can be seen at US Lacrosse's annual Youth Festival, where athletes 15 years of age and under participate in games in which they play multiple positions without any official score being kept (Wolff & Morrill, 2005). In fact, Brennan (2005) posited, "Lacrosse seems to be a sport bent on behaving itself" (p. 10c). The coaching style in itself, guided by US Lacrosse's educational programs and services, may in fact be a contributing factor to the continued growth of and interest in the sport of lacrosse. While coaches and parents of other sports, such as baseball, often demand high levels of performance from their children, such as turning a double play or making sure to hit the cut-on off man, lacrosse coaches and parents seek only marginal technical perfection in basic skills, such as cradling or scooping (Wolff & Morrill, 2005). As a result, children, teens, and collegiate athletes are attracted to the skill set, athletic requirements, physicality, and untainted nature of the sport that has been preserved by the governing body (US Lacrosse, 2012; US Lacrosse, 2010; Kerrigan, 2007; Kohl, 2006; Brennan, 2005; Wolff & Morrill, 2005). Brennan (2005) explained “this uniquely American sport is catching on because it plays right into the wheelhouse of what so many US kids want to do these days; that is run, throw, catch, score and hit people” (p. 10c). Lacrosse allows child athletes to enjoy themselves without being constricted and guided by win-thirsty adults and organizations, which has contributed immensely to the increases in youth participation, as well as decreases in participation in other sports, such as baseball and softball (US Lacrosse, 2011; National Federation of State High School Associations, 2010).

The combination of factors such as the introduction of new, more user-friendly equipment, media exposure, the foundation of a governing body, and the preserved nature of the sport, which attracts athletes with a multitude of skill sets, has resulted in what some refer to as the lacrosse explosion (Harris, 2008; Boston Herald, 2008; Brennan, 2005; Burton & O'Reilly, 2010; Coulter, 2001; Eddington, 2000; Halley, 2008; Kohl, 2006; Mees, 2005; Nelson, 2010). This study now will turn to an examination of the fundamentals of how the game is played and how this impacts the associated strength and conditioning programs.

Playing the Game

In this section, a conceptual framework of how collegiate men’s and women’s lacrosse is played will be established, which will clarify how and why professionals in the field are taking certain approaches to lacrosse strengthening and conditioning. The majority of information in this section comes from the NCAA Men’s and Women’s Lacrosse Division II Rule Books, which can be downloaded for free from the NCAA Publications website (National Collegiate Athletic Association, 2010, 2011). A detailed description of all of the rules and regulations of both men's and women's lacrosse is beyond the scope of this paper. Rather, one aim of this section is to provide a general guide to both sports, covering the key rules and regulations that have guided the formation of the strength and conditioning programs used in this study. Another aim of this section is to outline the major differences between men's and women's lacrosse in order to address the programming of gender-specific strength and conditioning services.

The major differences between men's and women's lacrosse include physical and stick contact limitations, required protective equipment, stick modeling, the number of legal players on the field, field dimensions, and time restrictions (Hinkson & Lombardi, 2010; March 17th, 2012). Possibly the most notable and significant difference between the two sports is that physical contact and stick contact are heavily restricted in women's lacrosse while facing much less restriction, and even being encouraged to some extent, in men's lacrosse (Brennan, 2005). Men's lacrosse is considered an extremely high-contact sport, combining aspects of football, soccer, basketball, and ice hockey (McCulloch & Bernard, 2007; Diamond & Gale, 2001). Conversely, women's lacrosse emphasizes finesse and skill (Hinkson & Lombardi, 2010; March 17th, 2012). The highly restricted contact in women's lacrosse results in a shift from the necessity for physical abilities toward technical skill and tactical knowledge as the most important factors for success (Hinkson & Lombardi, 2010). While men can rely on a combination of speed, agility, anaerobic power, and physicality, women must rely heavily on all of the above characteristics with the exception of physicality (Hinkson & Lombardi, 2010; Carbuhn, Fernandez, Bragg, & Green, 2010). For example, while defending, men can use body and stick contact to attempt either to offset an opponent's path or dislodge the ball from the opponent's stick; however, in women's lacrosse, a defender must rely of speed, agility, and quickness to force the opponent to change her path and/or redirect (Randolph, 2012). Thus, the training program used in this study for women's lacrosse targeted foot speed, quickness, and agility to a higher degree than for men's lacrosse. On the other hand, the men received more strength training than the women for this very reason. Because men's lacrosse is a high-contact sport, higher levels of strength, bone, and muscle density were targeted (Ballantyne, 2000; Burger & Burger, 2006; Enemark-Miller et al., 2009; Gutowski & Rosene, 2011; Harris, 2006; Pistilli et al., 2008; Shaver, 1980).

The contact restriction differences result in differences between the required protective equipment worn by players of each gender (Dick, Lincoln et al., 2007; Dick, Romani et al., 2007; Hammer, 1993). For example, women are required to wear only mouth guards and protective eyewear (except for the goalie, who wears full pads and a helmet), while men must wear helmets, mouth guards, shoulder pads, padded gloves, elbow pads, and sometimes rib pads (Otago et al., 2007). With less protective equipment, specific strength training for women arguably should focus on the development of a slightly lower strength-to-mass ratio than for men. Men move about the field with the added weight of their protective gear, so this study targeted higher levels of strength for men than for women. As mentioned, the women's strength program was geared toward not only strength gains but enhanced efficiency at moving near-body-weight and at-body-weight, while men were required to move at-body-weight and above-body-weight efficiently. More details about the program's design and rationale will be presented in Chapter 3. In addition to the differences in strength requirements resulting from the varying rules and regulations, men's and women's lacrosse differs in the number of players allowed on each team.

Women's lacrosse consists of 12 players responsible for offensive attack (first home, second home, third home, and two attack wings) and defense (center, two wings, point, cover point, third man, and goalie), whereas men's lacrosse is limited to 10 players consisting of three attack men, three midfielders, three defensemen, and one goalie (Hinkson & Lombardi, 2010). Women have a larger field and rely heavily on passing versus physicality, which helps to explain the need for more players (Hammer, 1993). The women's lacrosse field measures 120 yards long by 65 yards wide, which recently was reduced from 70 yards wide (National Collegiate Athletic Association, 2011; Hinkson & Lombardi, 2010). The goals are six feet by six feet, with a goal circle that has "a radius of 2.6m (8'6") measured from the center of the goal line to the outer edge of the goal circle line" (National Collegiate Athletic Association, 2011, p. 14). In women's lacrosse, the *crease*, or the area behind the net similar to that seen in ice hockey, is highly regulated and therefore does not contribute to strategy as much as in men's lacrosse (National Collegiate Athletic Association, 2011; Hinkson & Lombardi, 2010). A men's lacrosse field measures 110 yards long by 60 yards wide, with six-foot by six-foot goals located 80 yards apart. The crease facilitates the movement of the ball and players, resulting in many defensive and offensive strategies (Plisk, 1992). As playing the crease has become highly strategic for men, so has the face-off (Plisk, 1992; Hinkson & Lombardi, 2010).

Similar to ice hockey, men's lacrosse uses a face-off to begin game play (National Collegiate Athletic Association, 2010; Plisk, 1992). Women, on the other hand, use a *draw*, which is less physical and less strategic (National Collegiate Athletic Association, 2011; Hinkson & Lombardi, 2010). Unlike in ice hockey, where face-offs are performed following each suspension of play, lacrosse face-offs occur only at the beginning of the game, at the end of each period, and after a team scores (Plisk, 1992). Plisk (1992) noted that a successful face-off man embodies a specific set of characteristics, including "quickness, strength, agility, size, balance, peripheral vision, and coordination" (p. 78). These characteristics become extremely important in strength-training programs for men; if a team can achieve face-off success, it will enjoy a higher rate of possession than the opponent (Plisk, 1992). Thus, the face-off men in this study were given specific strength and conditioning drills. Conversely, the women's draw, similar to the tip-off in basketball, results in a 50/50 chance regardless of other factors. The draw is less physical and results in the ball going aerial, so there is no guarantee of possession; therefore, draw-women did not receive a specific draw-related strength training program in this study. The last two differences that will be discussed between men's and women's lacrosse regard how men and women are required to model their sticks and the timeframe for play.

Stick differences directly reflect contact restrictions and thus impact the skill set and physical abilities needed to play (Hinkson & Lombardi, 2010). The NCAA requires a men's Crosse to be "an overall fixed length of either 40 to 42 inches (short Crosse) or 52 to 72 inches (long Crosse), except for the goalkeeper's Crosse, which shall be 40 to 72 inches long" (National Collegiate Athletic Association, 2010, p. 19). For women, "The Crosse's overall length shall be a minimum of .9 m (35-1/2") and a maximum of 1.1 m (43-1/4"), there are no "long sticks" allowed except for that of a goalie which can have a stick at “a minimum of .9 m and a maximum of 1.22 m. (National Collegiate Athletic Association, 2011, p. 16; Hinkson & Lombardi, 2010). The top portion of a men’s Crosse or the head of the Crosse can be strung with mesh in such a way that the ball sits slightly deeper in the pocket than in a women’s Crosse, which is not allowed to be strung with mesh. The rule of thumb suggests that when in the pocket of a men’s stick, the ball must be at least even with the edge of the Crosse (Hinkson & Lombardi, 2010; National Collegiate Athletic Association, 2011, 2010). On a women’s stick, a much shallower pocket must be strung in the traditional way without mesh, and when in the pocket of a women’s stick, the ball must be above the wall / edge of the Crosse head (National Collegiate Athletic Association, 2011, p. 18). These differences directly impact how fast the ball travels and how easily the ball is dislodged from one’s stick. The ease with which a women’s ball can be dislodged highlights the need for more precise movement and stick skills for women than men.

The final difference between men’s and women’s lacrosse that affects strength and conditioning requirements involves the timeframe restrictions of game play. Although both games are 60 minutes long, a men’s game is divided into four 15-minute quarters with two-minute intervals between each quarter, whereas the women’s game is divided into 30-minutes halves with a ten-minute halftime (National Collegiate Athletic Association, 2011, p. 23; National Collegiate Athletic Association, 2010, p. 29). Longer halves versus shorter quarters play a role in the aerobic base and anaerobic capacity needed for successful participation in each sport. Plisk (1992) identified active versus inactive profiles for men’s lacrosse at the DI level, beginning by identifying characteristics of the midfielder position presenting an average of:

> nine to 14 shifts per game each subdivided by into 5.7 to 7.5 intermittent work repetitions (as function of official suspension of play) with no more than 20 seconds of relief, and with approximately 1.3 to 1.7 extended recovery intervals (as function of prolonged [greater than 20-second] suspensions of play after each goal). Fundamental intra- and inter shift exercise: relief ratios are therefore approximately 1.6:1 and 1:2, respectively. (p. 7-8)

No specific details regarding the work-to-rest ratios of women's lacrosse were found in the literature. Therefore, the information provided by Plisk (1992) in some fashion has been applied to women's lacrosse.

Both men's and women's lacrosse possess unique differences in terms of how the game is played; some experts claim that these difference result in two completely different sports (Hinkson & Lombardi, 2010). Therefore, strength coaches must understand the major difference between the two sports, which consist of a combination of physical contact restrictions, stick contact restrictions, protective equipment restrictions, number of players on the field, field dimensions, stick modeling restrictions, and time-of-play restrictions (National Collegiate Athletic Association, 2011, 2010; Hinkson & Lombardi, 2010; Plisk, 1992). In order to shed light on the differences and similarities between male and female lacrosse athletes, the following section will present a physiological profile of each.

Physiological Profile of Lacrosse Athletes

Certain key physiological attributes of successful play have influenced the design of the strength and conditioning program in this study. Understanding the sport's key physiological components for successful play requires more than just a subjective look at how the game is played; rather, it requires an in-depth look that considers the conclusions of other researchers. Operational terms from Chapter 1 will be applied to both men's and women's lacrosse, and a physiological profile of both sports will be outlined. The review will focus primarily on aerobic capacity, anaerobic power, body composition, strength, speed, power, and agility. An examination of injury prevalence within each sport will follow this outline of physiological profiles, as will a description of the strength training and conditioning programs offered by other professionals in the field.

Both men's and women's lacrosse have been found to depend heavily on several factors, including technical skill, tactical skill, speed, agility, strength, flexibility, and a combination of both aerobic capacity and anaerobic power (Hoffman et al., 2009; Ballantyne, 2000; Burger & Burger, 2006; Carbuhn et al., 2010; Enemark-Miller et al., 2009; Gutowski & Rosene, 2011; Hinkson & Lombardi, 2010; Otago et al., 2007; Pistilli et al., 2008). Hoffman and colleagues (2009) reported through a video analysis of work-to-rest ratios that anaerobic metabolism seems to be the primary performance contributor of the sport. Their study, entitled "Physical Performance Characteristics of National Collegiate Division III Champion Female Lacrosse Athletes," explained that "although midfielders cover the greatest distance during competition, work-to-rest ratios were similar between positions" (Hoffman et al., 2009p. 1528). In comparison to other sports, Hoffman and colleagues (2009) reported that the female lacrosse athlete's "aerobic capacity is higher than the 90th percentile of age matched individuals and is similar to values of collegiate basketball, team handball and ice hockey athletes but less than that seen in soccer players" (p. 1524). Levels of anaerobic power have been shown to be above the 90th percentile of age-matched individuals, and the levels are lower than primarily anaerobic sports such as football and basketball (Hoffman et al., 2009; Vescovi et al., 2007; Stienhagen, Meyers, Erickson, Noble, & Richardson, 1998). Baechle et al. (2008) suggested that the primary energy system demands of the sport require high levels of phosphagen metabolism and moderate levels of anaerobic glycolysis, as well as moderate levels of aerobic metabolism, adding support to Hoffman and colleagues' (2009) suggestion that lacrosse athletes express lower levels of anaerobic power and higher levels of aerobic capacity than football or basketball athletes and lower aerobic capacity but higher anaerobic power than soccer athletes. This research indicates that lacrosse is somewhat of an intermediate sport that combines certain requirements of football, ice hockey, basketball, and soccer (Hinkson & Lombardi, 2010). Table 3 is a general energy system chart provided adapted from Baechle et al. (2008) comparing the primary energy system demands of popular sports, which supports the notion that lacrosse is an intermediate energy system sport (p. 95). In addition, Shaver (1980) found the mean value of maximal oxygen uptake ($VO2_{MAX}$) for a group of male lacrosse athletes to be 59.5 ml/kg • min, which is similar to other sports such as football, gymnastics, wrestling, and basketball, all of which require quick bursts of speed (p. 215). This mean value, however, was much lower than similar college-aged athletes participating in long-distance running and swimming (Shaver, 1980, p. 215). Enemark-Miller et al. (2009) found mean $VO2_{MAX}$ scores for female lacrosse athletes to be 45.7 +/- 4.9 ml•kg-1•-1 (p. 41), which puts them "above the 90th percentile of normative data as described in *ACSM's Guidelines for Exercise Testing and Prescription* as well as NSCA's *Essentials of Strength Training and Conditioning"* (Enemark-Miller et al., 2009, p. 41). Furthermore, the $VO2_{MAX}$ scores of female lacrosse athletes were comparable to those of other female collegiate athletes, such as basketball players and track sprinters; the scores also were higher than those published for one NCAA Division I women's soccer team (Enemark-Miller et al., 2009). Additional information about the anthropometrics and performance characteristics of male and female lacrosse athletes was provided by Shaver (1980) and Enmark-Miller et al. (2009).

Table 3

Primary Energy Systems of Sports

Sport	Phosphagen	Anaerobic Glycolysis	Aerobic Metabolism
Lacrosse	High	Moderate	Moderate
Football	High	Moderate	Low
Ice Hockey	High	Moderate	Moderate
Field Hockey	High	Moderate	Moderate
Basketball	High	Moderate to High	-
Boxing	High	High	Moderate
Basketball	High	Low	-

Primary energy systems used when playing common sports
(Baechle et al., 2008, p. 95)

Shaver (1980) found men's lacrosse athletes to have lower body fat percentages than other college-aged athletes participating in football, baseball, throwing, ice-hockey, cross-country skiing, and basketball but higher body fat percentages than athletes participating in long-distance running, gymnastics, swimming, wrestling, volleyball, and tennis (p. 215). Enemark-Miller and colleagues (2009) found women's lacrosse athletes to have a mean body fat percentage of 22.3 =/- 5% as measured through air-displacement plethysmography (BOD POD), placing them in the 50th percentile. These scores also were similar to those of women's basketball, volleyball, and softball athletes (Enemark-

Miller et al., 2009). Shaver's (1980) inter-squad comparisons showed male lacrosse midfielders as taller, lighter, and having less body fat than attackmen and defenders, who are very similar to each other size and body composition (p. 215). Shaver (1980) and Hoffman et al. (2009) both suggested that the differences in both male and female midfielders' anthropometrics and performance characteristics may be the result of requirements specific to their position, as midfielders are the only players who cover the entire field during competition, thereby covering greater distances than attackers or defenders, including goalies. Vescovi et al. (2007) found no significant difference in body mass, aerobic capacity, sprint speed, vertical jump, pro agility, or Illinois agility for Division I female lacrosse athletes playing different positions (p. 337-338). Further tests by Enemark-Miller et al. (2009) indicated that female lacrosse athletes in the 2009 study had a mean vertical jump of 44.0 +/- 6.2cm, similar to observed NCAA women's college basketball and competitive female college athletes; a mean sit and reach of 50.1 +/- 16.8cm, above the 40th percentile and higher than the average female college-aged students; and a mean score of 45.8 +/- 20.0 for push-ups, above the 90th percentile.

These findings suggested that both male and female lacrosse players highly utilize anaerobic metabolism supported by aerobic metabolism for the primary demands of the sport (Schmidt et al., 1981; Baechle et al., 2008; Hoffman et al., 2009; Shaver, 1980). In addition, even though positions have overlapping responsibilities and utilize similar metabolic pathways, each of the four primary positions (i.e., attack, midfield, defense, and goalie) in both men's and women's lacrosse possess unique mechanical demands (Hoffman et al., 2009). For example, attack men spend the majority of their time on the opponent's side of the field, and their primary responsibility is to score goals; defense plays opposite of attack on the home side of the field and aids in the protection of the goal; midfielders cover both offensive and defensive responsibilities, playing both sides of the field; and goalies are responsible for defending the goal (Carter, Westerman, Lincoln, & Hunting, 2010; Enemark-Miller et al., 2009; Gutowski & Rosene, 2011; Hoffman et al., 2009). Neither Steinhagen et al. (1998) nor Vescovi et al. (2007) found any significant differences in regards to speed, agility, endurance, power, or vertical jump height positions for men's lacrosse. Regarding work-to-rest ratios, Hoffman et al. (2009) found significant differences in the performance traits between positions, contending the findings of Vescovi et al. (2007), who reported no significant differences in performance traits between positions. Hoffman et al. (2009) indicated that attackers were heavier than midfielders and more powerful than defenders and midfielders; in addition, midfielders had less body strength than both defenders and attackers (p. 1528).

When compared to other Division III female collegiate athletes, the lacrosse players in Hoffman et al.'s (2009) study were weaker and slower than soccer players, faster on a 40-yard dash than volleyball players, but not as fast as volleyball players on a T-Drill Test (p. 1528). Hoffman et al. (2009) suggested that these findings can guide coaches and strength coaches in differentiating training between athletes in different positions, noting the differences in physical performance parameters between the positions (p. 1528). Current research on lacrosse, although still in its infancy, has indicated that men's lacrosse athletes possess similar physiological characteristics and must meet similar demands as athletes in other sports, such as football, basketball, wrestling, ice hockey, soccer, and track (sprinting); additionally, female lacrosse athletes possess similar physiological characteristics and must meet similar demands as women's basketball, soccer, and track athletes (Enemark-Miller et al., 2009; Hoffman et al., 2009; Plisk, 1992; Shaver, 1980; Steinhagen et al., 1998; Vescovi et al., 2007).

Common Injuries Sustained in Collegiate Lacrosse

The purpose of this study was to examine the effectiveness of the strength and conditioning services offered to two specific sports teams, a men's lacrosse team and a women's lacrosse team, at a NCAA DII university from the beginning of the 2011 school year through the preseason phase of training, August 2011 through February 2012. The primary mission of strength and conditioning professionals is to enhance the athletic performance of their athletes in order to reduce the risk of injury for those athletes (Baechle et al., 2008, pp. 570-577). Therefore, understanding the most common and preventable types of injuries sustained by lacrosse athletes was essential to the design of the strength and conditioning program used in this study. Dick, Lincoln et al. (2007), along with Dick, Romani et al. (2007), gathered descriptive epidemiological data of collegiate male and female athletes through their NCAA Injury Surveillance System (ISS) from 1988-1989 through 2003-2004, providing details of the location, rate, timing, and type of injuries sustained by athletes in all participating sports.

Men's and women's lacrosse share a few commonalities in terms of injury location, rate, timing, and type (Dick, Lincoln et al., 2007; Dick, Romani et al., 2007; Hinton et al., 2005). The most common similarity between the two sports is the timing of injuries (Dick, Lincoln et al., 2007; Dick, Romani et al., 2007). Players of both genders were more likely to sustain injuries during games than practices; men were four times more likely to sustain an injury during a game versus practice, while women were twice as likely (Dick, Romani et al., 2007, p. 259; Dick, Lincoln et al., 2007, p. 267). A summary of the ISS findings for male and female lacrosse athletes follows. Each summary will highlight additional similarities and differences in order to shed light on the major injury issues on which a strength coach should focus preventative measures.

Men's Lacrosse Injury Analysis

Between 1988-1989 and 2003-2004, an average of 18% of varsity men's lacrosse programs participated in the yearly NCAA Injury Surveillance System. The number of participating teams grew from 150 in 1988-1989 to 211 in 2003-2004 (Dick, Romani et al., 2007, p. 255). During the study, the average number of games, athletes per game, practices, and athletes per practice were 13, 24, 66, and 34, respectively, for Division I; 13, 20, 57, and 25, respectively, for Division II; and 14, 22, 57, and 29, respectively, for Division III (Dick, Romani et al., 2007, p. 256). Table 4 clearly compares these numbers between the different NCAA divisions and genders. For all three divisions, injuries were four times more likely to occur during a game than during practice, and there were no notable trends over the period of time sampled (Dick, Romani et al., 2007, p. 255).

