A PROPOSAL FOR A STRENGTH

AND CONDITIONING LAB MANUAL

A Project

by

Danielle Jones

Summer 2019

APPROVED BY THE INTERIM DEAN OF GRADUATE STUDIES:

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Steve Henderson, Ph.D.

# A PROPOSAL FOR A STRENGTH AND CONDITIONING LAB MANUAL

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A Project

Presented

To the Faculty of

California State University, Chico

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In Partial Fulfillment

of the Requirements for the Degree

Master of Arts

in

Kinesiology

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by



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## ACKNOWLEDGMENTS

I would like to thank those who have helped with the creation of this project. The hours have been long, the process has been challenging, and the result would not be here without the continuous support of my family, friends, and colleagues.

I want to thank those in the profession who have given me insight, education beyond the classroom, and support to further my educational experience. For the professionals who have inspired me to be the best version of myself as a future professional, thank you for your guidance.

Thank you to my family and Martin for listening to me ramble about functional anatomy, exercise physiology, and many other science-based subjects. Though you did not understand a word of it, your support and attentiveness mean the world to me. Thank you for supporting me through all of my obstacles, failures, dreams, and accomplishments.

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# ABSTRACT

A PROPOSAL FOR A STRENGTH

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Strength and conditioning is a multifaceted approach to athletic performance. The profession requires knowledge in areas that include injury risk reduction techniques, conduction of performance assessments, identification of limitations with mobility and stability, muscle activation, and optimization of sports performance. With the creation of a lab manual, future professionals will have basic knowledge to succeed in their respective careers. The lab manual will bridge the gap of current teachings with a lack of kinesthetic hands-on experience for the field. It should include coaching cues, information on functional anatomy, and practical application pieces. The lab manual would further assist individuals aspiring to pursue a career in strength and conditioning. The purpose of this project is to propose the creation of a lab manual for kinesiology students, future strength and conditioning coaches and community.

# CHAPTER I

# INTRODUCTION

## Background

There is a plethora of evidence-based research in the field of strength and conditioning (SC) that supports athletic performance. Research assists in maximizing athletic potential and further provides strategies on how to maximize sports performance. Kinesiology has expanded to biomechanics, exercise physiology, sports medicine, sports nutrition, SC, coaching science, and sport psychology.

SC is a profession that specializes in sport performance. A strength and conditioning coach may focus on a single sport or oversee multiple sports. Universities have SC programs that interact with all athletic teams at the college level. SC programs are most common amongst Division I and II National Collegiate Athletic Association (NCAA) universities. If funding is available, a SC program may be present at Division III, private, and National Association of Intercollegiate Athletics (NAIA) schools as well. SC programs are the foundation of performance in professional and collegiate sports; however, they are also common in the private sector. Programs can include directors, head coaches, and specialized coaches for sports such as football, soccer, baseball, and basketball.

The role of a SC professional is to oversee the development of athletic potential through improved strength, power, speed, and agility. Whereas a coach will mentally, as well as physically, challenge athletes to prepare them for competition, the professional SC coach should analyze the movements of athletes. If athletes do not move properly, coaches should understand the reasoning behind the improper movements. With proper assessment, the *"why"* or reasoning for not moving properly is exploited and altered. The role of SC specialists is to first analyze the movements of the athletes and find the improper movements. Coaches then should assess and determine any deficits in mechanics, and generate specific programs to address any biomechanical deficit an athlete may have. These tasks have a clear and common goal: to have the athlete optimize athletic performance.

A large role of SC is to recognize the potential injury risks. Risks for injury should be continuously assessed regardless of the level of experience. Common strategies involved in SC are Olympic lifts, resistance training, plyometrics, as well as agility and/or sport-specific drills when implementing a SC program. Weight training is an added risk of injury if not done properly. However, the risk-to-benefit ratio is minimized when resistance exercises are performed properly. SC professionals should have a clear understanding of functional anatomy. Having the knowledge of the degrees of freedom with which the body can move will assist the coach in recognizing high risk movements. Therefore, a SC specialist should be aware of potential risks and constantly assess for proper lifting mechanics.

## Statement of the Problem

SC is much more than lifting weights. The science behind the field has evolved exponentially. SC requires knowledge in reducing the risk of injuries, assessments, mobility and stability limitations, muscle activation, as well as sport performance. The current problem is that exercises are prescribed without addressing lack of mobility and poor biomechanics. SC specialists should employ a multifaceted approach. An example of this is the availability of lab manuals. Currently, there are lab manuals for exercise physiology as well as testing measurements, but not specifically for SC. Thus, there is a void in the field of SC inasmuch as there are no (or very few) manuals to assist SC coaches. The problem with the absence of movement learning through lab manuals is the practice of teaching lifts and assessing movements. This is problematic for athletes working with future professionals. The risk of injury may not be recognized if future professionals are unaware of biomechanical limitations.