Table 4

Injury Surveillance Survey Demographics

Gender and Division	Number of Games	Athletes Per Game	Practices	Athletes Per Practice
Male DI	13	24	66	34
Male DII	13	20	57	25
Male DIII	14	22	57	29
Female DI	16	16	60	23
Female DII	14	16	55	21
Female DIII	14	16	48	20

(Dick, Lincoln et al., 2007; Dick, Romani et al., 2007)

Although game and practice injury rates did not differ across divisions, these rates did differ across seasons, such as the preseason, in-season, and postseason; for all programs, preseason practice injury rates were over two times higher than in-season practice injury rates, and in-season game injury rates were nearly two times as high as postseason injury rates (Dick, Romani et al., 2007, p. 256). In terms of injury location, there are five main injury sites, including the head/neck, upper extremity, trunk/back, lower extremity, and other/system; 48.1% of all game injuries and 58.7% of all practice injuries were to the lower extremity (Dick, Romani et al., 2007, p. 256). The second most common injury site was the upper extremity at 26.2% during games and 16.9% during practices. Head/neck injuries occurred least frequently at 11.7% during games and 6.2% during practices (Dick, Romani et al., 2007, p. 256).

Combining data from all years and divisions, the most common body part and injury types during games were ankle ligament sprains, internal knee disarrangements, concussions, upper leg contusions, and muscle strains; during practices, the most common body part and injury types were ankle ligament sprains, upper leg muscle strains, internal knee disarrangements, and concussions (Dick, Romani et al., 2007, p. 256). Concussions, internal knee disarrangements, and ankle ligament sprains were nine, five, and three times more likely to occur in a game than in a practice, respectively (Dick, Romani et al., 2007, p. 256). Furthermore, the study shed light on three primary mechanisms of injury for men’s lacrosse players.

The mechanism or cause of injuries sustained during practices and games has been categorized as follows: 1) player contact, 2) other contact (stick / ball / ground), and 3) no contact (Dick, Romani et al., 2007). During games, 45.9% of all injuries occurred from player contact, 26.7% from other contact, and 26.4% from no contact; during practices, only 24% of injuries were from player contact, 24% from other contact, and 50% from no contact (Dick, Romani et al., 2007, p. 259). Of the game and practice injuries, 21% were considered severe, having resulted in more than 10 days of restricted or total loss of participation (Dick, Romani et al., 2007, p. 259). Internal knee disarrangement, acromioclavicular joints, ankle ligament sprains, upper leg muscle strains, and concussions accounted for 27.3%, 7.3%, 7.1%, 5.6%, and 3%, respectively, of all severe injuries during games; the same was seen for practice injuries, with the exception that acromioclavicular joint injuries accounted for the majority of severe injuries (Dick, Romani et al., 2007, p. 259).

Dick, Romani et al. (2007) indicated a few prevention and intervention methods that lacrosse coaches may choose to utilize based upon these findings. First, the highest injury rates occurred during preseason games versus postseason games, which results from the players' increased physical accommodation to games as the season progresses. Therefore, Dick, Romani et al. (2007) suggested that a supervised, lacrosse-specific, preseason conditioning program may be of value to increase accommodation more quickly before the preseason games take place, as well as to reduce the emphasis on conditioning during the regular season practices. However, coaches must be cautious when implementing such a program as research indicates that similar exercise patterns, volumes, and intensities over a prolonged period of time may result in overtraining; thus, specific attention must be paid to the pattern, volume, and intensity of preseason conditioning (Baechle et al., 2008; Bompa & Haff, 2009; Stone et al., 2007; Stoppani, 2006; Ratamess, 2011). Dick, Romani et al. (2007) suggested a preseason template that mirrors the NCAA football model, having supervised practices and/or conditioning in the early preseason with limitations on required gear, contact, sessions, and session length (p. 261).

Women's Lacrosse Injury Analysis

Between 1988-1989 and 2003-2004, an average of 23.1% varsity women's lacrosse programs participated in the annual NCAA Injury Surveillance System. The number of teams grew from 119 in 1988-1989 to 261 in 2003-2004 (Dick, Lincoln et al., 2007, p. 262). During the study, the average number games, athletes per game, practices, and athletes per practice were 16, 16, 60, 23, respectively, for Division I; 14, 16, 55, 21, respectively, for Division II; and 14, 16, 48, 20, respectively, for Division III (Dick, Lincoln et al., 2007, p. 264). Table 4 clearly compares these numbers between the different NCAA divisions and genders. For all three divisions, the injury rate was two times higher during games versus practices, and there was a noted 2.4% average annual increase in game injury rates, as well as a 1.6% average annual increase in practice injury rates (Dick, Lincoln et al., 2007, p. 263). Divisional differences were found, with higher injury rates in both games and practices for Division I athletes versus Division III athletes, higher practice injury rates in Division I than Division II, and higher game injury rates in Division I than II (Dick, Lincoln et al., 2007, p. 264). Seasonal differences included pre-season practice injury rates for all divisions that were nearly twice as high as in-season rates. Additionally, comparable to men's lacrosse, all levels of women's lacrosse had a higher rate of injury during in-season games compared to postseason games (Dick, Lincoln et al., 2007, p. 264).

Women's lacrosse injuries were grouped into the same five categories as men's, including head/neck, upper extremity, trunk/back, lower extremity, and other/systems. Over 60% of all game and practice injuries were to the lower extremity, while 22% of game injuries and 12% of practice injuries were to the head/neck (Dick, Lincoln et al., 2007, p. 264). The most common body part and injury types in women's lacrosse for both games and practices were ankle ligament sprains, internal knee disarrangements, concussions, and upper leg muscle strains, which is similar to men's being ankle ligament sprains, knee internal disarrangements, concussions, upper leg contusions, and upper leg muscle strains during games and ankle ligament sprains, upper leg muscle strains, knee internal disarrangement, and concussions during practices (Dick, Lincoln et al., 2007, p. 264; Dick, Romani et al., 2007, p. 256).

The mechanism of injury again was categorized as player contact, other contact (stick / ball / ground), or no direct contact. As a result of the highly restricted player and stick contact in women's lacrosse, the majority of game injuries (44.3%) came from no direct contact, 35.9% came from other contact, and only 18.6% came from player contact; additionally, non-contact injuries accounted for 62% of practice injuries (Dick, Lincoln et al., 2007, p. 264; National Collegiate Athletic Association, 2011, 2010). As for severe injuries (over 10 days of restricted or total loss of participation), internal knee disarrangements accounted for nearly half (47%) of such injuries, followed by ankle ligament sprains at 14.2%. During practices, lower leg stress fractures, internal knee disarrangements, and ankle ligament sprains constituted the majority of severe injuries (Dick, Lincoln et al., 2007, p. 265). A game injury analysis indicated that the majority of injuries took place without direct contact (40.5%), while handling the ball (39.5%), and during loose ball situations (30.2%); the most common injury scenario occurred with no contact while handling the ball (16.4%), followed by contact from a stick while handling the ball (10.5%) (Dick, Lincoln et al., 2007, p. 265).

Dick, Lincoln et al. (2007) suggested that the annual average increase in injuries over the 16-year period of the study may have resulted from “increased participation, greater athleticism among players, the use of more sophisticated equipment (e.g., sticks made of stronger, lighter weight composite materials rather than wood), and changes in tactics” (p. 266). Furthermore, the most common injuries for women appeared to be minor strains, sprains, and contusions from the ankle and knee ligaments, along with head, face, and eye contact injuries (Dick, Lincoln et al., 2007, p. 266). These findings prompted Dick, Lincoln et al. (2007) to suggest that coaches add a lower extremity injury prevention system to the women’s lacrosse conditioning regimen, as these types of injuries constitute the greatest injury burden to the athletes; additionally, the findings supported the need for athletes (especially collegiate female lacrosse athletes) to maintain conditioning during the off-season and participate in a progressive conditioning system of training immediately upon initiating preseason practices (p. 267).

Strength and Conditioning for Lacrosse: Testing and Performance Assessments

The purpose of this study was to examine the effectiveness of the strength and conditioning services offered to NCAA Division II men’s and women’s lacrosse teams at a medium-sized, private, four-year institution in the Midwest. Additionally, this study aimed to add proven, empirical evidence to the field of research on appropriate strength and conditioning for lacrosse. Thus far, this literature review has identified how the game is played, the physiological profiles of male and female lacrosse athletes, and injury prevalence for male and female athletes at the collegiate level. The literature review will conclude with an investigation of what other professionals have documented in terms of strength and conditioning services for both male and female lacrosse athletes.

The relevant body of literature does not appear to include proven, empirical evidence on effective strength training and conditioning programs for lacrosse players. A handful of articles, however, have suggested strength training and/or conditioning programs for male and female lacrosse players (Gutowski & Rosene, 2011; Howley, 2011; Pistilli et al., 2008; Burger & Burger, 2006; Devoe, 2006; Harris, 2006; Ballantyne, 2000; Moore, 1985; Morrill, 1980). These suggestions will be synthesized and summarized in order to provide a general sense of what other professionals have been implementing for lacrosse athletes in regards to strength and conditioning programs.

Before designing a strength and/or conditioning program for an athlete, a strength and conditioning professional should conduct a needs assessment / analysis (Ratamess, 2011; Baechle et al., 2008). One major component of a needs analysis is to determine how an athlete's improvements will be assessed and evaluated before, during, and after a strength program, conditioning program, or entire season; these assessments and evaluation tools also can be used to identify detraining resulting from time off or overtraining if volumes and intensities are thought to be too high (Bompa & Haff, 2009; Baechle et al., 2008; Stone et al., 2007; Stoppani, 2006). Gutowski and Rosene (2011) presented an appropriate and specific testing model for men's lacrosse that also could be used as it stands or slightly modified for women's lacrosse. In their 2011 article, *Preseason Performance Testing Battery for Men's Lacrosse*, Gutowski and Rosene outlined a testing battery for assessing all of the necessary components of successful lacrosse play, including speed, agility, strength, endurance, power, and body composition. The researchers selected performance tests specific to mechanics, movement, and physiology to assess maximum aerobic power, maximum muscular power, muscular strength, speed, agility, balance, and body composition. Specifically, the tests chosen included anthropometrics, such as height, weight, and body fat percentages from skin fold calipers; vertical jump (maximum anaerobic vertical power); maximum oxygen consumption (maximum aerobic power); 1RM bench press (maximum upper body strength); 1RM back squat (maximum lower body strength / full body exercise / general strength); 40-yard sprint (explosive sprinting power); t-run or t-drill (acceleration, change of direction, deceleration, explosion, and speed); agility run (rapid acceleration, deceleration, and change of direction in a localized area); and box run (change in direction with speed, balance, and coordination) (Gutowski & Rosene, 2011). The performance test selection parameters provided by Gutowski and Rosene (2011) are biomechanically and metabolically appropriate for the sport of lacrosse and are the only highly specific and appropriate testing parameters published to date. Unpublished email correspondence between the researcher and Curtis Lamb of Limestone College in Gaffney, South Carolina, an NCAA Division II program boasting one of each of the most successful men's and women's lacrosse teams in the nation, provided additional insight into the testing and evaluation procedures utilized by other highly successful strength and conditioning programs for lacrosse athletes Lamb (personal communication, August 20th, 2011).

Lamb (personal communication, August 20th 2011) indicated the use of multiple rep max muscular strength and power tests, such as the 3RM power clean, 3RM bench press, and 3RM front squat; the use of a 3RM may provide more specificity for lacrosse because the sport requires multiple expressions of strength and power as opposed to single expressions. Additionally, he suggested evaluating all muscular strength and power performance tests in terms of strength-to-mass ratio, factoring in one's body weight. In terms of linear speed, agility, and endurance, Lamb indicated using a 10-yard Sprint, Illinois agility run, timed half gasser runs, and a timed ladder conditioning run (personal communication, August 20th, 2011).

These published sources and the personal communication provided specific detail concerning what may be appropriate performance testing parameters and drills for both men's and women's lacrosse players. In terms of a needs assessment/analysis, once the specific biomotor patterns, requirements, and performance abilities have been identified, assessed, and evaluated, a strength coach then must begin the program design process (Baechle et al., 2008; Bompa & Haff, 2009; Ratamess, 2011; Stone et al., 2007; Stoppani, 2006). Program design suggestions from other professionals in the field contributed to the outlining of the program design used in this study.

Strength and Conditioning for Lacrosse: Speed, Agility, Quickness, and Conditioning

Lacrosse combines elements of speed, agility, and quickness, similar to such sports as basketball, football, hockey, and soccer, and similar metabolic pathways as basketball, hockey, and soccer; therefore, speed, agility, quickness, aerobic conditioning, and anaerobic power should take substantial priority when designing strength and conditioning programs for lacrosse athletes (Ballantyne, 2000; Boston Herald, 2008; Burger & Burger, 2006; Burton & O'Reilly, 2010; Carter et al., 2010; Enemark-Miller et al., 2009; Gutowski & Rosene, 2011; Hinkson & Lombardi, 2010; Kerr & Males, 2010; Matz & Nibbelink, 2004; McCulloch & Bernard, 2007; Mees, 2005; Mihata, Beutler, & Boden, 2006). Although the use of speed, agility, quickness, aerobic conditioning, and anaerobic power methods of training have been well documented for such sports as football, baseball, basketball, hockey, soccer, gymnastics, and wrestling, the purpose of this section again is to focus strictly on what has been documented for lacrosse (Baechle et al., 2008; Bompa & Haff, 2009; Baker & Nance, 1999; Barker, Wyatt, Johnson, Stone, O'Bryant, & Kent, 1993; Clark et al., 2010; Cormie et al., 2011; Durell et al., 2003; Earp & Kraemer, 2010). The next section focuses on what has been published and how this information was applied to the strength and conditoining program in this study. As lacrosse only recently has experinced high rates of growth, the next section will include a discussion of recent publications first before examining older publications.

Devoe (2006), of Devoe Human Performance in Richardson, Texas, indicated the use of five specific drills to improve the speed and agility of lacrosse athletes. Devoe (2006) separated speed and agility into two specific categories, straight-ahead speed and small-area quickness (p. 60). The first drill for straight-ahead speed is the “lean-fall-run,” also known as the falling start. Devoe (2006) has explained that this drill puts one’s body in the most optimal position to emphasize triple flexion (ankle/knee/hip), as well as to generate one’s maximum speed and power (p. 60). The second drill for straight-ahead speed is called “scramble out with loose balls.” In this drill, lacrosse balls are placed 10, 20, and 30 yards away from an athlete lying on his/her stomach with lacrosse stick in hand. Responding to the coach’s command, the athlete rises, accelerates towards the first ball, decelerates in order to pick the ball up, drops the ball, and proceeds in the same fashion toward the second and then the third ball (Devoe, 2006, p. 60). This drill allows the athlete to practice acceleration and deceleration, as well as ball-handling skills (Devoe, 2006, p. 61). Harris (2006), in his article “Off-Season Conditioning for Women’s Lacrosse,” documented the use of similar drills. The third drill mentioned by Devoe (2006) is the standard four-cone drill in which four cones are placed at equal distances 17 feet apart from each other; athletes perform a variety of moves consisting mainly of a forward move, lateral move, backward move, and finishing with a lateral move opposite the previous lateral move (p. 61). The fourth and fifth drills become more complex and random in nature, more closely mimicking lacrosse-specific moves. The fourth drill, “sprint to back pedal with directional changes,” utilizes coaches to randomly determine whether the athlete sprints forward, back pedals, or executes a defensive slide to the left or right; this drill lasts approximately 30 seconds (Devoe, 2006, p. 61). The fifth drill, which Devoe (2006) referred to as “Krazy Cones,” involves 10 cones placed in game-specific positions, forcing the athlete to cut at unusual times and maintain an appropriate center of gravity, pick up his/her feet, and break down properly (p. 61). Additional drills for quickness, foot speed, and agility that have been used for lacrosse include multiple agility ladder drills, which are limited only by the coach’s imagination and can be executed forward, laterally, and backwards to train a large number of athletes in a minimal amount of time (Harris, 2006, p. 93).

In addition to agility, lacrosse athletes require a great deal of speed moving forward, laterally, and backward. Harris (2006) and Moore (1985) offered suggestions for lacrosse-specific speed development. Harris (2006) divided speed into two categories, linear and lateral; when training for either linear or lateral speed, he used distances less than 15 yards and in utilized full recovery order to optimize neural performance (p. 94). Kraemer's (2000) commentary on allowing for full recovery may be the most important aspect of training that strength coaches must understand when developing speed, agility, quickness, and power, not only for lacrosse players, but for all athletes; he explained that these four components cannot be developed when athletes are performing skills in a fatigued state. When conducting speed, agility, quickness, or power development drills, athletes must be allowed to recover fully in order to maximize the potential of the neuromuscular and bioenergetics systems specific to the development of these components (Kraemer, 2000; Ratamess, 2008). Additional drills for developing lower body power (quickness), as well as shoulder and trunk stabilization, are called weighted (PVC) jumps, as noted by Pistilli et al. in their 2008 article entitled "Sport-Specific Strength Training Exercises for the Sport of Lacrosse." In this drill, athletes utilize a weighted PVC pipe held in the overhead position one arm at a time while jumping in place, landing with proper lower body/upper torso positioning and repeating the movement up to 10 times for one set (Pistilli et al., 2008, p. 35). As a result of the high degree of quickness associated with lacrosse, plyometrics similar to weighted PVC jumps have been incorporated into lacrosse-specific training programs in order to enhance lower body quickness and power; such drills include jumping, hopping, and/or bouncing on two feet, one foot, with an implement, without implements, on a box, over a barrier, forward, laterally, and backwards (Burger & Burger, 2006; Moore, 1985; Ballantyne, 2000). All of the drills and modalities just described represent suggested appropriate speed, agility, and quickness exercises used by other lacrosse professionals.

Additionally, aerobic and anaerobic conditioning exercises require the attention of lacrosse strength and conditioning coaches.

Perhaps the oldest known official documentation of suggested lacrosse-specific conditioning drills/programs comes from Moore (1985) of the University of Maryland's lacrosse program. Moore's 1985 lacrosse program focused on weight training, flexibility, and aerobic and anaerobic conditioning. Moore identified the off-season as the starting point for the program; at that point, the focus of the program was to develop a foundation or base level of conditioning and workload capacity. Ballantyne (1985) and Burger and Burger (2006) implemented the same design principle for a female and male off-season lacrosse program, respectively. Moore (1985) used basic conditioning exercises, long runs of two or more miles three to five times per week, in order to develop a base level of aerobic endurance. To increase anaerobic capacity, Moore (1985) implemented a circuit-style resistance-training program on variable resistance machines, limiting rest between sets and progressively increasing the work performed throughout the off-season (p. 37). Ballantyne (2000), on the other hand, utilized two different phases for his off-season conditioning program, starting with 30 minutes of continuous exercise at 70-75% max heart rate performed three days a week through phase one (four weeks long), and followed by 30 minutes of continuous exercise at 70-80% max heart rate performed two days a week through phase two (four weeks long).

Harris (2006) provided an additional suggestion as to an appropriate off-season lacrosse conditioning program; he recommended splitting the off-season into two phases and utilizing slightly more game-specific distances, rest intervals, and intensities. He used a 120-yard run with jog back, 60 yard shuttles, and a 60-yard run with jog back for the first phase of off-season training, and a 150-yard shuttle (30x5), 60-yard shuttle, and 150-yard shuttle (50x3) for the second phase, noting specific times for each run and the associated rest period, as well as the number of sets and reps for both phases (Harris, 2006, p. 94). Although Burger and Burger (2006) did not provide specifics, they posited that an early off-season program should focus on cardiovascular fitness while initially limiting running, and then progress toward running while continuing to focus on cardiovascular fitness; as the off-season progresses further towards the preseason, the conditioning should progress to interval running (improving glycolytic capacity) and high-intensity, short-duration sprints and change-of-direction drills (p. 21). Baechle et al. (2008), Bompa and Haff (2009), Stone et al. (2007), and Zatsiorsky and Kraemer (2006) support using the off-season as a foundational period for developing base levels of strength, endurance, muscle hypertrophy, and/or workload capacity. Although this phase takes place during the off-season, some authors suggest that it more appropriately should be referred to as the *preparatory phase* because competitive athletes never truly have an off-season (Bompa & Haff, 2009).

At the start of the preseason, Moore (1985) switched gears and began to focus on preparing the athletes to master the specific skills and abilities required for the upcoming competitions. This strategy has been used for many years and is well documented in the literature (Baechle et al. , 2008). Additionally, Ballantyne (2000) followed a similar theoretical concept by removing longer, slower aerobic conditioning and adding more lacrosse-specific, higher-intensity conditioning exercises. He implemented two preseason phases, first emphasizing strength development and then power development. During phase one, the volume of metabolic conditioning was reduced to two days of general aerobic conditioning and one day of anaerobic conditioning. The anaerobic training day consisted of three 45-second runs at near maximum intensity, with two minutes of rest between each run, followed by three minutes of rest, and then three 30-second runs at maximum intensity, with 90-second rests between runs, with the addition of one interval per week throughout the four-week phase (Ballantyne, 2000, p. 45). During phase two of the pre-season training program, which emphasized power development, Ballantyne (2000) focused on game-specific metabolic demands by removing long, slow aerobic training and adding anaerobic intervals, speed-agility drills, and plyometrics (p. 46). Returning to Moore's (1985) pre-season conditioning, he utilized box lacrosse tournaments as the modality of game-specific conditioning; in addition to the smaller team round-robin conditioning from box lacrosse, he also utilized interval running, starting with 300 meters early in the preseason and ending with sprints between 20 and 40 meters later in the preseason as the regular season neared (p. 38). Bompa and Haff (2009) also supported playing on a smaller field, with fewer players, and/or in a man-down format, meaning that either the offense or defense would play with one less player, suggesting that doing so forces athletes to move faster and perform at higher intensities than otherwise required in a normal game setting (p. 125). Although the specific drills and exercises differed, Moore (1985), Ballantyne (2000), and Burger and Burger (2006) used the same theoretical approach in their progressive conditioning designs for men's and women's lacrosse from the off-season to the preseason, utilizing general aerobic conditioning early in the off-season and progressing toward higher-intensity, more sport-specific, interval-type training mechanisms as the regular season drew nearer.

Ballantyne (2000), Burger and Burger (2006), and Moore (1985) also agreed on how conditioning should progress once the regular or in-season lacrosse phase begins. Each author identified maintenance aerobic conditioning, anaerobic power, and the prevention of injury and overtraining as the main areas of emphasis for the in-season conditioning program. Similar progression design concepts have been used over a wide range of sports and have been deemed most appropriate for optimal performance; in addition, these same progression design concepts are used when planning resistance-training programs for lacrosse and other sports (Baechle et al., 2008; Ballantyne, 2000; Barker et al., 1993; Bompa & Haff, 2009; Burger & Burger, 2006; Earp & Kraemer, 2010; Harris, 2006; Hoffman et al., 2009; Kraemer, 2000; Moore, 1985). Next, the literature review will conclude with a direct discussion of the resistance/strength training programs documented by other professionals in the field.

Strength and Conditioning for Lacrosse: Resistance Training

Resistance training has been shown to increase muscular strength, endurance, anaerobic power, balance, coordination, throwing velocity, kicking performance, baseball bat swing velocity, tennis serve velocity, wrestling performance, cycling power and performance, muscle hypertrophy, and aerobic power; to decrease fat mass and increase lean mass; to increase the maximum rate of force production; and to increase vertical jump ability, sprint speed, and ligament, tendon, collagen, and bone strength (Ratamess, 2011, p. 10; Ratamess, 2008, p. 96; Stone et al., 2007, pp. 201-228; Krieger, 2010). Therefore, the need for a resistance-training program for competitive athletes is obvious. Additionally, resistance-training programs for football, baseball, basketball, hockey, soccer, gymnastics, and wrestling, as well as many other popular sports, have been well documented (Baechle et al., 2008; Bompa & Haff, 2009; Baker & Nance, 1999; Barker et al., 1993; Clark et al., 2010; Cormie et al., 2011; Durell, Pujol, & Barnes, 2003; Earp & Kraemer, 2010; Zatsiorsky & Kraemer, 2006; Komi, 1991). Again, however, this section focuses specifically on lacrosse.

While the relevant body of literature at the time of the literature search contained several articles that identified suggested resistance-training programs and exercises for the sport of lacrosse, none offered proven, empirical evidence of successful and appropriate strength and conditioning programs for lacrosse based on lacrosse-specific pre- and post-testing analyses (Ballantyne, 2000; Burger & Burger, 2006; Moore, 1985; Morrill, 1980; Plisk, 1992; Pistilli et al., 2008). The available articles will be synthesized in order to display a general concept of seasonal progression, volume, intensity, exercise selection, and sport-specific drills documented as appropriate for men's and women's lacrosse.

The five documented lacrosse resistance-training programs for males and females have several differences and similarities; focusing first on their similarities may provide stronger insight into the general direction a coach should take when designing a resistance-training program for lacrosse (Ballantyne, 2000; Burger & Burger, 2006; Moore, 1985; Morrill, 1980; Plisk, 1992; Pistilli et al., 2008). The most common ideological similarity informing these program design concepts is that lacrosse requires a high degree of power and quickness; thus, lacrosse exercises and the program design should be based on increasing one's ability in these areas (Ballantyne, 2000; Burger & Burger, 2006; Moore, 1985; Morrill, 1980; Plisk, 1992; Pistilli et al., 2008). While the designers of each of the five programs understood the importance of power and quickness, each tackled the issue in a slightly different way. Ballantyne (2000), Burger and Burger (2006), Morrill (1985), Pistilli et al. (1980), and Plisk (1992) all used some combination of Olympic-style lifts and plyometrics in order to build quickness and power, while Moore (1985) chose to utilize variable resistance machines and develop quickness through plyometrics. Perhaps the reason Moore did not utilize Olympic-style lifts to develop power and quickness was because of the lack of research and common understanding at that time of the transferability of Olympic-style lifting to team sports such as lacrosse (Cormie et al., 2011). Those who used Olympic-style lifts selected the clean pull, power clean, hang clean, jerk, and snatch pull (Ballantyne, 2000; Burger & Burger, 2006; Morrill, 1980; Plisk, 1992). Other power-type exercises used by these program developers included nontraditional, non-Olympic-style lifts and plyometrics, such as weighted lateral jumps, weighted squat jumps, medicine ball throws, jammer rotation and press, lateral upper body step ups, skater hops, barrier hops, broad jumps, skips, bounds, and maximal vertical jumps (Ballantyne, 2000; Burger & Burger, 2006; Moore, 1985; Morrill, 1980; Plisk, 1992). Pistilli et al. (2008) added several suggested lacrosse-specific strength-training exercises, including the walking lunge with weighted hammer; Russian boxer exercise; various weighted PVC pipe forearm exercises, such as a partner twist and kneeling elbow extension/flexion; weighted PVC jumps; incline hammer hits; and draw/release phase and goalie-specific training with PVC pipes and rubber tubing (p. 33-36). Additionally, the developers agreed that these sport-specific strength-training exercises are most appropriate for preseason and in-season training programs (Ballantyne, 2000; Burger & Burger, 2006; Moore, 1985; Morrill, 1980; Plisk, 1992). Regarding seasonal concepts of program design, the majority of the program developers agreed on how to set up the *periodization* of program design for lacrosse.

Bompa and Haff (2006) best defined the term periodization as “the division of training seasons, typically one year long, into smaller and more manageable intervals” (p. 97). These intervals often are referred to as periods of training, lending the term periodization its name; these periods are broken into mesocycles, or longer periods (several weeks), and microcycles, shorter periods (usually one week) (Baechle et al., 2008; Bompa & Haff, 2009; Ratamess, 2008, 2011; Stone et al., 2007; Stoppani, 2006; Zatsiorsky & Kraemer, 2006). These intervals or periods are sequenced over the course of a year with the aim of reaching the best possible performance goals specific to the sport during the primary competitions of the season (Zatsiorsky & Kraemer, 2006, p. 97). In order to distinguish the different periods of training, whether a microcycle or mesocycle, the program designs should involve adjustments of exercise type, volume, intensity, duration, frequency and/or recovery (Ratamess, 2011).

Zatsiorsky and Kraemer (2006) noted that if the same training program is repeated throughout the season, from the early preparatory phase to the in-season phase, improvements will occur only during the first part of training and will plateau during the middle and latter parts of the program (p. 98). Morrill (1980) did not mention the formal use of periodization in the details of his lacrosse program, though he set guidelines for when to increase weight: “After a trainee reaches his maximum on any day (light, medium, or heavy), add 5% to the weight for that next day (light, medium, or heavy)” (p. 100). This type of continual increase is called *linear periodization* and in actuality negates the true principle of periodization, making it not periodization at all (Bompa &

Haff, 2009). In 1985, Moore explained his use of periodization techniques for the University of Maryland lacrosse program:

> The offseason was used as a foundation period to condition the individual for higher intensity workloads, which were to follow on in the year. The preseason showed a gradual decrease in the volume of work done and a similar increase in the intensity of the workouts, bringing the body to a higher state of condition to prepare the athlete for the competitive season. The in-season phase of training was used both as a sharpening and maintenance program. (p. 37)

In addition, Moore (1985) provided a periodization template outlining the focus areas from period to period with regard to running, strength training, plyometrics, stretching, and technique. The off-season focused on endurance, strength endurance, long bounding, flexibility, and fall scrimmages; the preseason consisted of speed endurance, strength endurance/absolute strength, long bounding, stretching, and box style tournaments; the in-season was comprised of speed, absolute strength, short bounding, and stretching; and the post season consisted of active rest (Moore, 1985, p. 38). Plisk (1992) followed a similar training calendar consisting of three major phases: a) summer off-season (11-13 weeks), b) fall/winter preseason (17 weeks), and c) winter spring in-season (14-16 weeks), with a transition between each and followed by an active-rest post season. Plisk (1992) subdivided the pre- and in-season phases into three and two sub-phases of training, respectively. However, it appears that he used the same workout scheme for his off-season, preseason 1, and preseason 3 training, and a separate scheme for preseason 2 and the in-season. The first scheme consisted of three days per week of resistance training, alternating through two different routines; the second scheme consisted of two days of training, alternating through two different routines (Plisk, 1992, p. 82). Plisk (1992) focused on structural explosive-type movements (clean / jerk / squat) throughout each scheme in order to develop musculature in the trunk, hips, and lower extremities, supplemented by pushing and pulling movements of the upper body, as well as the isolation of other heavily used areas such as the forearms, wrist, and neck (p. 82). Plisk alternated the training days as follows: Scheme 1 - Monday heavy (100% RM Loads), Wednesday medium (95% RM Loads [reps to failure]), and Friday light (90% RM Loads [explosive]); Scheme 2 - Monday (95% RM Loads) and Thursday (85% RM Loads). It appears that Plisk (1992) used a model, though varied, of only five separate workouts over the course of the off-season, preseason, and in-season; one could argue that this model may not provide enough training variation throughout the year (Bompa & Haff, 2009).

Burger and Burger (2006) divided their annual periodization macrocycle (year-long program) into five total phases, with the addition of four transitional phases consisting of the preseason (6-8 weeks), transition, in-season, postseason, evaluation, off-season 1, transition, off-season 2, and transition (p. 21). They provided in-depth detail about the preseason training program variables; in this preseason program, Burger and Burger (2006) identified the need for the goalie to be explosive and reactive and to have the ability to change direction as the foundation of the program. In essence, they designed the program for the goalie, and that program served as the foundation for the other positions (Burger & Burger, 2006, p. 20). The preseason program focused on power development through progressive heavy resistance training and plyometrics over the course of eight weeks (Burger & Burger, 2006). The focus of the eight-week preseason training program was to increase neuromuscular adaptation through power development and high-speed movements; Olympic-style lifts such as clean pulls, snatch pulls, and jerks were used, as were plyometric jumps and jammer rotational presses (Burger & Burger, 2006). The Olympic-style lifts used during the preseason were set at lighter loads (less than 90% 1RM) in order to maintain high velocities and continually improve power and speed development (Burger & Burger, 2006). Interval weight training (IWT) and complex training were implemented for attack men, defenders, and midfielders in order place a more specific training demand on these athletes, who place higher demands on the glycolytic energy system than goalies (Burger & Burger, 2006). IWT protocols combine major multi-joint lifts, such as clean pulls, power clean high pulls, and squats, with two to three minutes of intense anaerobic exercises, such as stationary biking, stair climbing, or treadmill running; it has been hypothesized that this type of training may increase anaerobic power (Burger & Burger, 2006). This type of IWT training was based upon similar types of training used for soccer players (Burger & Burger, 2006). Complex training consists of performing lifts such as power clean pulls, squats, or bench presses, along with other plyometric lifts such as medicine ball jumps to box, band squat jumps, and plyometric push-ups (Burger & Burger, 2006). Although set up differently, Burger and Burger (2006) used similar exercises as Plisk (1992), such as multi-joint power and structural lifts; upper body pushing and pulling for muscular balance; isolation exercises of the shoulder, wrist, forearm, and neck for injury prevention; and plyometric exercises. One major difference was that Burger and Burger (2006) used more rotational core, balance, and stabilization exercises, whereas Plisk (1992) utilized single-plane, non-rotational core exercises, no balance, and no stabilization exercises, other than dynamic plyometrics incorporated into the conditioning component of his training.

Lastly, Ballantyne (2000) implemented a program with an off-season 1 (4 weeks), off-season 2 (4 weeks), preseason emphasis on strength development (4 weeks), preseason emphasis on power development (4 weeks), and in-season phases emphasizing fitness and strength maintenance and injury prevention (p. 46). Ballantyne (2000), however, provided specific details only about the 24 weeks of training just noted and did not detail the other 28 weeks of the athletic calendar. Off-seasons 1 and 2 of Ballantyne's (2000) program focused on general conditioning, with exercise technique emphasized in phase 1, and the development of a strength base for further high-intensity training emphasized in phase 2. Weight training again consisted of multi-joint structural exercises, which could be applied to power movements later. For example, lifts used in phase 1 included squats, lunges, dumbbell exercises for the upper body, and rotational trunk movements (Ballantyne, 2000). During phase 2, lifts utilizing more power were incorporated, such as the hang clean and high pull; these movements led to the incorporation of power cleans later in the preseason phases (Ballantyne, 2000). During preseason phase 1, the emphasis shifted from basic conditioning and technique to strength development; more specifically, the program began to focus on absolute strength and the incorporation of Olympic-style lifts (Ballantyne, 2000). In addition, Ballantyne (2000) increased the amount of neck and trunk injury prevention training during preseason phase 1. Preseason phase 2 emphasized the development of lacrosse-specific strength and power achieved through velocity movements such as Olympic-style lifts and plyometric exercises (Ballantyne, 2000). Additionally, the preseason 2 phases of

Ballantyne's (2000) program reduced the frequency of resistance training from three to two days per week and shifted the conditioning focus from general aerobic and anaerobic conditioning to lacrosse-specific plyometrics, speed, and agility, with daily flexibility training. Upon the arrival of the regular season, the athletes underwent a final unloading phase and a taper while the program focused on fitness and strength maintenance as well as injury prevention (Ballantyne, 2000).

Regarding resistance training for lacrosse, the literature review has revealed that several similarities exist in the foundations of program design. Most program developers agreed that lacrosse athletes must develop power and quickness, ideally through Olympic-style lifts and/or plyometrics (Ballantyne, 2000; Burger & Burger, 2006; Moore, 1985; Morrill, 1980; Plisk, 1992; Pistilli et al., 2008). In addition, these authors presented the necessary muscular balance of the upper body and injury prevention exercises, focusing on the forearms, wrists, shoulder girdle, trunk, and neck (Ballantyne, 2000; Burger & Burger, 2006; Moore, 1985; Morrill, 1980; Plisk, 1992; Pistilli et al., 2008). In the injury analysis performed by Dick, Lincoln et al. (2007) and Dick, Romani et al. (2007), the majority of all injuries in men's and women's lacrosse occurred to the lower extremities. Furthermore, distinct differences remain between each program's design in terms of the use of periodization or how lifts were sequenced. Plisk (1992) used the same scheme for three of his five phases, and one separate scheme for the other two phases. Morrill (1985) used linear periodization, which is not a true form of periodization. Moore (1985) outlined a periodization template but did not provide specific detail regarding any variation within each period; moreover, he did not use Olympic-style lifts. Ballantyne (2000) detailed 24 out of 28 weeks but provided the truest outline of a periodized model by sequencing volume and intensity in a progressive and sensible manner while not rotating through the same workout. Finally, Burger and Burger (2006) used the same scheme for all eight weeks of preseason training, implementing slight variations in volume and intensity between microcycles one, two, and three and adding an additional day of IWT for midfielders in microcycle two.

Summary

For professionals in the field to better understand what constitutes an appropriate strength and conditioning model for both men's and women's lacrosse, more research that provides empirical evidence supporting the effectiveness of such programs is needed. Chapter 3 will outline how this study aims to provide strength and conditioning professionals with an annual training program that is proven to effectively enhance performance and prevent injury for both males and females participating in NCAA Division II lacrosse.

Conclusion

The underlying theme of lacrosse from a physiological and biomechanical standpoint is that the sport is transitional, explosive, fast-paced, and, especially for men, physical. These themes are broken down further by suggesting the means by which to increase performance in each category. *Transitional* sports such as lacrosse require high levels of anaerobic capacity and power that can be enhanced through interval-based training. *Explosiveness* is a colloquial term for biomechanical strength and, more specifically, power, in relation to the ability to quickly start, stop, change direction, and/or jump. Increasing an athlete's strength in relationship to his or her body weight and subsequently utilizing the strength in high-powered, multi-joint exercises such as

Olympic lifts, plyometrics, and other lacrosse-specific drills (see Appendix G) should be the preferred method of increasing the explosiveness of the lacrosse athlete.

The term *fast-paced* refers to the speed of the game. Athletes move quickly, and those in certain positions, such as midfielders, are required to maintain this speed for several seconds. Thus, developing the appropriate speed capabilities specific to each position becomes increasingly important. Midfielders require more top-end speed, while attack, defense, and goalies require less top-end speed and more explosiveness.

Lastly, as a result of rule differences between genders, men's lacrosse requires more *physicality*. Thus, lacrosse athletes can benefit from having more muscle mass and a slightly elevated body fat compared to athletes in other transitional sports, such as soccer, in order to assist with bracing stick and body impacts. Thus, lacrosse coaches primarily must work toward developing the athletes' anaerobic capacity, anaerobic power, strength, sprint speed, and biomechanical power. For male athletes, coaches also must consider developing a heightened level of muscular mass to round out a quality strength and conditioning program.

Chapter 3: Methodology

Overview

The purpose of this study was to examine the effectiveness of the strength and conditioning services offered to provisional NCAA Division II men's and women's lacrosse student-athletes at a mid-sized, four-year liberal arts university in the Midwest. The researcher also aimed to add to the field of research an empirically proven model for effective strength and conditioning for both men's and women's lacrosse. All data in this study are secondary. Program design, training, and evaluation were to have been completed regardless of this study, as the researcher served also as the head strength and conditioning coach for the two lacrosse teams under investigation. The researcher collected, analyzed, and interpreted the secondary performance data available through his position as strength coach. The university's provost granted the researcher permission to collect, analyze, and interpret secondary data for the purposes of this study on November 30th, 2011. Institutional Review Board (IRB) approval was granted on December 20th, 2011 (see Appendix H), allowing the researcher to proceed with the study by collecting, analyzing, and interpreting the secondary data from the strength and conditioning program.

Being a study of secondary data, the methodology will be categorized by the actions performed by the researcher. The data collection process, statistical analysis, and evaluation are the only methods that will be discussed from the researcher's point of view. Athlete screening; test selection, administration, and evaluation; exercise selection; program design and implementation; the periodization model; and exercise instruction methods will be discussed in the second section of the methodology from the perspective of the researcher's role as the strength coach. The methods of the researcher versus the methods of the strength coach should not be confused as being the same. This study is simply an analysis of the effectiveness of the strength and conditioning methods designed and implemented by the head lacrosse strength coach. However, in order to provide more insight into what is being analyzed, the strength coach's methods will be outlined in detail. The methodology behind the strength coach's primary services will be detailed in the following sections: time frame; participants; test selection, administration, and evaluation; exercise selection; program design; and periodization model. The methodology used by the researcher for the purposes of this study will be detailed in one section outlining the data collection, statistical analysis, and evaluation processes used to determine the effectiveness of the strength coach's services.

Data Collection, Analysis, and Evaluation

This study began after IRB approval on December 20th, 2011. This study did not involve direct participation but rather consisted of an analysis of secondary data given to the researcher by the strength coach. In this case, these individuals were the same person. The secondary data consisted of the performance measurements detailed in Table 5. The researcher collected the first round of performance measurements during the week of August 29, 2011, the second during the week of November 14, 2011, and the third during the week of February 14, 2012. The strength coach removed all identifying information, such as athletes' names, from all performance data and recorded the secondary data in a separate electronic folder to undergo statistical analysis from the perspective of the researcher for the purposes of this study. Males and females were tested on separate days, and for each gender, the bench press and squat were tested on a separate day than the 40-yard dash, 5-10-5, and vertical jump. For each gender, the bench press was performed first, and the squat second. For each gender, the vertical jump was performed first, 5-10-5 next and 40-yard dash last.

Table 5

Performance Measurements

Performance Test	Unit of Measure
40 – Yard Dash	Seconds to the nearest one-hundredth of a second using iPhone's Timer Application
5-10-5 (Pro) Agility Drill	Seconds to the nearest one-hundredth of a second using iPhone's Timer Application
Vertical Jump	Inches using a Vertex vertical measuring device, measured to the nearest 0.5 inch
1RM Squat	Measured by bench pressing maximum possible pounds for 1 repetition
1RM Bench Press	Measured by bench pressing maximum possible pounds for 1 repetition

The quantitative performance data for each of these variables were analyzed statistically by conducting a *z*-test for differences in means, with a 95% confidence level. The collected performance data from the men's lacrosse team were sampled randomly from 30 athletes to 25 athletes, while the women's data were sampled randomly from 20 athletes to 15 athletes. The data were sampled randomly using the StatPlus add-in for Microsoft Excel 2011 on a Macintosh OSX 10.5.8 laptop. The null hypotheses addressed in this study were as follows:

Null Hypotheses 1a-e: There are no differences in athletic performance as measured by (a) a timed 40-yard dash, (b) a timed 5-10-5 agility test, (c) 1 repetition maximum bench press measured in pounds, (d) 1 repetition maximum barbell back squat measured in pounds, and (e) vertical jump measured in inches, between the university's men's and women's lacrosse athletes at the August 2011 testing date as compared to the university's men's and women's lacrosse athletes at the November 2011 testing date.

Null Hypotheses 2a-e: There are no differences in athletic performance as measured by (a) a timed 40-yard dash, (b) a timed 5-10-5 agility test, (c) 1 repetition maximum bench press measured in pounds, (d) 1 repetition maximum barbell back squat measured in pounds, and (e) a vertical jump measured in inches, between the university's men's and women's lacrosse athletes at the November 2011 testing date as compared to the university's men's and women's lacrosse athletes at the February 2012 testing date.

Descriptive statistics and *z*-test scores also were generated through the same add-in on the same computer. A *z*-test for differences in means with a 95% confidence level was used to analyze scores from August 2011 compared to scores from February 2012; the statistical significance of the data from each comparison was determined by comparing the *z*-test value to the *z*-critical value of the two-tailed distribution. Using this evaluation, *z*-test values for squats, benches, and vertical jumps lower than the negative *z*-critical value would suggest performance increases; *z*-test values for the timed 1-mile run, 40-yard dash and 5-10-5 agility drill higher than the positive *z*-critical values also would suggest performance increases.

Methodology of Services Being Analyzed

Time Frame

The strength and conditioning services offered to both the men's and women's lacrosse teams began at the beginning of the 2011 school year on August 23, 2011. Prior to that point, there was no official strength and conditioning system of training in place for either team. The training that took place from August 2011 to February 2012 is that which has been analyzed statistically in this study. This methodology section will detail the training system implemented for the two teams from August 2011 to August 2012. Though the training program lasted throughout that year, the data from February 12, 2012 through August 2012 did not undergo statistical analysis.

Participants

Participants in the strength and conditioning program consisted of 38 male and 20 female varsity lacrosse student-athletes at a mid-sized provisional NCAA DII university in the Midwest. Participants ranged in age from 18-22 years, and all scheduled training was considered mandatory practice logged as countable hours under NCAA guidelines. The mandatory, countable nature of the training sessions resulted in 90% and 100% participation of male and female lacrosse student-athletes, respectively. These percentages were based on daily roll calls from team rosters. All 20 female lacrosse athletes and at least 30 of the 38 male lacrosse athletes were present for each of the three testing sessions.

Test Selection and Administration

Lacrosse requires agility, aerobic capacity, anaerobic power, musculoskeletal/ neuromuscular power, strength, quickness, and speed (Gutowski & Rosene, 2011; Howley, 2011; Pistilli et al., 2008; Burger & Burger, 2006; Devoe, 2006; Harris, 2006; Ballantyne, 2000; Moore, 1985; Morrill, 1980). Therefore, the strength coach aimed to select tests reflecting each of these requirements. Prior to the 2011 school year, the coaches, rather than a certified strength and conditioning specialist, had offered strength and conditioning services to these athletes. Therefore, the coaches already had established their own set of tests for their athletes. Some of these tests did not directly reflect the specific requirements of lacrosse, and any changes to the tests and additions of new tests were negotiated between the certified strength coach and each team's head coach. The tests proposed by the strength coach included VO2MAX, timed half-gasser, 30-second wingate, vertical jump, 5-10-5 agility, L-drill agility, 1RM bench press, 1RM squat, body composition (Bod Pod), and anthropometrics. However, not all of these tests received approval from the head coaches for various reasons pertaining to organization, scheduling, and transportation to the off-campus testing facility used by the university. Therefore, the final selection of tests reflected those that could be performed easily in the field without dedicating significant amounts of time or utilizing advanced technology. The final tests agreed upon by both the coaches and the strength coach consisted of those mentioned in Table 5. The timed one-mile run was eliminated from the secondary data analysis in this study because the researcher and the strength coach did not find the test to directly reflect the specific needs of a lacrosse athlete.

The tests were administered on three separate occasions: 1) the beginning of the fall semester, the week of August 29th, 2011, after the initial NCAA-restricted period; 2) the week before finals, the week of November 14th, 2011, at the end of the first semester; and 3) the week before in-season training/regular season play, the week of February 13th, 2011. The 40-yard dash, 5-10-5, and vertical jump were tested at the beginning of the week on the first test day. The 1RM bench press and squat were tested on the second and third test days. This routine remained constant during each of the three separate testing weeks. Three certified strength and conditioning specialists served as the primary test administrators throughout each testing session. One coach administered all 40-yard dash, 5-10-5, and one-mile run timed trials, while another coach administered all vertical jump attempts. All athletes were allowed only two attempts for each test during each testing session. The three coaches verified all bench press and squat 1RMs, ensuring that all bench press maxes were performed while the athlete remained in the five-point body contact position with a full range of motion; additionally, these coaches verified that all squat maxes had sufficient depth, defined as the femur lining up parallel to the ground, and also ensured proper body alignment through the full range of motion. Before each of the testing sessions, the athletes engaged in a specific warm-up pertinent to that day's testing. The warm-up before the movement-based tests was dynamic, while the warm-up before the strength tests involved the use of barbells. These warm-ups will be defined further in the exercise selection and program design section of this chapter. Figures 13 through 22 comprise all comparative data collected at each testing date for both teams.

Exercise Selection

Athlete screening revealed that the majority of the male and female athletes had not participated in a well-structured, concurrent strength and conditioning system of training over two years long prior to the fall of 2011. The majority of athletes in these two samples trained sporadically and had never trained consecutively in a progressive program that lasted two years or longer. As a result, the strength coach categorized all athletes under the training status of *Intermediate* as defined by Baechle et al. (2008). Exercises were selected based on the intermediate skill and experience level of these athletes and assigned various degrees of priority and focus as the training progressed from the fall preparatory period toward the spring preseason. The selected lifts and exercises for each category will be explained in the following paragraph, while the program design and ordering of the exercises will be explained in the *Periodization* section.

The strength exercises selected for both men's and women's lacrosse were categorized as structural non-power, structural power, functional power, plyometrics, rotational core, injury specific, and position specific. The conditioning exercises were categorized as linear acceleration, deceleration, and speed; lateral acceleration, deceleration, and quickness; and reaction, anaerobic power, aerobic capacity, and jump ability. Structural non-power lifts consisted of traditional lifts such as the back squat, deadlifts, lunges, split squats, front squats, bench press, push press, bent-row, and pull-ups; these lifts were selected as the primary exercises during the beginning three phases of training, each of which lasted four weeks with a one- to two-week unloading period focusing on the techniques of structural power lifts, such as the clean and jerk. Upon the successful execution of proper technique for these structural lifts, athletes advanced to variations of the structural power lifts, such as the clean, beginning with a mid-thigh pull, above-knee pull, and below-knee pull. Only those male athletes who successfully completed all pulls using proper technique were allowed to advance into a full clean from the floor. At no time during the first year of training did any of the female athletes perform a full clean from the floor.

The snatch is a structural power lift that was considered but not utilized in any of the training for the 2011-2012 season; however, various snatch-related skill lifts were utilized in preparation for the following year's strength and conditioning program, which would incorporate the snatch. These snatch-related lifts consisted of the behind-the-neck press, snatch press, overhead squat, and snatch balance. Functional power lifts selected for their transferability into lacrosse consisted of non-traditional lifts such as the k-chain variations shoulder-to-shoulder single- and double-hand toss, thigh-to-thigh rotational explosions, kinetic extensions, switch grip pull-ups, grip switch shrugs, tire flips, and various types of sledge hammer hitting drills. Appendix G contains a description of these exercises. Other power-related, sport-specific exercises that were utilized consisted of lower body plyometrics and jump ability exercises, including drop jumps, drop and hold, body weight squat jumps, barbell squat jumps, quick feet drills, split jumps (both weighted and non-weighted), assisted squat jumps, resistance band squat jumps, skater hops, and various barrier hops. Next, rotational core exercises consisting of various medicine ball throws and tosses, cable trunk rotations, sledgehammer rotational hits, and k-chain trunk rotation variations were implemented. As a result of the high incidence of wrist, elbow, shoulder, knee, and ankle injuries in both men's and women's lacrosse athletes, various injury prevention exercises were chosen to target these specific areas (Dick, Lincoln et al., 2007; Dick, Romani et al., 2007). These injury prevention exercises for the upper body included wrist extensions, flexions, and rotations; released medicine ball throws; released bar tosses; reactive push-ups; internal and external shoulder rotations; kneader presses; ninety-degree elbow-bend shoulder rotations; and weighted t-rotations. Lower body exercises such as drop jumps; drop and holds; various ankle, knee, and hip related plyometrics; eccentric knee extensions and flexions; calf raises; and ankle pops were selected as injury prevention exercises for the ankles, knees, and hips. A few position-specific exercises were used primarily for face-off men and both male and female goaltenders. During the true preseason phase (January term through the first game), face-off men focused predominantly on performing exercises related to grip strength, hand quickness, rotational push and pull, and lower body explosiveness. Both male and female goalies during this same time period focused predominantly on various reactive exercises within the makoto audiovisual reaction towers. Additionally, these goalies spent extra time working on linear and lateral acceleration, explosiveness, and quickness through various types of double- and single-leg plyometrics. These listed exercises were the primary resistance exercises used in the strength component of this annual model. A number of other exercises were chosen for the conditioning component of the model.

The conditioning exercises used in this annual model were categorized as foot speed; linear acceleration, deceleration, and speed; lateral acceleration, deceleration, and quickness; and reaction, anaerobic power, and aerobic capacity. During the fall preparatory phase, few conditioning exercises were performed, aside from foot speed drills and plyometrics. The head lacrosse coach implemented various types of anaerobic conditioning in the form of sprint intervals and gassers, as well as aerobic endurance running in the form of stadiums, one-mile runs, and two-mile runs. This strength and conditioning professional disagree with a heavy-handed use of aerobic, endurance-type conditioning unless implemented in the early stages of the off-season (April, May, June, and July at the latest).

As a result of the importance of lacrosse athletes possessing a great deal of anaerobic power, interval-based, high-intensity foot speed/ladder drills and plyometrics were the primary exercises used during the fall season. Once the J-term arrived, the program shifted focus in order to target sport-specific skills and physical requirements.

Over speed treadmills (OSTs), resisted treadmills, and resisted rope trainers were the primary types of equipment used for linear speed and acceleration training. Both lateral and linear deceleration drills, such as stopping on command or stopping at a specific line, also were incorporated during this time period. For midfielders, 55-yard half gassers, as well as 40- and 60-yard sprint intervals, were included for game-specific anaerobic conditioning.

All athletes, especially goalies, defenders, and attack men, utilized a 35% graded treadmill to perform acceleration intervals by slowing their jogging speed, letting their bodies fall to the back of the treadmill, and then accelerating toward the front of the treadmill for three to five repetitions. Other anaerobic conditioning and acceleration (linear and lateral) exercises included sand pit sprint intervals, sand pit jump intervals, and sand pit sprint techniques; ground-based sprint techniques; and treadmill submaximal sprint intervals ranging from 10-30 seconds in duration. Lateral quickness, acceleration, and deceleration drills were incorporated in the form of predetermined and open agility exercises, such as the Illinois agility, m-drill, staggered cone drills, random ball drills, and partner mirror drills.

Periodization

The strength and conditioning exercises and their order, number of sets, number of reps, intensity, frequency, and duration were systematically assigned and varied according to the athletes' needs, practice and game schedules, availability, and holiday schedule. The specific periodization load sequencing used in this model followed a step pattern. A typical microcycle lasted one week, and a typical mesocycle lasted between four and six weeks. Within a six-week mesocycle, either the volume or load increased each week for the first four weeks and then decreased during weeks five and six below the original volume or load for a period of unloading. Within a four-week mesocycle, either the volume or intensity would increase each week for the first three weeks, while the fourth week provided an unloading period. Typically, the focus shifted during the unloading period, moving away from the focus of the prior stepped weeks. For example, during the early fall, the focus of the four-week step was strength, the volume of which increased every week for four weeks; during the fifth and sixth weeks, the volume dropped back to the original level as the emphasis shifted away from strength and toward power. Some may call this type of shift a conjugated sequence; however, because these weeks were used as recovery periods, the load and/or intensity was not high enough to constitute a true conjugated sequence-type periodization model. From the beginning to the end of the fall semester 2011, both teams engaged primarily in strength-related sessions three to four days per week. From the beginning of the January term up to the week prior to the start of the season (February 13th), both teams engaged in primarily strength-related sessions two days per week and primarily conditioning-related sessions two days per week.

Summary

This study is an examination of the effectiveness of services offered to one men's and one women's provisional NCAA DII lacrosse team. This study did not involve direct participants; rather, it is an analysis of the performance data collected by the strength coach for each team. The secondary data were analyzed through descriptive statistics as well as a *z*-test performed for differences in means, with a 95% confidence level, for August 2011 performance data compared to February 2012 performance data. This span of time covers the entire preseason for both teams. The lack of research in the field of lacrosse strength and conditioning prompted the researcher to describe in detail the services offered from a design, implementation, and progression standpoint. Detailed program examples for each team can be found in Appendix A through Appendix F. Major differences between the men's program and women's program can be seen in the lower volume for the females and the use of a hang clean from above the knee versus a full clean from the floor. Additionally, the grouping and emphasis of conditioning differed in that the women's team was trained as offense, defense, and goalies, while the men's team was trained as attack, defense, midfielders, and goalies. Other than the program design differences, the programs were implemented and progressed in similar step patterns with scheduled unloading weeks and preparation periods before testing. In each group, the test selection and administration remained consistent by separating strength testing days and speed, agility, and power testing days. Lastly, the testing order remained consistent between genders, with the vertical jump performed first, 5-10-5 agility drill second, and 40-yard dash third on the speed, agility, and power-testing day. On the strength testing days, each gender performed the bench press first and the squat last. The administration, administrators, test order, test selection, and test sequence remained consistent across each of the three testing dates through the preseason.

Chapter 4: Results

The purpose of this study was to examine the effectiveness of the strength and conditioning services offered to provisional NCAA Division II men's and women's lacrosse student-athletes at a mid-sized, four-year liberal arts university in the Midwest. This study also aims to add to the field of research an effective, empirically proven strength and conditioning model for both men's and women's lacrosse. Results of the data comparison between the first (August 2011) and third (February 2012) testing batteries supported each proposed hypothesis, indicating an increase in the athletic performances, timed 40-yard dash, timed 5-10-5 agility test, 1 repetition maximum bench press measured in pounds, 1 repetition maximum barbell back squat measured in pounds, and vertical jump measured in inches, of the men's and women's lacrosse athletes from August 29th, 2011, to February 14th, 2012.

Collected Men's Lacrosse Data Results

Descriptive statistics revealed an increase in the average performance of the team in each performance category. These results indicate an increased performance of the team as a whole. A higher average performance in each category indicates that the team as a whole became faster, more agile, stronger, and more powerful. The averages for each test date are listed in Table 6, in which the mean for each performance category and test date is outlined. Further quantitative measures of performance data for each of these variables were statistically analyzed by conducting a *z*-test for difference in means, with a 95% confidence level. The collected performance data from the men's lacrosse team were sampled randomly from 30 athletes to 25 athletes, while the women's data were sampled randomly from 20 athletes to 15 athletes.

Table 6

Summarized Men's Lacrosse Performance Results

Descriptive Analysis	Test Date 1	Test Date 2	Test Date 3	Performance
Mean	5.3078	5.2072	4.986	40-Yard Dash
Mean	4.7278	4.5414	4.48	5-10-5
Mean	24.68	26.38	27.02	Vertical Jump
Mean	216.6	281.4	290	1RM Squat
Mean	185	201	215.4	1RM Bench

A *z*-test for differences in means at a 95% confidence level was used to analyze mean scores from August 2011 compared to mean scores from February 2012; the statistical significance of each data comparison was determined by comparing the *z*-test value to the *z*-critical value of the two-tailed distribution. Using this evaluation, *z*-test values for squats, bench presses, and vertical jumps lower than the negative *z*-critical value would indicate performance increases; likewise, *z*-test values for the timed 40-yard dash and 5-10-5 agility drill higher than the positive *z*-critical values would indicate performance increases. This statistical analysis further supported each hypothesis, as performance increases in each tested area were statistically significant, with a 0.05 confidence interval. Each two-tailed comparison test provided a *z*-critical value of +/-1.95996. Therefore, any *z*-test value above +1.95996 would indicate a change in mean scores from the first test to the third test. Any *z*-test value between -1.95996 and +1.95996 would indicate no difference in mean scores from the first test to the third test.

Likewise, any *z*-test value below -1.95996 would indicate a change in mean scores from the first test to the third test. The results of the *z*-tests for difference in means from the first to the third test dates are listed in Table 7. For each test, the null hypotheses were rejected, meaning that performance increased as shown by a positive *z*-test value, which indicates a decrease in time to completion for the speed and agility tests, as well as a negative *z*-test value, which indicates an increase in weight lifted and height jumped in the strength and power tests.

Table 7

Men's Lacrosse z-Test Results

z-Critical Value	*z*-Test Value	Performance Test
+/-1.95996	6.44125	40-Yard Dash
+/-1.95996	7.26872	5-10-5
+/-1.95996	-2.83433	Vertical Jump
+/-1.95996	-40.16405	1RM Squat
+/-1.95996	-6.57120	1RM Bench

The null hypotheses applied to data collected from the men's lacrosse team were as follows:

Null hypotheses 1a-e: There are no differences in athletic performance as measured by (a) a timed 40-yard dash, (b) timed 5-10-5 agility test, (c) 1 repetition maximum bench press measured in pounds, (d) 1 repetition maximum barbell back squat measured in pounds, and (e) vertical jump measured in inches, between the university's men's and women's lacrosse athletes at the August 2011 testing date as compared to the university's men's and women's lacrosse athletes at the November 2011 testing date.

Null hypothesis 1a stating that there are no differences in athletic performance as measured by a timed 40-yard dash from August 2011 to February 2012 was rejected. In this measure, the *z*-critical value was +/-1.95996, meaning that the *z*-test value must be above 1.95996 or below -1.95996. For the 40-yard dash, the *z*-test value was 6.44125, supporting hypothesis 1a, which states that there is a difference in performance between a timed 40-yard dash from August 2011 to February 2012. The rejected null hypothesis from a positive *z*-test supports that the difference in means from August 2011 to February 2012 indicates a decrease in time to completion, meaning that, on average, the male athletes ran 40-yard dashes faster in February than in August.

Null hypothesis 1b stating that there are no differences in athletic performance as measured by a timed 5-10-5 agility drill from August 2011 to February 2012 was rejected. In this measure, the *z*-critical value was +/-1.95996, meaning that the *z*-test value must be above 1.95996 or below -1.95996. For the 5-10-5-agility drill, the *z*-test value was 7.26872, supporting hypothesis 1b, which states that there is a difference in performance between a timed 5-10-5-agility drill from August 2011 to February 2012. The rejected null hypothesis from a positive *z*-test value supports that a difference in means from August 2011 to February 2012 represents a decrease in time to completion, meaning that, on average, the male athletes performed faster on the agility test in February than in August.

Null hypothesis 1c stating that there are no differences in athletic performance as measured by a vertical jump from August 2011 to February 2012 was rejected. In this measure, the *z*-critical value was +/-1.95996, meaning that the *z*-test value must be above 1.95996 or below -1.95996. For the vertical jump, the *z*-test value was -2.83433, supporting hypothesis 1c, which states that there is a difference between performances on a vertical jump from August 2011 to February 2012. The rejected null hypothesis from a negative *z*-test value supports that a difference in means from August 2011 to February

2012 represents an increase in inches jumped, meaning that, on average, the male athletes jumped higher in February than in August.

Null hypothesis 1d stating that there are no differences in athletic performance as measured by 1 repetition maximum bench press from August 2011 to February 2012 was rejected. In this measure, the *z*-critical value was +/-1.95996, meaning that the *z*-test value must be above 1.95996 or below -1.95996. For the 1 repetition maximum bench press, the *z*-test value was -6.57120, supporting hypothesis 1c, which states that there is a difference between performances on the bench press from August 2011 to February 2012. The rejected null hypothesis from a negative *z*-test value supports that a difference in means from August 2011 to February 2012 represents an increase in pounds pressed, meaning that, on average, the male athletes lifted more weight from an upper body perspective in February than in August.

Null hypothesis 1e stating that there are no differences in athletic performance as measured by 1 repetition maximum back squat from August 2011 to February 2012 was rejected. In this measure, the *z*-critical value was +/-1.95996, meaning that the *z*-test value must be above 1.95996 or below -1.95996. For the 1 repetition maximum back squat, the *z*-test value was -40.16405, supporting hypothesis 1c, which states that there is a difference between back squat performances from August 2011 to February 2012. The rejected null hypothesis from a negative *z*-test value supports that a difference in means from August 2011 to February 2012 represents an increase in pounds pressed, meaning that, on average, the male athletes lifted more weight from a lower body perspective in February than in August.

Collected Women's Lacrosse Data Results

Descriptive statistics revealed an increase in the average performance of the team in each performance category. These results indicate that the performance of the team as a whole increased. A higher average performance in each category indicates that the team as a whole became faster, more agile, stronger, and more powerful. The averages for each test date are listed in Table 8, in which the mean for each performance category and test date is outlined.

Table 8

Summarized Women's Lacrosse Performance Results

Description	Test Date 1	Test Date 2	Test Date 3	Performance
Mean	5.85	5.66	5.56	40-Yard Dash
Mean	5.29	5.10	5.05	5-10-5
Mean	19.86	20.86	21.5	Vertical Jump
Mean	134.3	161.6	174.6	1RM Squat
Mean	77	97	101.3	1RM Bench

A *z*-test for differences in means at a 95% confidence level was used to analyze mean scores from August 2011 compared to mean scores from February 2012. The statistical significance of each data comparison was determined by comparing the *z*-value to the *z*-critical value of the two-tailed distribution. Using this evaluation, *z*-test values for squats, bench presses, and vertical jumps lower than the negative *z*-critical value would indicate performance increases; likewise, *z*-test values for the timed 1-mile run, 40-yard dash, and 5-10-5 agility drill higher than the positive *z*-critical values would indicate performance increases. This statistical analysis further supported each hypothesis, as performance increases in each tested area were statistically significant with a 0.05 confidence interval. Each two-tailed comparison test provided a *z*-critical value of

+/-1.95996. Therefore, any *z*-test value above +1.95996 would indicate a change in mean scores from the first to the third test. Any *z*-test value between -1.95996 and +1.95996 would indicate no difference in mean scores from the first to the third test. Finally, any *z*-value below -1.95996 would indicate a change in mean scores from the first to the third test. The *z*-test results for differences in means from the first to the third test dates are listed in Table 9. For each test, the null hypotheses were rejected, indicating an increase in performance as shown by a positive *z*-test value, which indicates a decrease in time to completion for the speed and agility tests, as well as a negative *z*-test value, which indicates an increase in weight lifted and height jumped in the strength and power tests.

Table 9

Women's Lacrosse z-Test Results

z-Critical Value	*z*-Test Value	Performance Test
+/-1.95996	5.33062	40-Yard Dash
+/-1.95996	4.58148	5-10-5
+/-1.95996	-3.50358	Vertical Jump
+/-1.95996	-5.09377	1RM Squat
+/-1.95996	-8.06170	1RM Bench

The null hypotheses applied to data collected for women's lacrosse were as follows:

Null hypotheses 1a-e: There are no differences in athletic performance as measured by (a) a timed 40-yard dash, (b) timed 5-10-5 agility test, (c) 1 repetition maximum bench press measured in pounds, (d) 1 repetition maximum barbell back squat measured in pounds, and (e) vertical jump measured in inches, between the university's men's and women's lacrosse athletes at the August 2011 testing date as compared to the university's men's and women's lacrosse athletes at the November 2011 testing date.

Null hypothesis 1a stating that there are no differences in athletic performance as measured by a timed 40-yard dash from August 2011 to February 2012 was rejected. In this measure, the *z*-critical value was +/-1.95996, meaning that the *z*-test value must be above 1.95996 or below -1.95996. For the 40-yard dash, the *z*-test value was 5.33062, supporting hypothesis 1a, which states that there is a difference between performances on a timed 40-yard dash from August 2011 to February 2012. The rejected null from a positive *z*-test supports that a difference in means from August 2011 to February 2012 represents a decrease in time to completion, meaning that, on average, the female athletes ran 40-yard dashes faster in February than in August.

Null hypothesis 1b stating that there are no differences in athletic performance as measured by a timed 5-10-5 agility drill from August 2011 to February 2012 was rejected. In this measure, the *z*-critical value was +/-1.95996, meaning that the *z*-test value must be above 1.95996 or below -1.95996. For the 5-10-5-agility drill, the *z*-test value was 4.58148, supporting hypothesis 1b, which states that there is a difference between performances on a timed 5-10-5-agility drill from August 2011 to February 2012. The rejected null hypothesis from a positive *z*-test value supports that a difference in means from August 2011 to February 2012 represents a decrease in time to completion, meaning that, on average, the female athletes performed faster on the agility test in February than in August.

Null hypothesis 1c stating that there are no differences in athletic performance as measured by a vertical jump from August 2011 to February 2012 was rejected. In this measure, the *z*-critical value was +/-1.95996, meaning that the *z*-test value must be above 1.95996 or below -1.95996. For the vertical jump, the *z*-test value was -3.50358, supporting hypothesis 1c, which states that there is a difference between performances on a vertical jump from August 2011 to February 2012. The rejected null hypothesis from a negative *z*-test value supports that a difference in means from August 2011 to February 2012 represents an increase in inches jumped, meaning that, on average, the female athletes jumped higher in February than in August.

Null hypothesis 1d stating that there are no differences in athletic performance as measured by 1 repetition maximum bench press from August 2011 to February 2012 was rejected. In this measure, the *z*-critical value was +/-1.95996, meaning that the *z*-test value must be above 1.95996 or below -1.95996. For the 1 repetition maximum bench press, the *z*-test value was -509377, supporting hypothesis 1c, which states that there is a difference between bench press performances from August 2011 to February 2012. The rejected null hypothesis from a negative *z*-test value supports that a difference in means from August 2011 to February 2012 represents an increase in pounds pressed, meaning that, on average, the female athletes lifted more weight from an upper body perspective in February than in August.

Null hypothesis 1e stating that there are no differences in athletic performance as measured by 1 repetition maximum back squat from August 2011 to February 2012 was rejected. In this measure, the *z*-critical value was +/-1.95996, meaning that the *z*-test value must be above 1.95996 or below -1.95996. For the 1 repetition maximum back squat, the *z*-test value was -8.06170, supporting hypothesis 1c, which states that there is a difference between back squat performances from August 2011 to February 2012. The rejected null hypothesis from a negative *z*-test value supports that a difference in means from August 2011 to February 2012 represents an increase in pounds pressed, meaning that, on average, the male athletes lifted more weight from a lower body perspective in February than in August.

Summary

Hypotheses a-e all were supported, as the null hypothesis in each was rejected. The results indicate that a difference in performance occurred after the implementation of the preseason program. The statistical analysis coupled with the descriptive statistics indicate that the difference in performance for each tested performance area in each of the groups, both male and female, resulted in a positive performance difference. All of the athletes increased in strength, power, speed, and agility. As a result of the genetically predetermined gender differences between the rate of adaptation and available muscular size/strength of males and females, the rate or magnitude of performance increase was not compared between males and females. Regardless, the results of this study indicate that the programs for both male and female lacrosse athletes successfully enhanced sprint speed, acceleration, change of direction, vertical power, upper body strength, and lower body strength.

Chapter 5: Discussion

Overview

The purpose of this study was to examine the effectiveness of the preseason strength and conditioning services offered to men's and women's lacrosse teams at a mid-sized NCAA DII university in the Midwest from the beginning of the 2011 school year through the preseason phase of training, up to the start of the spring season 2012. The calendar time frame of this study was August 2011 to February 2012. In addition to examining the effectiveness of services, this study adds empirical data to the field of literature on lacrosse strength and conditioning. The proposed selection of exercises, program design, periodization model, and implementation of strength training and conditioning were proven to successfully increase performances in the 40-yard dash, 5-10-5 agility drill, vertical jump, one repetition maximum bench press, and one repetition maximum back squat. Although performance increased within these performance parameters, more appropriate and specific testing parameters exist that a coach should attempt to implement for lacrosse athletes. Furthermore, this study did not investigate how the program may have influenced injury rates, therefore leaving room for additional research.

Summary of Findings

Men's lacrosse combines similar athletic abilities as seen in football, basketball, soccer, and ice hockey. Women's lacrosse combines similar athletic abilities as seen in soccer, field hockey, and basketball. The major difference between the two genders in how the sport is played is that women's lacrosse does not allow contact. This rule forces female lacrosse athletes to rely heavily on speed, agility, jump ability, tactical skill, and technical ability, while men can rely on all of the same abilities with the addition of physicality. As with most team-based sports, lacrosse requires the ability to maneuver effectively and efficiently more so than simply being strong or powerful. Thus, a lacrosse coach should place primary consideration on the athlete's strength-to-mass and power-to-mass ratios rather than absolute strength or absolute power. Lacrosse athletes also need lateral and linear acceleration and deceleration.

This study's findings suggest that an agility model based on the development of linear acceleration first, linear deceleration second, lateral acceleration third, lateral deceleration fourth, and multi-directional acceleration/deceleration last would benefit lacrosse athletes. Additionally, it is important for players of both genders to achieve their maximum possible speed. This study's results indicate that the use of assisted, resisted, proprioceptive, and strength-related running drills aided in the increase in maximum speed for both genders. This study suggests that players can expect to achieve significant results by following a program that emphasizes speed one day and agility or conditioning on other, separate days, though the ability to implement such a program will depend on space and on the number of athletes and strength coaches. In this study, the emphasis was shifted between positions each day. For males, all midfielders, goalies, and attack/defensemen had separate foci each day, including speed, agility, and conditioning training. Goalies focused more on step quickness, short-range change of direction, and then reaction speed. Midfielders focused to a higher extent on interval-based speed development, reflecting their longer-range speed and agility needs. Attack/defensemen focused more on acceleration, deceleration, and multidirectional change of direction.

However, all athletes, regardless of position, focused on rotational core strength, stability, mobility, and power.

While some researchers, such as Kraemer, strongly support the use of rotational cores as a staple for athletes in rotational sports such as lacrosse, additional research should be conducted to validate the extent of lacrosse-specific skill transfer that these exercises offer (Earp & Kraemer, 2010). Specific conditioning exercises were planned to a larger degree for midfielders of both genders; however, as the coach and the strength coach did not agree on how to assess lacrosse-specific anaerobic capabilities, anaerobic power and aerobic capacity were not studied. Findings from the literature review suggested that the use of a VO2max aerobic capacity test would be the most appropriate if coaches simply want to know how fit their athletes are (Enemark-Miller et al., 2009). However, other findings indicated that a 300-yard shuttle or half gasser type anaerobic power test would be the most appropriate (Gutowski & Rosene, 2011).

Suggested Testing Parameters for Future Studies and Coaches

Creating an appropriate testing battery for lacrosse athletes will become increasingly important as the sport continues to grow and college recruitment becomes more competitive. Developing a standardized testing battery for both male and female lacrosse players is the only way organizations can accurately compare athleticism on a national scale. This study's findings will aid in the indication of lacrosse-appropriate testing parameters, some of which were used in this study and some of which were not. All incoming freshman athletes and transfers, regardless of their sport, should undergo a Functional Movement Screen. This study did not perform a Functional Movement Screen, which would have made administering the 1 repetition maximum testing easier.

Furthermore, testing the acceleration capabilities, both linear and multi-directional, of lacrosse athletes is highly appropriate. Therefore, the 40-yard dash and 5-10-5 agility should remain constant in a lacrosse testing battery. Adding a testing parameter that measures a more continuous combination of linear and lateral multi-directional acceleration and deceleration capabilities would further enhance the appropriateness of a lacrosse testing battery. The best test for this would be the reliable and valid Illinois agility test, which can accurately compare the performance capabilities of different athletic populations.

Creating new agility or speed tests for lacrosse, although creative and possibly useful for inner-squad comparisons, would not allow for comparisons across schools or other athletic populations; thus, using a test that is applicable, reliable, valid, and widely used across athletic populations would provide more useful data to lacrosse coaches. Given the importance of maximum speed in lacrosse, a 100M sprint or maximum sprint effort on an overspeed treadmill would be more useful than the 40-yard dash. Additionally, a 3 repetition maximum may prove more useful than a 1 repetition maximum because the former represents multiple applications of strength, which is more congruent with the sport of lacrosse. The bench press and back squat should remain constant in a lacrosse testing battery; however, maximum power output exercises, such as the clean, power clean, or hand clean, also should be incorporated for athletes with proper technique and physical abilities.

Conclusion

Lacrosse has become the fastest growing sport in North America in recent years. As the sport's participation continues to rise, there should be a matching increase in the amount and availability of lacrosse-specific strength and conditioning research to allow coaches to gain a better understanding of the necessary physical requirements of playing the sport. This study indicates a need for multiple expressions of speed, quickness, power, and reactiveness for both men and women. Men may require additional physical, hypertrophy-centered training to increase bone mineral density and muscle mass in order to prevent contact injuries. Women, on the other hand, may benefit more from training that focuses on increasing their acceleration and deceleration capabilities because of the no-contact rule. Regardless of gender, rotational strength, power, stability, and mobility will undoubtedly need to be training staples, as the sport is highly rotational and multi-planar. The development of general strength that can transfer into lacrosse-specific total body power has been proven to be essential. Kinetic chain exercises, as well as traditional clean- and snatch-related exercises, provide a solid means by which this total multiple repetition power can be repeatedly expressed and developed. Focusing too much on aerobic conditioning is cautioned against. The literature review findings indicate a higher demand on the anaerobic systems of lacrosse athletes. The proposed strength training and conditioning design in this study was proven to be effective at developing increases in each of the performance characteristics required for successful play. All athletes have different characteristics, so the generalization of this study's results depends on the age, maturity, training status, and skill level of the athlete, as well as the availability of space, time, and equipment possessed by the institution. For similar athletes at the intermediate training level, a similar step-loading pattern, or even a flatloading pattern, of periodization may be the most beneficial, as with these athletes, the goal should be to enhance strength related to technique and motor coordination. For more advanced athletes, coaches may wish to use a conjugated sequence model to stimulate more morphological and physiological adaptations necessary for further performance enhancements.

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Appendix A: Men's Lacrosse Speed, Agility, and Conditioning Program: January 2012-April 2012

Date	Group A	Day	Group B	Day	Group C	Day	(Goalies & Poles)	Day	(O-Mids)	Day	(Attack & D-Mids)
1/2/08	OST	1	Sand Intervals	1	Turf Agility	1	Makoto - Plyoboards	1	Accelerations	1	Turf Agility
1/4/08	Turf Agility	2	OST	2	Sand Intervals	2	Accelerations - Ladder	2	40's	2	Plyoboards
1/9/08	Sand Intervals	3	Turf Agility	3	OST	3	Makoto-UB Plyos	3	80's	3	Accelerations-Ladder
1/11/08	OST	1	Boxes	1	Ladder	1	Turf Agility	1	55 Half Gasser (Timed)	1	Makoto UB Plyos
1/16/08	Ladder	2	OST	2	Boxes	2	Accelerations - Ladder	2	120's	2	Makoto-Plyoboards
1/18/08	Boxes	3	Ladder	3	OST	3	Makoto - Plyoboards	3	Accelerations	3	Turf Agility
1/22/08	OST	1	V-Jump	1	Turf Agility	1	Makoto-UB Plyos	1	40's	1	Accelerations-Ladder
1/24/08	Turf Agility	2	OST	2	V-Jump	2	Accelerations - Ladder	2	80's	2	Makoto UB Plyos
1/29/08	V-Jump	3	Turf Agility	3	OST	3	Makoto-Turf Agility	3	55 Half Gasser (Timed)	3	Plyoboards
1/31/08	OST	1	Force TM	1	Sand Plyo	1	Makoto - Plyoboards	1	120's	1	Turf Agility
2/5/08	Sand Plyo	2	OST	2	Force TM	2	Accelerations - Ladder	2	80's	2	Plyoboards
2/7/08	Force TM	3	Sand Plyo	3	OST	3	Makoto-UB Plyos	3	40's	3	Accelerations-Ladder
2/12/08	OST	1	Turf Agility	1	Boxes	1	Turf Agility	1	Accelerations	1	Makoto UB Plyos
2/14/08	Boxes	2	OST	2	Turf Agility	2	Accelerations - Ladder	2	40's	2	Makoto-Plyoboards
2/19/08	Test	Test	Test	Test	Test	Test	Test	Test	Test	Test	Test
2/21/08	Turf Agility	3	Boxes	3	OST	3	Makoto - Plyoboards	3	80's	3	Turf Agility
2/28/08	OST	1	Ladders	1	V-Jump	1	Makoto-UB Plyos	1	40's	1	Accelerations-Ladder
3/6/08	V-Jump	2	OST	2	Ladder	2	Ladder	2	Accelerations	2	Makoto UB Plyos
3/13/08	Ladder	3	V-Jump	3	OST	3	Makoto-Turf Agility	3	80's	3	Plyoboards
3/20/08	OST	1	Sand Plyo	1	Turf Agility	1	Makoto - Plyoboards	1	40's	1	Turf Agility
4/9/08	Turf Agility	2	OST	2	Sand Plyo	2	Accelerations - Ladder	2	80's	2	Plyoboards
4/18/08	Sand Plyo	3	Turf Agility	3	OST	3	Makoto-UB Plyos	3	40's	3	Accelerations-Ladder
4/24/08	Test	Test	Test	Test	Test	Test	Test	Test	Test	Test	Test

Appendix B: Women's Speed, Agility, and Conditioning Program: January 2012-April 2012

Group A	Day	Group B	Goalies	Attack/Defense	Mids
OST Intro	1	Sand Intervals	Makoto 2 Min	Ladders	Accelerations
Sand Intervals	2	Ost Intro	Makoto 2 Min/ UB Plyos	Accelerations	40's
OST	1	LB Plyos (Boxes/V-J)	Agility/V-Jump	Makoto 1 min	80's
LB Plyos (Boxes/V-J)	2	OST	Makoto 2 Min/UB Plyos	Agility	Accelerations
OST	1	Turf Agility/Ladder	Agility/V-Jump	UB Plyos	55 Half Gasser
Turf Agility/ Ladder	2	OST	Makoto 1 Min/ UB Plyos	Agility	Accelerations
OST	1	Sand Intervals	Agility/V-Jump	Accelerations	80's
Sand Intervals	2	OST	Makoto 1 Min/UB Plyos	Ladders	40's
OST/ Ground Tech	1	OST/Ground Tech	V-Jump	Makoto 1 min	UB Plyos
Test	Test	Test	Test	Test	Test
OST	1	Turf Agility/Ladder	Makoto 30s/ UB Plyos	Ladders	80's
Turf Agility/Ladder	2	OST	Agility/V-Jump	Accelerations	120's
OST	1	LB Plyos (Boxes/V-J)	Makoto 30s/ UB Plyos	Makoto 30s	Accelerations
LB Plyos (Boxes/V-J)	2	OST	Agility/V-Jump	Accelerations	120's
OST	1	Turf Agility/Ladder	Makoto 30s/ UB Plyos	Agility	80's
Turf Agility/ Ladder	2	OST	Agility/V-Jump	UB Plyos	40's
OST	1	Turf Agility	Makoto 30s/ UB Plyos	Ladders	Accelerations
OST/ Ground Tech	2	OST/Ground Tech	V-Jump	Makoto 30s	UB Plyos
Test	Test	Test	Test	Test	Test

Appendix C: Example Women's Lacrosse Strength Training Program

Week of September 26th, 2011, through Week of October 24th, 2011

Phase: 2			**Phase: 2**			**Phase: 2**		
Week of: 9/26/2011	**Monday**		Week of: 9/26/2011	**Wednesday**		Week of: 9/26/2011	**Thursday**	
Core			**Core**			**Core**		
Snatch Press	Sets	Reps	Push Press	Sets	Reps	Hang Clean	Sets	Reps
	2	6		3	6		5	3
Squat	Sets	Reps	Bent Over Row	Sets	Reps	Split Jerk	Sets	Reps
	4	6		3	6		5	3
Lunge	Sets	Reps	Incline Press	Sets	Reps	Front Squat	Sets	Reps
	4	6		3	6		3	5
RDL	Sets	Reps						
	3	10						
Step Up	Sets	Reps						
	2	12						
Auxiliary Lifts	Sets	Reps	**Auxiliary Lifts**	Sets	Reps	**Auxiliary Lifts**	Sets	Reps
Partner Hamstrings	3	8	Lat Pull	3	8	K-Chain	3	10
Calf Raises	3	8	Dips	3	10	Vertical Jump Routine	3	10
Shoulder Series	1	15	High Pull	3	6			
			Core Stability	Sets	Reps			
			Wrist Series	1	15			
			Mid Cable Twist	2	20			
			Medball Ground	2	20			
			Medball Wall	2	20			

Phase: 2			Phase: 2			Phase: 2		
Week of: 10/3/2012	**Monday**		Week of: 10/3/2012	**Wednesday**		Week of: 10/3/2012	**Thursday**	
Core			**Core**			**Core**		
Snatch Press	Sets	Reps	Push Press	Sets	Reps	Hang Clean	Sets	Reps
	3	4		4	4		5	3
Squat	Sets	Reps	1 Arm Row	Sets	Reps	Split Jerk	Sets	Reps
	5	5		4	6		5	3
Side Lunge	Sets	Reps	Bench Press	Sets	Reps	Front Squat	Sets	Reps
	4	6		4	6			
RDL	Sets	Reps						
	3	10					3	5
Lunge and Press	Sets	Reps		Sets	Reps		Sets	Reps
10 Each	2	20						
Auxiliary Lifts	Sets	Reps	**Auxiliary Lifts**	Sets	Reps	**Auxiliary Lifts**	Sets	Reps
Squat Jumps	3	10	Inverted Row	3	8	K-Chain	3	10
Partner Hamstrings	3	8	Push Ups	3	10	Boxes	3	10
Shoulder Series	1	15	Explosive HP	3	6			
Core Stability	Sets	Reps	**Core Stability**	Sets	Reps	**Core Stability**	Sets	Reps
K-Chain Rotation	3	12	Rotational Toss	2	20	Lock and Load	2	6
			Medball Ground	2	20			
			Medball Wall	2	20			

Phase:2			**Phase:2**			**Phase:2**		
Week of: 10/10/2012	**Monday**	Week of: 10/10/2012		**Wednesday**		Week of: 10/10/2012	**Thursday**	
Core			**Core**			**Conditioning**		
Snatch Press	Sets	Reps	Push Press	Sets	Reps	Warm Up	Sets	Reps
	4	4		5	4	Short Interval 3	3	30s
Split Squat	Sets	Reps	Incline Press	Sets	Reps	Quick Feet F (Boxes)	3	30
	5	5		5	6	Quick Feet L	3	30
Lunge	Sets	Reps	RDL	Sets	Reps	Explosive F	3	20
	5	5		4	8	Explosive L	3	20
Deadlift	Sets	Reps	Bench Press	Sets	Reps	Random Ladder	5	
	4	8		4	6			
Step Up	Sets	Reps						
	3	10						
Auxiliary Lifts	Sets	Reps	**Auxiliary Lifts**	Sets	Reps			
Partner Hamstrings	3	8	Seated Row	3	8			
PVC Jumps	3	5	Iso Hang	3	5			
Wrist Series	1	15	Explosive High Pull	3	6			
Medball Partner Touches	2	10						
Core Stability	Sets	Reps	**Core Stability**	Sets	Reps			
K-Chain Rotation	3	12	Plate Up Down	2	20			
			Side Toss	2	20			
			Kneeling Med Toss	2	20			

Phase: 2			**Phase: 2**			**Phase: 2**		
Week of: 10/3/2012	**Monday**		Week of: 10/3/2012	**Wednesday**		Week of: 10/3/2012	**Thursday**	
Core			**Core**			**Core**		
Snatch Press	Sets	Reps	Push Press	Sets	Reps	Hang Clean	Sets	Reps
	3	4		4	4		5	3
Squat	Sets	Reps	1 Arm Row	Sets	Reps	Split Jerk	Sets	Reps
	5	5		4	6		5	3
Side Lunge	Sets	Reps	Bench Press	Sets	Reps	Front Squat	Sets	Reps
	4	6		4	6			
RDL	Sets	Reps						
	3	10					3	5
Lunge and Press	Sets	Reps		Sets	Reps		Sets	Reps
10 Each	2	20						
Auxiliary Lifts	Sets	Reps	**Auxiliary Lifts**	Sets	Reps	**Auxiliary Lifts**	Sets	Reps
Squat Jumps	3	10	Inverted Row	3	8	K-Chain	3	10
Partner Hamstrings	3	8	Push Ups	3	10	Boxes	3	10
Shoulder Series	1	15	Explosive HP	3	6			
Core Stability	Sets	Reps	**Core Stability**	Sets	Reps	**Core Stability**	Sets	Reps
K-Chain Rotation	3	12	Rotational Toss	2	20	Lock and Load	2	6
			Medball Ground	2	20			
			Medball Wall	2	20			

Phase:2			Phase:2			Phase:2		
Week of: 10/10/2012	**Monday**		Week of: 10/10/2012	**Wednesday**		Week of: 10/10/2012	**Thursday**	
Core			**Core**			**Conditioning**		
Snatch Press	Sets	Reps	Push Press	Sets	Reps	Warm Up	Sets	Reps
	4	4		5	4	Short Interval 3	3	30s
Split Squat	Sets	Reps	Incline Press	Sets	Reps	Quick Feet F (Boxes)	3	30
	5	5		5	6	Quick Feet L	3	30
Lunge	Sets	Reps	RDL	Sets	Reps	Explosive F	3	20
	5	5		4	8	Explosive L	3	20
Deadlift	Sets	Reps	Bench Press	Sets	Reps	Random Ladder	5	
	4	8		4	6			
Step Up	Sets	Reps						
	3	10						
Auxiliary Lifts	Sets	Reps	**Auxiliary Lifts**	Sets	Reps			
Partner Hamstrings	3	8	Seated Row	3	8			
PVC Jumps	3	5	Iso Hang	3	5			
Wrist Series	1	15	Explosive High Pull	3	6			
Medball Partner Touches	2	10						
Core Stability	Sets	Reps	**Core Stability**	Sets	Reps			
K-Chain Rotation	3	12	Plate Up Down	2	20			
			Side Toss	2	20			
			Kneeling Med Toss	2	20			

Phase: 2			Phase: 2			Phase: 2		
Week of: 10/17/2012	**Monday**		Week of: 10/17/2012	**Wednesday**		Week of: 10/17/2012	**Thursday**	
Core			**Core**			**Core**		
Snatch Press	Sets	Reps	Hang Clean	Sets	Reps	Power Shrug	Sets	Reps
	5	4		5	3		4	3
Squat	Sets	Reps	Bench Press	Sets	Reps	Bottom Out Squat	Sets	Reps
	6	5		4	6		3	5
Drop Lunge	Sets	Reps	RDL	Sets	Reps	K-Chain	Sets	Reps
	6	5		4	6		4	10
Deadlift	Sets	Reps	Push Press	Sets	Reps			
	4	8		5	4			
Single Leg Hop	Sets	Reps		Sets	Reps			
	2	20						
Auxiliary Lifts	Sets	Reps	**Auxiliary Lifts**	Sets	Reps	**Conditioning**		
Anterior Toe Touches	3	8	Lat Pull Down	3	8	Side Lunges	3	12
Hammer Jumps	3	5	Med Ball Chest Pass	3	10	Ladder	5	
Shoulder Series	1	15	PVC Rows	2	5	Leg Crank	2	20
MedBall Explosions	2	10	EX Front Raise			Red Mile	1	1
Core Stability	Sets	Reps	**Core Stability**	Sets	Reps			
K-Chain Rotation	3	12	Hanging Leg Raises	2	10			
			Plate Up Down	2	20			
			Side Toss	2	20			

Phase:2 (2 Weeks Unloading)			Phase:2 (2 Weeks Unloading)		
Week of:10/24 (Fall Game Week) & 10/31/2012	**Monday**		Week of: 10/2012 (Fall Game Week) & 10/31/2012	**Tuesday**	
Core			**Core**		
Hang Clean	Sets	Reps	Snatch Press	Sets	Reps
	3	3		3	3
Split Jerk	Sets	Reps	Incline Bench	Sets	Reps
	3	3		3	3
Squat Jump	Sets	Reps	RDL	Sets	Reps
	3	3		3	5
Auxiliary Lifts	Sets	Reps	**Auxiliary Lifts**	Sets	Reps
Shoulder Series	1	20	Explosive Push Ups	3	5
Wrist Series	1	20			
Core Stability	Sets	Reps	**Core Stability**	Sets	Reps
T2T	2	10	Turkish Get Up	2	10
			Drop n Roll	2	10

Appendix D: Example Women's Strength Training Program

Week of January 2nd 2012 through Week of January 30th 2012

Phase: 4			**Phase: 4**		
Week of 1/2/2012	**Monday**		Week of 1/2/2012	**Wednesday**	
Core			**Core**		
Hang Clean	Sets	Reps	Hang Clean	Sets	Reps
2 Box	5	3	1 Box	5	3
Bench Press	Sets	Reps	Split Jerk	Sets	Reps
10/8/6/6/3				4	3
K-Chain	Sets	Reps	Back Squat	Sets	Reps
S2S 2H	4	12		4	8
Chin Ups	Sets	Reps	Push Press	Sets	Reps
Less than 5 Hang	4	MAX		5	8
Incline Bench	Sets	Reps	Dead Lift	Sets	Reps
	4	8		4	6
Assisted Pull Up	Sets	Reps	Snatch Press	Sets	Reps
	4	8		5	8
Auxiliary Lifts	Sets	Reps	**Auxiliary Lifts**	Sets	Reps
EX Push Ups	3	10	RDL	4	8
1 Arm Row	3	8	Military Press	3	10
			F Lunge/Press	2	6
			F Lunge	2	6
Core Stability	Sets	Reps	**Core Stability**	Sets	Reps
Cable Twist HI	1	10	2 ARM T2T	2	20
K-Extension	3	12	K-Chain 1arm Thigh	2	10
Med Ball Over Head	2	20	Med Ball Distance	2	5

Phase 4			**Phase 4**		
Week of: 1/9/2012	**Monday**		Week of: 1/9/2012	**Wednesday**	
Core			**Core**		
Hang Clean	Sets	Reps	Hang Clean	Sets	Reps
2 Box	3	3	1 Box	5	3
Bench Press	Sets	Reps	Split Jerk	Sets	Reps
10/8/6/6/3	4	10		4	3
K-Chain	Sets	Reps	Back Squat	Sets	Reps
S2S 2H	4	12		4	8
RDL/Bent Row	Sets	Reps	Push Press	Sets	Reps
Bent 2x5/RDL 2x5	3	5		5	8
Incline Bench	Sets	Reps	Dead Lift	Sets	Reps
10/10/5/5	4	8		4	6
Assisted Pull Up	Sets	Reps	Snatch Press	Sets	Reps
	4	8		5	8
Auxiliary Lifts	Sets	Reps	**Auxiliary Lifts**	Sets	Reps
EX Push Ups	2	10	RDL	4	8
1 Arm Row	3	8	Military Press	3	10
			Side Lunge	2	6
			F Lunge/Press	2	6
Core Stability	Sets	Reps	**Core Stability**	Sets	Reps
Cable Twist HI	2	10	2 ARM T2T	2	20
Curl and Press	3	5	K-Chain 1arm Thigh	2	10
Med Ball Over Head	2	20	Med Ball Toss	2	10

Phase 4			Phase 4		
Week of: 1/16/2012	**Monday**		Week of: 1/16/2012	**Wednesday**	
Core			**Core**		
Hang Clean	Sets	Reps	Hang Clean	Sets	Reps
2 Box Pull	3	3	1 Box	5	3
Bench Press	Sets	Reps	Split Jerk	Sets	Reps
10/8/6/6/3				4	3
K-Chain	Sets	Reps	Back Squat	Sets	Reps
S2S 2H	4	12		4	8
Chin Ups	Sets	Reps	Push Press	Sets	Reps
Less than 5 Hang	4	MAX		5	8
Incline Bench	Sets	Reps	Dead Lift	Sets	Reps
	4	8		4	6
Assisted Pull Up	Sets	Reps	Snatch Press	Sets	Reps
	4	8		5	8
Auxiliary Lifts	Sets	Reps	**Auxiliary Lifts**	Sets	Reps
EX Push Ups	3	10	RDL	4	8
1 Arm Row	3	8	Military Press	3	10
			F Lunge	2	6
			F Lunge/Press	2	6
Core Stability	Sets	Reps	**Core Stability**	Sets	Reps
Cable Twist HI	1	10	2 ARM T2T	2	20
K-Extension	3	12	K-Chain 1arm Thigh	2	10
Med Ball Over Head	2	20	Med Ball Distance	2	5

Phase 5 (Unload Shift to Sport Specific)	Monday		Phase 5 (Unload Shift to Sport Specific)	Tuesday	
Week Of: 1/23/2012			Week Of: 1/23/2012		
SPORT SPECIFIC	Sets	Reps	**SPORT SPECIFIC**	Sets	Reps
LINE DRILLS	2	20	K-CHAIN	2	20
QUICK TUCK J	2	10	K-CHAIN	2	12
R X LUNGE	2	5	K-CHAIN	2	12
Core			**Core**		
CLEAN	Sets	Reps	Clean	Sets	Reps
2 BOX	6	3	1 Box		
SQUAT	Sets	Reps	Bench	Sets	Reps
	2	10		2	10
	2	5		2	5
	3	3		3	3
Push Press	Sets	Reps	Ovr Squat PVC	Sets	Reps
	4	6		4	10
Auxiliary Lifts	Sets	Reps	Bent Row	Sets	Reps
RDL	4	8		4	6
Lunge & Press	3	6	**Auxiliary Lifts**	Sets	Reps
Glute Ham Raise	3	6	Push Ups	2	10
Side Lunge Press	3	6	Band Pull Ups	3	8
TRUNK	Sets	Reps	High Pull	3	8
K-CHAIN	2	20	Calf Raises	3	10
K-CHAIN	2	20	**TRUNK**	Sets	Reps
Single Leg Med Toss	1	20	Cable Twist	2	10
PRE HAB	Sets	Reps	Bird Dog	2	20
LATERAL RAISE	1	15	2Legraise	2	20
REVERSE FLY	1	15	**PRE HAB**	Sets	Reps
FRONT RAISE	1	15	Shuffle Shuffle Lunge	2	10
90 ROTATIONS	1	10	Single Leg 1/4 Squat	2	10
PLATE ROTATIONS	1	20	R Plank Single	1	20
			Ankle Pops	2	10

Phase 5 (Unload Shift to Sport Specific)			Phase 5 (Unload Shift to Sport Specific)		
Week of: 1/30/2012	**Monday**		Week of: 1/30/2012	**Tuesday**	
SPORT SPECIFIC	Sets	Reps	**SPORT SPECIFIC**	Sets	Reps
Quick F/L	2	20	K-CHAIN	2	20
Bar Squat Jumps	2	5	K-CHAIN	2	12
Bar Split	2	5	K-CHAIN	2	12
Core			K-CHAIN	2	20
Clean	Sets	Reps	**Core**		
1 Box	4	3	Clean	Sets	Reps
Front Squat	Sets	Reps	1 Box	4	3
	1	10	Dead Lift	Sets	Reps
	1	5		1	10
	2	3		1	5
Auxiliary Lifts	Sets	Reps		2	3
Split Jerk	4	3	**Auxiliary Lifts**	Sets	Reps
Barbell Lunge	3	8	Incline Bench	3	8
Push Press	4	6	Inverted Row	3	8
RDL	3	8	High Pull	3	8
TRUNK	Sets	Reps	Snatch Press	3	8
Cable Twist	1	10	**TRUNK**	Sets	Reps
Single Leg Med Toss	1	10	Med Ball Toss	1	20
Lunge and Press	2	10	Med Ball Toss	1	20
			Stager Downward Toss	1	10

Appendix E: Example Men's Lacrosse Strength Training Program

Week of September 26th, 2011 through Week of October 24th, 2011

Phase: 2			Phase: 2			Phase: 2		
Week of: 9/26/2011	**Tuesday**		Week of: 9/26/2011	**Tuesday**		Week of: 9/26/2011	**Thursday**	
Core			**Core**			**Core**		
Power Shrug	Sets	Reps	Hang Clean	Sets	Reps	Power Clean	Sets	Reps
	4	4		3	3		3	3
Front Squat	Sets	Reps	Incline Press	Sets	Reps	Split Jerk	Sets	Reps
	4	5		4	5		3	3
RDL	Sets	Reps	Bent Over Row	Sets	Reps	Front Squat	Sets	Reps
	3	6		4	6		4	4
Split Squat	Sets	Reps	Shoulder Press	Sets	Reps		Sets	Reps
	3	5		3	8			
Auxiliary Lifts	Sets	Reps	**Auxiliary Lifts**	Sets	Reps	**Auxiliary Lifts**	Sets	Reps
Partner Hams	3	8	Lat Pull Down	3	8	Kinetic Chain		
Red Mile	1	1	DB Swing	2	0	MedBall Wall	2	20
Shoulder Series	1	15	Wrist Series	2	20	Medball Ground	2	20
Calf 3 Way	3	18	Plate Chops	2	20	Vertical Jump Routine	8	10
			Core Stability	Sets	Reps			
			High Pull/Front Raise	2	10			
			Cable HI/LO	2	20			
			Cable LO/HI	2	20			

Phase 2		
Week of: 10/3/2011	**Tuesday**	
Core		
Squat	Sets	Reps
	5	5
Dead Lift	Sets	Reps
	5	6
Barbell Lunge	Sets	Reps
	3	6
Side Lunge	Sets	Reps
	3	6
Auxiliary Lifts	Sets	Reps
ANT Toe Touch	3	8
Blue Mile	1	1
Shoulder Series	1	15
Calf Raises	3	15

Phase 2		
Week of: 10/3/2011	**Monday**	
Core		
Hang Clean	Sets	Reps
	4	3
Incline Press	Sets	Reps
	5	5
1 Arm Row	Sets	Reps
	4	6
Push Press	Sets	Reps
	4	6
Auxiliary Lifts	Sets	Reps
Lat Pull Down	3	8
DB Bench	3	8
Cable Twist Hi/LO	2	20
Cable Twist LO/HI	2	20
Core Stability	Sets	Reps
High Pull/Front Raise	2	10
Cable HI/LO	2	20
Cable LO/HI	2	20

Phase 2		
Week of: 10/3/2011	**Thursday**	
Core		
Power Clean	Sets	Reps
	3	4
Split Jerk	Sets	Reps
	3	4
Overhead Squat	5	Reps
	Sets	Reps
Auxiliary Lifts	Sets	Reps
Lock and Load		
MedBall Rotational Toss	2	10
Box Jumps	2	10

Phase: 2		
Week of 10/10/2011	**Tuesday**	
Core		
Dead Lift	Sets	Reps
	4	6
Bench Press	Sets	Reps
	5	5
Chin Up/CG Pull Down	Sets	Reps
	4	6
Military Press	Sets	Reps
	3	8
Auxiliary Lifts	Sets	Reps
Reverse Curl and Press	3	8
Inverted Row	4	8
Med Ball Push Ups	2	20
BUS Driver	2	10
T to T EX	2	12

Phase: 2		
Week of 10/10/2011	**Monday**	
Core		
Hang Clean	Sets	Reps
	4	3
Power Clean	Sets	Reps
	4	4
Split Jerk	Sets	Reps
	4	3
	Sets	Reps
Auxiliary Lifts	Sets	Reps
Tire Flip	2	5
Med Ball Vertical Explosion	2	10
Hammer Jumps	2	10
PVC Jumps	2	10
Quick Hands /Boxes	2	
Kextension	2	12
Core Stability	Sets	Reps
Cable LO to HI	2	20

Phase: 2		
Week of 10/10/2011	**Thursday**	
Core		
Front Squat	Sets	Reps
	5	5
Back Squat	Sets	Reps
	5	5
RDL	Sets	Reps
	4	6
Split Squat	Sets	Reps
DB	3	6
Auxiliary Lifts	Sets	Reps
Leg FX	3	8
Leg Crank	1	1
Lateral Step Up	2	20
	3	6
Core Stability	Sets	Reps
Hanging Leg Raises	3	10
Cable LO HI	2	20

Phase: 2 (Unload)			Phase: 2 (Unload)		
Weeks 10/17 - 10/24-11	**Tuesday**		Weeks 10/17 - 10/24-11	**Monday**	
Core			**Core**		
Power Clean	Sets	Reps	DB Bench	Sets	Reps
	4	3		4	3
Split Jerk	Sets	Reps	Deadlift	Sets	Reps
	4	3		3	3
Squat	Sets	Reps	Push press	Sets	Reps
	3	3		4	3
Auxiliary Lifts	Sets	Reps	**Auxiliary Lifts**		
Glute Ham/Partner Ham	2	8	Lat Pull	2	8
Cable HI/LO	2	10	Med Ball Push Ups	2	10
Shoulder Series	1	15	Wrist Series	1	15

Appendix F: Example Men's Lacrosse Strength Training Program

Week of January 2nd 2012 through Week of January 30th 2012

Phase 5			**Phase 5**		
Week of: 1/2/12	**Monday**		Week of: 1/2/12	**Wednesday**	
Core			**Core**		
Hang Clean	Sets	Reps	Clean	Sets	Reps
1 Box Pull	5	3		5	3
Dead Lift	Sets	Reps	Split Jerk	Sets	Reps
10/8/6/6/3				4	3
Bench Press	Sets	Reps	Squat Jump	Sets	Reps
10/8/6/6/3			Bar	3	10
Chin Ups	Sets	Reps	Back Squat	Sets	Reps
Less than 5 Hang	4	MAX		4	6
Incline Bench	Sets	Reps	Push Press	Sets	Reps
	3	10		3	10
Lat Pull	Sets	Reps	Snatch Press	Sets	Reps
	3	10	Snatch Squat Press	3	10
Auxiliary Lifts	Sets	Reps	**Auxiliary Lifts**	Sets	Reps
K-Chain 1Arm	3	16	RDL	3	10
1 Arm Row	3	10	High Pull	3	10
K-Extension	3	12	F Lunge	2	6
			F Lunge/Press	2	6
Core Stability	Sets	Reps	**Core Stability**	Sets	Reps
Cable Twist HI	1	10	K-Chain s2s	2	8
Cable Twist Lo	1	10	K-Chain 1arm Thigh	2	20
MT Line Hops	2	20	Med Ball Distance	2	5
Hammer	2	10			

Phase 5			Phase 5		
Week of: 1/9/12	Monday		Week:------->	Wednesday	
Core			**Core**		
Hang Clean	Sets	Reps	Hang Clean	Sets	Reps
2 Box Pull/1Box Pull	3	3	1 Box	5	3
Deadlift	Sets	Reps	Split Jerk	Sets	Reps
K-Extn (4)	4	10		4	3
Bench Press	Sets	Reps	Squat Jump	Sets	Reps
Med Pass (3)	4	10	Bar	3	10
RDL/Bent Row	Sets	Reps	Front Squat	Sets	Reps
Bent 2x5/RDL 2x5	3	5		4	6
Incline Bench	Sets	Reps	Push Press	Sets	Reps
10/10/5/5				3	10
Lat Pull	Sets	Reps	Snatch Press	Sets	Reps
	3	10	Snatch Squat Press	3	10
Auxiliary Lifts	Sets	Reps	**Auxiliary Lifts**	Sets	Reps
K-Chain Throw	2	20	RDL	3	10
1 Arm Row	3	12	High Pull	3	10
Curl and Press	3	5	Side Lunge	2	6
			F Lunge/Press	2	6
Core Stability	Sets	Reps	**Core Stability**	Sets	Reps
Cable Twist HI	2	10	K-Chain s2s	2	8
Cable Twist Lo	2	10	K-Chain 1arm Thigh	2	20
Cable Circles	2	10	Med Ball Toss	2	10
Hammer	2	10			

Phase 5			Phase 5		
Week of: 1/16/2012	**Monday**		Week of: 1/16/2012	**Wednesday**	
Core			**Core**		
Hang Clean	Sets	Reps	Power Clean	Sets	Reps
1 Box	3	3		5	3
Bench Press	Sets	Reps	Split Jerk	Sets	Reps
10/8/6/6/3/1				5	3
Med Ball Toss (5)					
Pull Ups Max	Sets	Reps	Back Squat	Sets	Reps
Less Than 6 (10 Assist)	4			4	6
Incline Bench	Sets	Reps	Deadlift	Sets	Reps
	4	8		4	6
Seated Row	Sets	Reps	Push Press	Sets	Reps
	3	10		5	8
Push Ups	Sets	Reps	RDL	Sets	Reps
	4	Max		4	8
Auxiliary Lifts	Sets	Reps	**Auxiliary Lifts**	Sets	Reps
1 Arm Throw	3	10	Military Press	4	8
Lat Pull	3	10	High Pull	3	10
Under Hand Med	3	5	F Lunge	4	6
Core Stability	Sets	Reps	**Core Stability**	Sets	Reps
Cable Twist HI	1	10	K-Chain s2s	2	8
Med Over Head	2	20	K-Chain 1arm Thigh	2	20
Shoulder Pre	2	20	Med Ball Distance	2	5

Phase 5			Phase 5		
Week of 1/23/12	**Tuesday**		Week of 1/23/12	**Thursday**	
SPORT SPECIFIC	Sets	Reps	**SPORT SPECIFIC**	Sets	Reps
K-CHAIN	2	20	Quick Tuck	2	10
K-CHAIN	2	12	Bar Squat Jumps	2	5
K-CHAIN	2	12	Bar Split	2	5
K-CHAIN	2	20			
Core			**Core**		
CLEAN	Sets	Reps	Split Jerk	Sets	Reps
1 Box	6	3			
SQUAT	Sets	Reps	Bench	Sets	Reps
	2	10		2	10
	2	5		2	5
	3	3		3	3
Auxiliary Lifts	Sets	Reps	**Auxiliary Lifts**	Sets	Reps
Incline Bench	4	8	Barbell Lunge	3	6
Pull Ups	4	8	1 Arm Row	4	8
Push Press	4	8	Push Press	4	8
RDL	4	8	Partner/Glute Ham	3	6
TRUNK	Sets	Reps	**TRUNK**	Sets	Reps
Cable Twist	1	10	Med Ball Toss	1	20
Single Leg Med Toss	1	10	Med Ball Toss	1	20
Lunge and Twist	2	10	Med Ball Toss	1	10

Phase 5			Phase 5		
Week of: 1/30/12	**Tuesday**		Week of: 1/30/12	**Thursday**	
SPORT SPECIFIC	Sets	Reps	**SPORT SPECIFIC**	Sets	Reps
K-CHAIN	2	20	Line Drills	2	15
K-CHAIN	2	12	Broad Jump	2	10
K-CHAIN	2	12	Barrier Jump	2	10
K-CHAIN	2	20			
Core			**Core**		
CLEAN	Sets	Reps	Split Jerk	Sets	Reps
Floor	6	3		4	3
Front Squat	Sets	Reps	Deadlift	Sets	Reps
	2	10		2	10
	2	5		2	5
Auxiliary Lifts	Sets	Reps	**Auxiliary Lifts**	Sets	Reps
DB Bench	4	8	Incline Bench	4	6
Inverted Row	4	8	1 Arm Row	4	8
Push Press	4	8	Military Press	4	8
RDL	4	8	Single Pistol	2	5
TRUNK	Sets	Reps	**TRUNK**	Sets	Reps
Cable Twist	1	10	Med Ball Toss	1	20
Bent Knee Med Toss	1	10	Russian Twist	2	10
Lunge and Reach	2	10	Med Ball Toss	1	10

Appendix G: Sample New Lacrosse-Specific Exercises and Instructions

Figure G1. Kinetic Chain Shoulder-to-Shoulder Throw Start Position

Figure G2. Kinetic Chain Shoulder-to-Shoulder Throw Release

Figure G3. Kinetic Chain Shoulder-to-Shoulder One Arm Transfer

Figure G4. Kinetic Chain Shoulder-to-Shoulder One Arm Transfer Start

Figure G5. Kinetic Chain One Arm Press Start

Figure G6. Kinetic Chain One Arm Press Finish

Figure G7. Kinetic Chain Thigh-to-Thigh Start

Figure G8. Kinetic Chain Thigh-to-Thigh Quarter Phase

Figure G9. Kinetic Chain Thigh-to-Thigh Mid Phase

Figure G10. Kinetic Chain Thigh-to-Thigh Finish

Figure G11. Kinetic Chain Single Arm Thigh-to-Thigh Start

Figure G12. Kinetic Chain Single Arm Thigh-to-Thigh Finish

Figure G13. Kinetic Chain Curl-and-Press Finish

Figure G14. Kinetic Chain Curl-and-Press Start

Figure G15. Kinetic Chain Curl-and-Press Mid Phase

Figure G16. Kinetic Chain Extension Start

Figure G17. Kinetic Chain Extension Mid Phase

Figure G18. Kinetic Chain Extension Mid Finish

Figure G19. Cable High-to-Low Start Phase

Figure G20. Cable High-to-Low Mid Phase

Figure G21. Cable High-to-Low Finish

Figure G22. Cable Single Arm High-to-Low Start

Figure G23. Cable Single Arm High-to-Low Finish

Figure G23. Cable Single Arm High-to-Low Start

Figure G24. Cable Single Arm High-to-Low Finish

Figure G25. Cable Low-to-High Start

Figure G26. Cable Low-to-High Finish

Figure G27. Cable Single Arm Low-to-High Mid Phase


Figure G28. Cable Single Arm Low-to-High Finish


Figure G29. Cable Single Arm Low-to-High Finish

Figure G30. HIT Switch Start

Figure G31. HIT Switch Repetitions

Figure G32. Vertical HIT Switch Start


Figure G33. Vertical HIT Switch Repetitions

Figure G34. Medicine Ball Rotational Throw Start

Figure G35. Medicine Ball Rotational Throw Finish

Figure G36. Lateral Medicine Ball Rotational Throw Start

Figure G38. Lateral Medicine Ball Rotational Throw Finish

Figure G39. Medicine Ball Overhead Throw Wall Start

Figure G40. Medicine Ball Overhead Throw Wall Finish

Figure G41. Standing Stager Medicine Ball Rotational Low-to-High Toss Start

Figure G42. Standing Stager Medicine Ball Rotational Toss Low-to-High Finish

Figure G43. Standing Stager Medicine Ball Rotational Toss High-to-Low Start


Figure G44. Standing Stager Medicine Ball Rotational Toss High-to-Low Finish

Figure G45. Lunging Stager Medicine Ball Rotational Toss Low-to-High Start

Figure G46. Lunging Stager Medicine Ball Rotational Toss Low-to-High Finish

Figure G47. Lunging Stager Medicine Ball Rotational Toss High-to-Low Start

Figure G48. Lunging Stager Medicine Ball Rotational Toss High-to-Low Finish

Figure G49. Tire Flip Start

Figure G50. Tire Flip Ascension

Figure G51. Tire Flip Mid Phase

Figure G52. Tire Flip Finish

Figure G53. Rotational Hammer Hit Start

Figure G54. Rotational Hammer Hit Rotational Phase

Figure G55. Rotational Hammer Hit Overhead Phase

Figure G56. Rotational Hammer Hit Hand Slide Phase

Figure G57. Rotational Hammer Hit Finish

Figure G58. Overhead Extension Hammer Hit Start

Figure G59. Overhead Extension Hammer Hit Mid Phase

Figure G60. Overhead Extension Hammer Hit Finish

Figure G61. 35% Grade Acceleration Start

Figure G62. . 35% Grade Acceleration Descent (Prep Phase)

Figure G63. 35% Grade Accelerations Accent (Acceleration Phase)

Figure G64. 35% Grade Acceleration Finish and Recover Phase

Figure G65. Overspeed Treadmill

Figure G66. Figure G65. Overspeed Treadmill

Figure G67. Vertical Jump (VJ) Routine Exercise One Hack Squat Jump

Figure G68. Vertical Jump (VJ) Routine Body Weight Squat Jump Start

Figure G69. Vertical Jump (VJ) Routine Body Weight Squat Jump Flight

Figure G70. Vertical Jump (VJ) Routine Body Weight Split Jump Start

Figure G71. Vertical Jump (VJ) Routine Body Weight Split Jump Flight

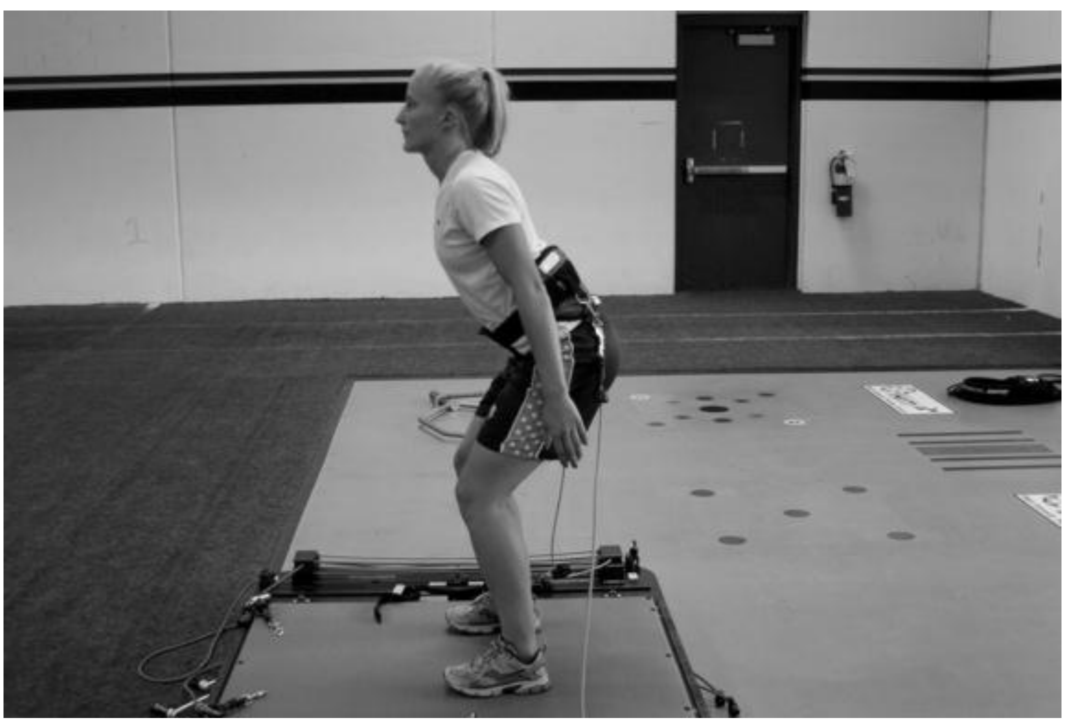


Figure G72. Vertical Jump (VJ) Routine Resistance Band Squat Jump Start

Figure G73. Vertical Jump (VJ) Routine Resistance Band Squat Jump Flight

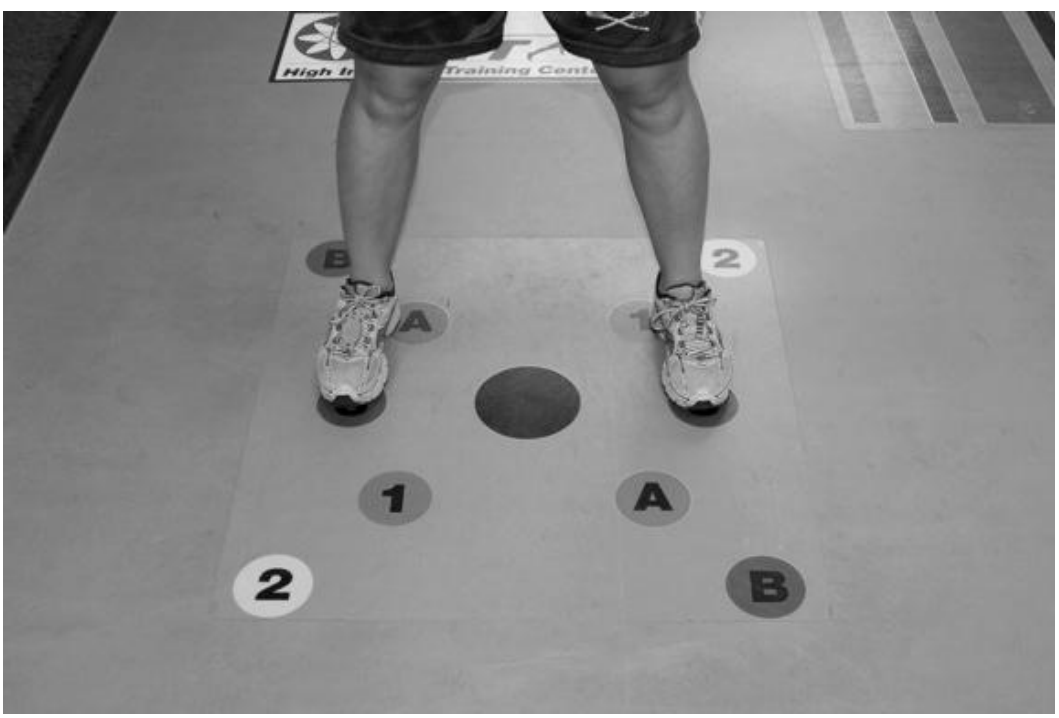


Figure G74. Plyoboards One (A1)

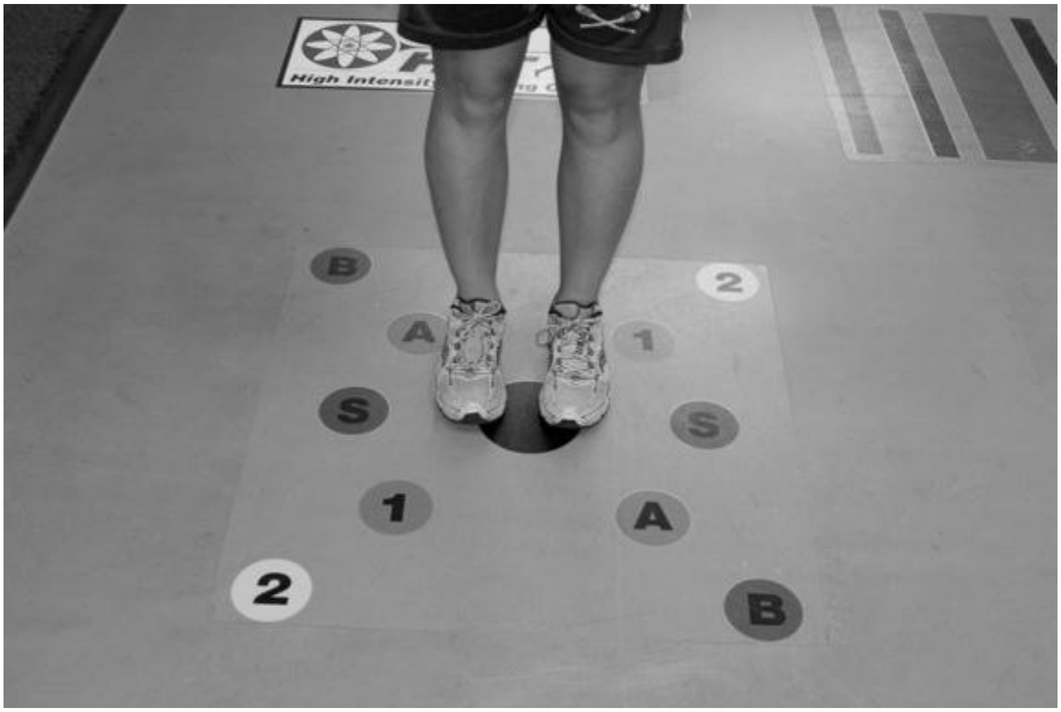


Figure G75. Plyoboards One (A2)

Figure G76. Plyoboards One (A3)

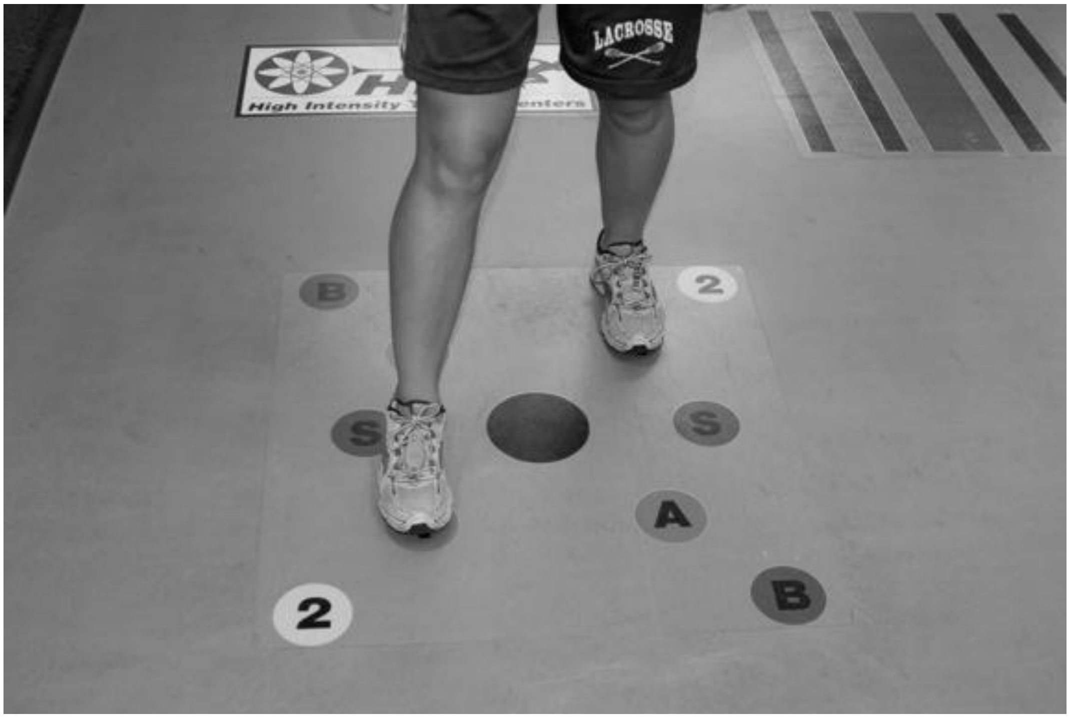


Figure G77. Plyoboards One (A4)

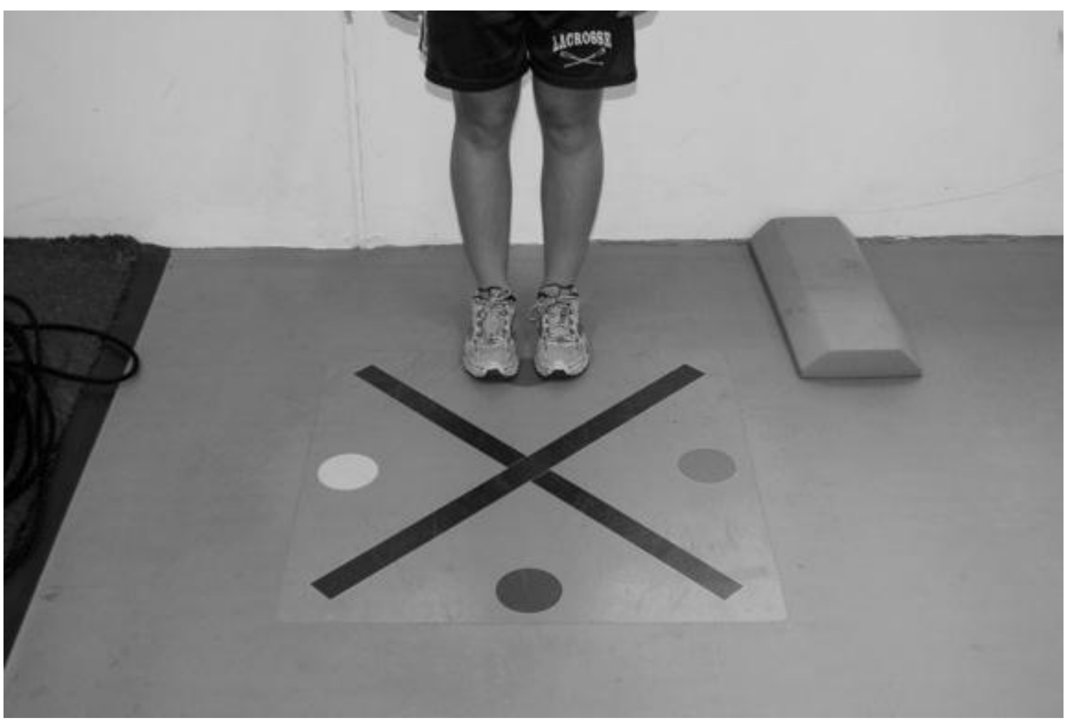


Figure G78. Plyoboards Two (A1)

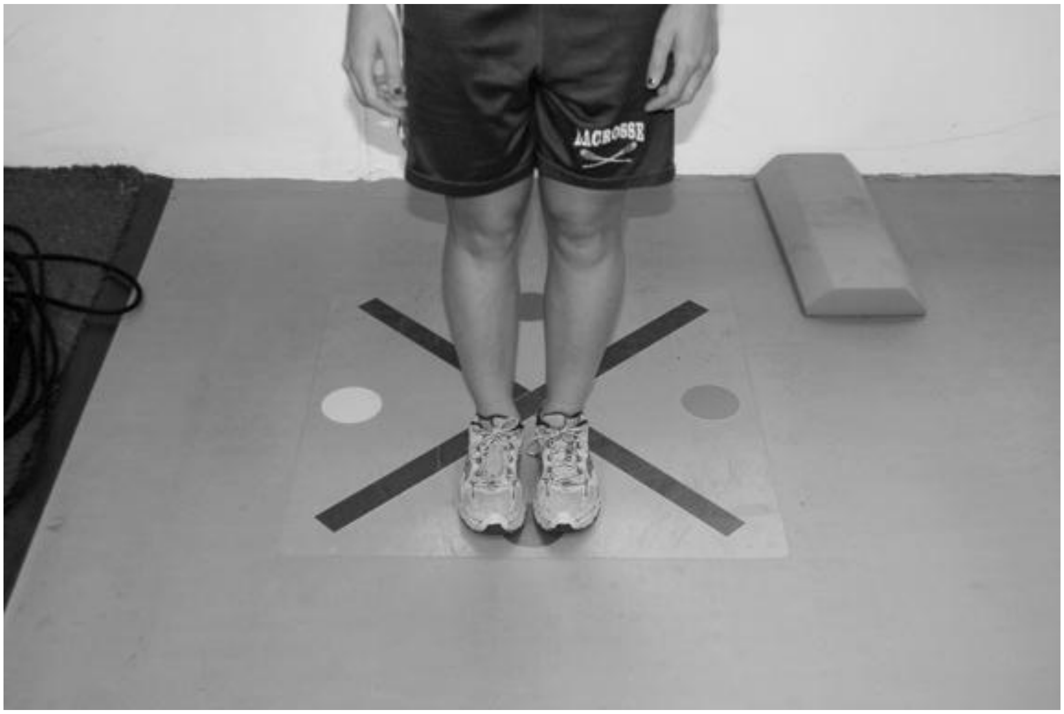


Figure G79. Plyoboards Two (A2)

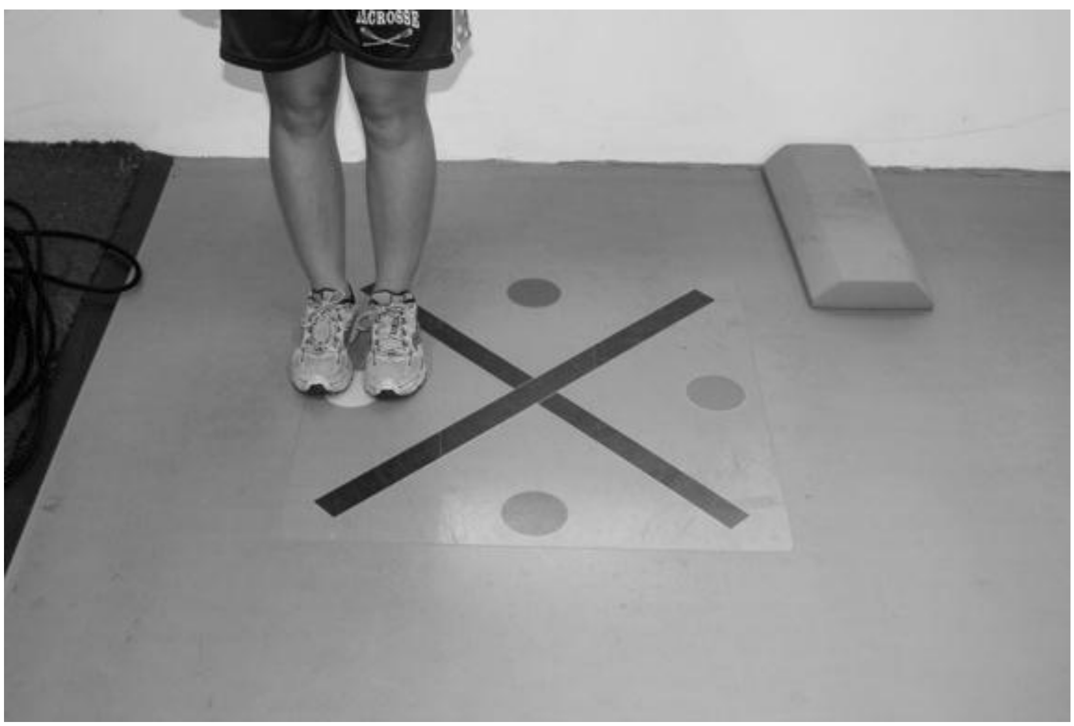


Figure 80. Plyoboards Two (B1)

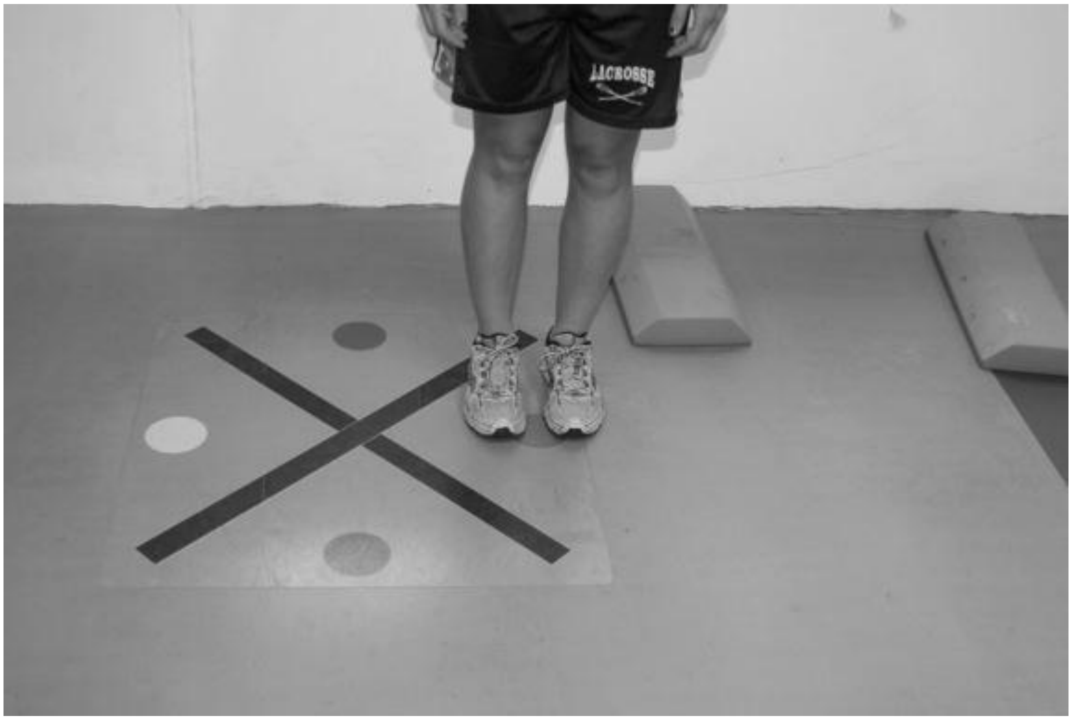


Figure G81. Plyoboards Two (B2)

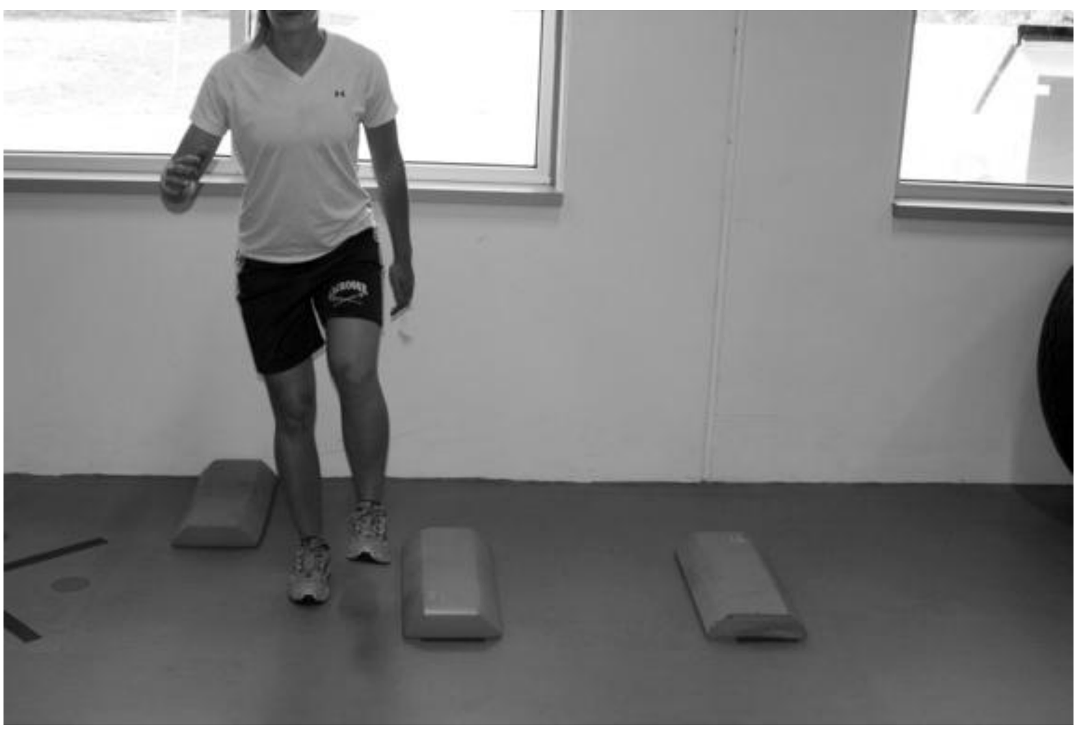


Figure G82. Plyoboards Three (A1)

Figure G82. Plyoboards Three (A2)

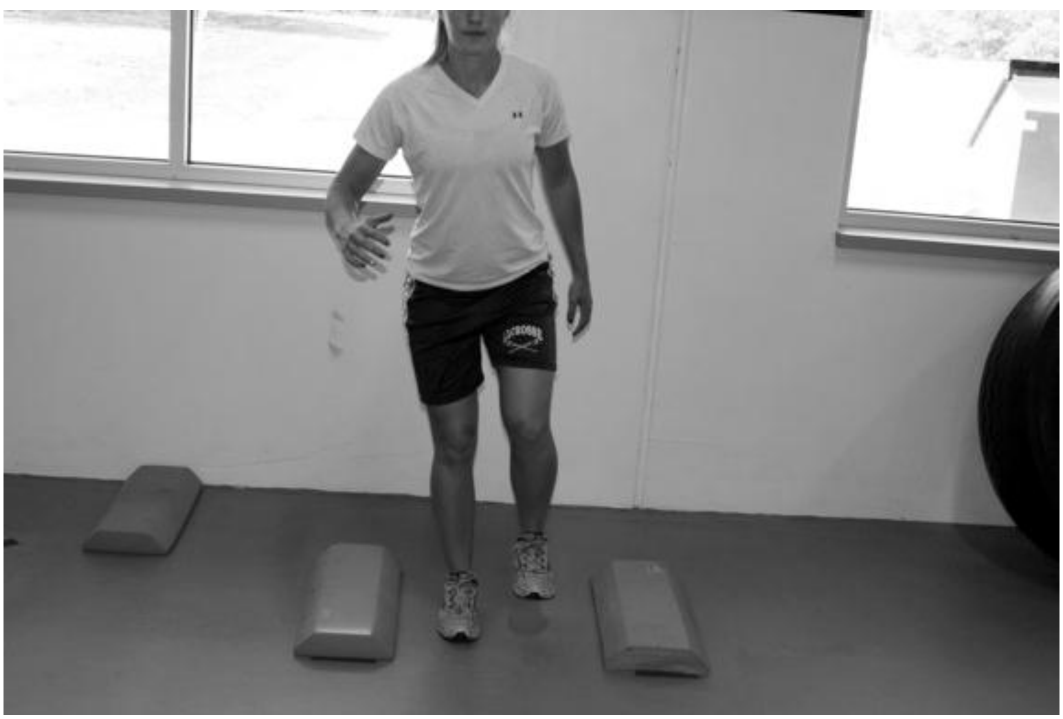


Figure G83. Plyoboards Three (A3)

Figure G84. Plyoboards Three (A4)

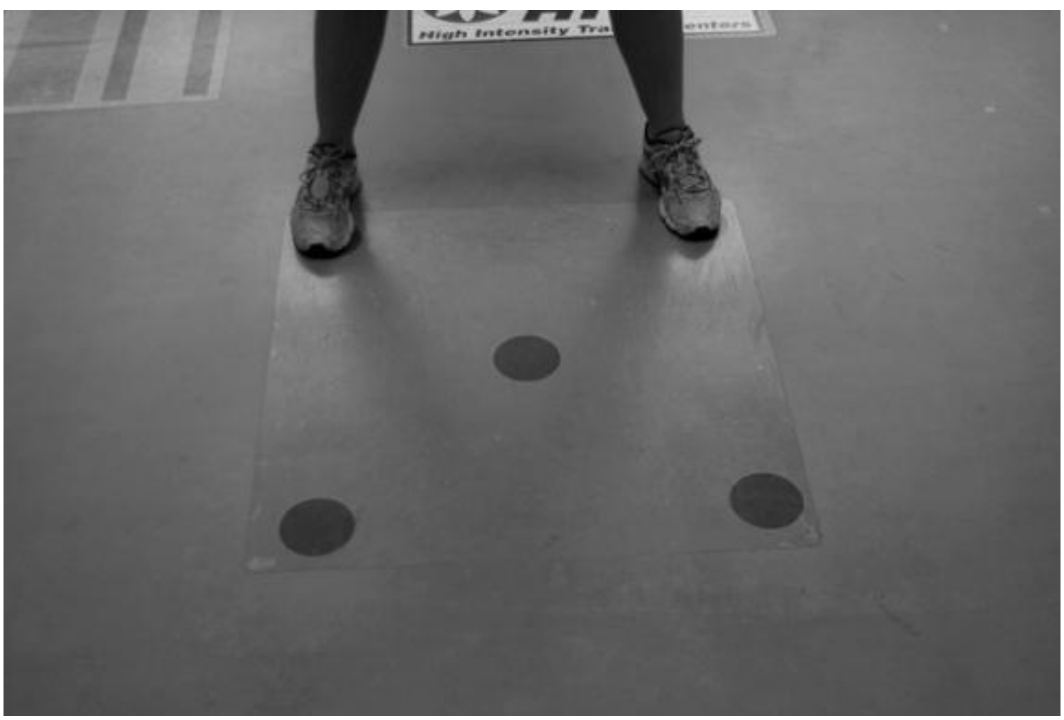


Figure G85. Plyoboards Four (A1)

Figure G86. Plyoboards Four (A2)

Figure G87. Plyoboards Four (A3)

Figure G88. Plyoboards Four (A4)

Figure G89. Plyoboards Four (A5)

Figure G90. Plyoboards Four (A6)

Figure G91. Plyoboards Four (A7)

Figure G92. Plyoboards Four (B1)

Figure G93. Plyoboards Four (B2)

Figure G93. Plyoboards Four (B3)

Figure G94. Sand Sprint

Figure G95. Sand Defensive Slide

Figure G96. Sand Carioca

Figure G105. Sand Backward Run

Figure G106. Sand Squat Jump Start

Figure G107. Sand Squat Jump Flight

Figure G108. Sand Split Jump Start

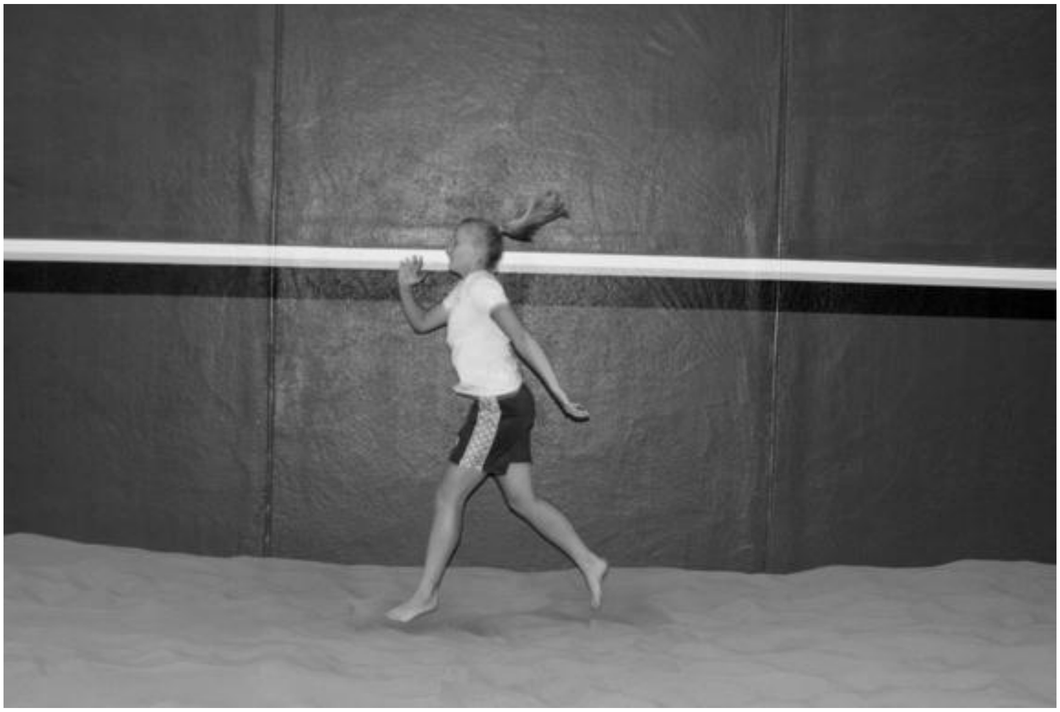


Figure G109. Sand Split Jump Flight

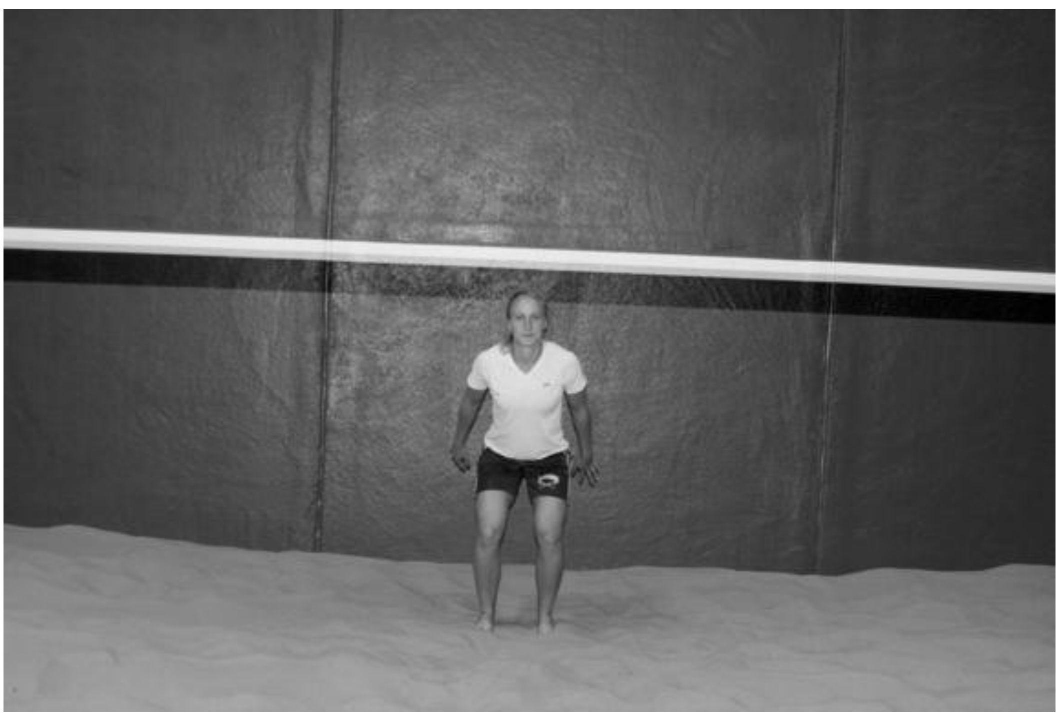


Figure G110. Sand Tuck Jump Start

Figure G111. Sand Tuck Jump Flight

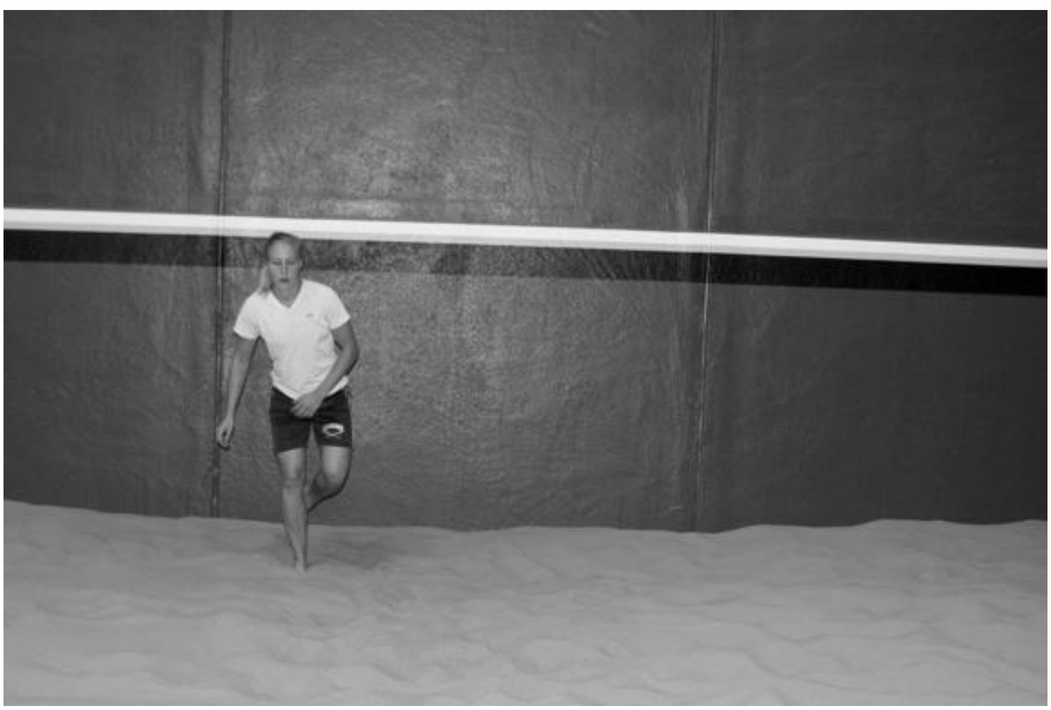


Figure G112. Sand Skater Jump Start

Figure G113. Sand Skater Jump Flight

Figure G114. Sand Skater Jump Landing

Figure G115. Makoto Three Towers

Figure G116. Makoto Three Towers

Figure G117. Makoto Three Towers

Figure G118. Makoto One Tower

Figure G119. Makoto One Tower

Figure G120. Makoto One Tower

Figure G121. Makoto One Tower

Figure G122. Makoto Start Screen

Figure G123. Makoto Two Towers with Stick

Figure G124. Makoto Two Towers with Stick

Figure G125. Makoto Two Towers with Stick

Figure G126. Makoto Two Towers with Stick

Appendix H: Institutional Review Board Approval

LINDENWOOD UNIVERSITY

Institutional Review Board Disposition Report

To: Aaron Randolph
CC: Dr. Cynthia Schroeder
IRB Project Number 12-47
Title: *Effects of the first year of the reorganized strength and conditioning practices at Lindenwood University for Men's and Women's Lacrosse.*

The IRB has reviewed your application for research, and it has been approved, with clarification. Please address the following points:

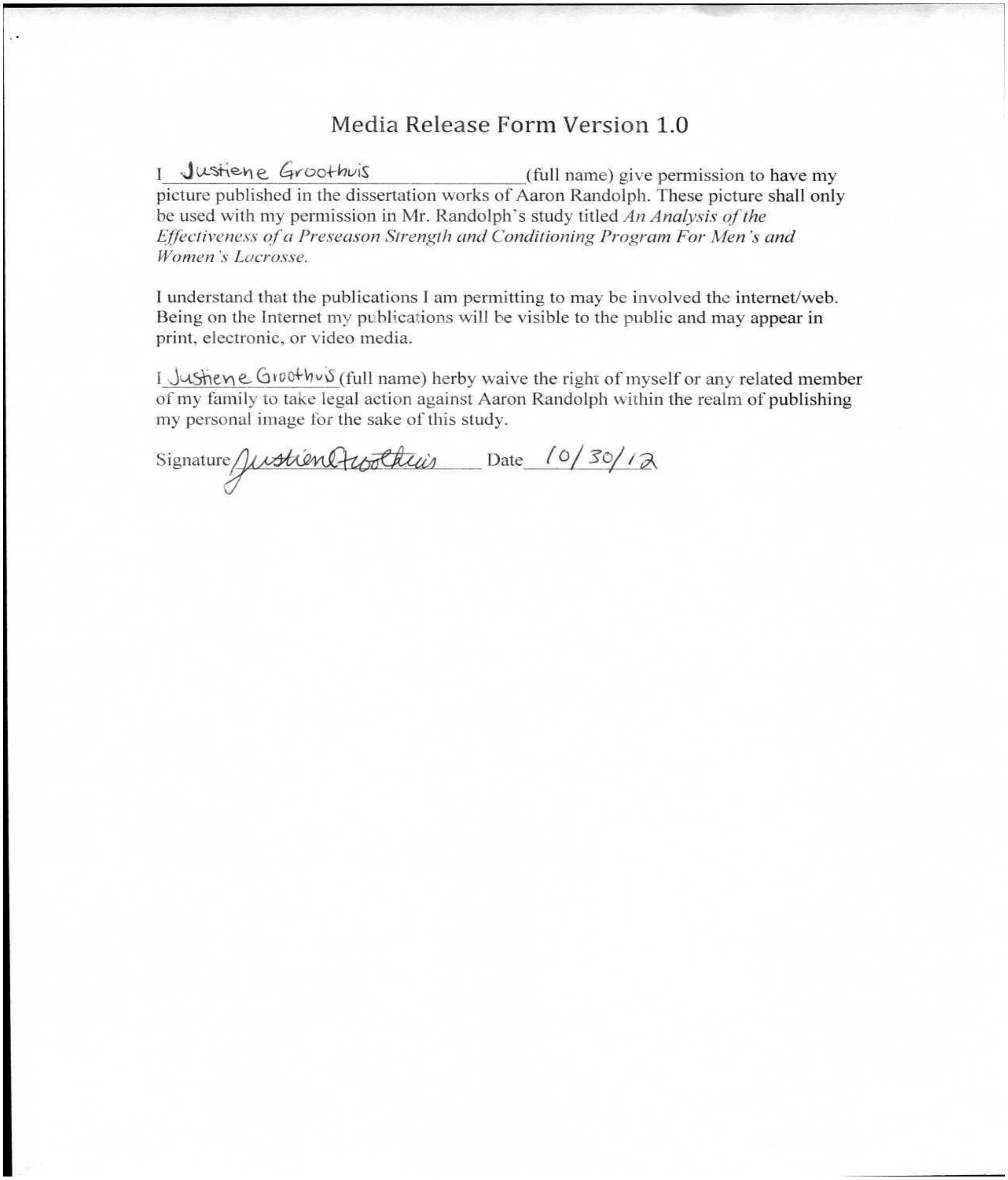
- To make this application complete, please provide method of data analysis. Please provide brief statement of how your data will be analyzed, using what statistical and what qualitative procedures.

Please submit changes directly to the IRB Chair. Thank you.

Dana Klar

Dana Klar Date 12/20/11
Institutional Review Board Chair

Appendix I: Media Release Form



Media Release Form Version 1.0

I Justiene Groothuis (full name) give permission to have my picture published in the dissertation works of Aaron Randolph. These picture shall only be used with my permission in Mr. Randolph's study titled *An Analysis of the Effectiveness of a Preseason Strength and Conditioning Program For Men's and Women's Lacrosse.*

I understand that the publications I am permitting to may be involved the internet/web. Being on the Internet my publications will be visible to the public and may appear in print, electronic, or video media.

I Justiene Groothuis (full name) herby waive the right of myself or any related member of my family to take legal action against Aaron Randolph within the realm of publishing my personal image for the sake of this study.

Signature Justiene Groothuis Date 10/30/12

Vitae

Aaron Randolph holds an undergraduate degree in exercise science from Southeast Missouri State University, a master's degree in business administration from Lindenwood University, and upon completion of this dissertation will have earned his doctorate in education with an emphasis in higher education administration. Aaron is a Certified Strength and Conditioning Specialist (CSCS) through the National Strength and Conditioning Association (NSCA) and a Level One Sport Performance Coach through USA Weightlifting. To date, Aaron has published one other article in the Saint Louis Sport Magazine titled *Lacrosse Takes Over North America.*

Aaron has been involved in the strength and conditioning field since 2006 and has had the pleasure of training a wide range of both youth and professional athletes. Aaron began his career at Southeast Hospital in Cape Girardeau Missouri as a Sport Performance Coach. He continued his experience as an exercise scientist for The High Intensity Training Center, Saint Peters Missouri from 2008 to 2009. In 2009 he began working as a strength and conditioning coach for Lindenwood University. While working for Lindenwood University from 2009 to 2012, Aaron became increasingly fascinated with the sport of lacrosse. The time Aaron spent as the head strength coach for both the men's and women's lacrosse teams allowed him to learn more about the sport's physiological demands and unique history. Understanding lacrosse's history and bright future as the sport continues to grow was the inspiration for this study.