## Purpose of the Project

The purpose of this project is to propose the creation of a SC lab manual that should encompass numerous subjects related to SC into a simple, condensed lab manual to better suit a comprehensive learning experience. This SC lab manual should be tailored to equip students in preparing to pursue a career in SC. The lab manual, such as the one being proposed, will influence a hands-on experience within the classroom. It should focus on performance assessments, mobility and stability limitations, reducing the risk of injury, muscle activation, and sports performance.

The aim of this project is to weave peer-reviewed evidence-based results into a proposal for one single application for SC. The lab manual would bridge the gap between the one directional thinking and the global SC approach. The SC approach should include topics of biomechanics, movement assessments, injury risk reduction, muscle activation, and exercise programming.

The SC field is massive when considering the various sports, sport positions, potential clientele, and the physiological processes involved. Therefore, a SC lab manual is in great need. The intended audience for the proposed SC lab manual are future professionals who are looking to advance their skills in SC or enhancing their professional role by supplementing the knowledge of SC. Professionals who seek to pursue a career in the SC field need to have extensive education and background in exercise science. The ideal consumer of this lab manual are students at a university level continuing their education towards obtaining a bachelor's or master's degree in kinesiology, exercise physiology, biomechanics, SC, and coaching. However, a lab manual should not be limited to those within the undergraduate and graduate academic setting. Dependent on a professional's dedication to continuously educate themselves of current research, a manual could be a tool that would further strengthen the SC professional and client relationship. The global goal would be to better educate SC professionals regardless of their current career setting.

## Significance

As stated previously, this proposal for a lab manual will contain various topics to provide a multi-dimensional approach to the field of SC. Professionals overseeing athletes of various levels should be fully equipped and knowledgeable in the current sport science data. This proposed lab manual will play a vital role for professionals to assist athletes and patients. With it, professionals should have access to the most current exercises and techniques for injury reduction and sports performance enhancement.

## Limitations

The field of SC is continuously evolving. The proposal for a lab manual may not be able to cover all aspects of SC. This project will be the beginning of an opportunity to expand the learning experience of future professionals. Multiple lab manuals will be required to fully educate on the field of SC. Therefore, the focus of this project will be on the mechanics of movement, injury reduction, and exercises for program design.

There will always be conflict between research findings and practical applications. Research findings are meant for generalized results. Research findings may not always translate to a practical setting. For example, practical applications for SC assessments can use the functional movement screen (FMS). The FMS assesses muscular imbalances and potential future injuries. It has been mentioned to use caution when using the FMS. This is due to a possibility of utilizing resources that are not needed such as injury reduction (Bushman, Grier, Canham-Chervak, Anderson, North, & Jones, 2015). However, professionals should be familiar with the FMS to aid in detection potential risk of injuries. This conflict of research findings and practical applications can be common.

Publications are produced at alarming rates dedicated to exercise physiology, SC, biomechanics, sports nutrition, and risk assessments for injury prevention. The potential of overseeing research articles that are currently being published is not plausible. However, efforts are being made to include meta-analysis of concepts that could be embodied in the proposed lab manual. By placing an emphasis on meta-analysis, a general consensus will be collected to review the validity and reliability of tests and measurements used in the field.

There is a need for a lab manual in SC. This project was created with the best efforts of condensing large amounts of research and educational tools into a single source. A limitation to the project was the given time and resources available to create an in-depth search to propose a lab manual. Condensing various platforms of research and educational tools into one single source was a challenge. Future research should continue to expand the premise of including various approaches to SC. Research should be conducted on assessment, lifting mechanic, and muscular imbalance improvements and the effects on athletic performance. This lab manual proposal should be treated as the premise of a larger approach to SC. It should be supplemented with other lab manuals. There may be a need for focusing on specific regions and going into greater depth of connections of research and application. Various teaching approaches for upcoming SC professionals should be considered when creating lab manuals.

## Definition of Terms

*Abduct, abduction:* To bring away the midline of the body. Typically referring to movement of a joint or limb of the body (i.e., abduct the arm = bring the arm away to the body).

*Acetabulofemoral joint*: A joint that is made up of the femur and ischium. This joint is also known as the hip joint. Ligaments and tendons are included in this joint to keep the head of the femur in the acetabulum socket.

Acute: A short duration of time (e.g., exercise is completed in one 15-minute bout)

*Adduct, adduction*: To bring towards the midline of the body. Typically referring to movement of a joint or limb of the body (i.e., adduct the arm = bring the arm closer to the body).

*Aerobic*: Exercise lasting 2 minutes or longer which requires oxygen to synthesize ATP.

*Agonist*: The muscle in which is predominantly involved as the primary mover to allow an action to occur. This is the muscle involved in the concentric movement of an action.

*Anatomical position*: The universal reference point for the positioning of the body. The body is facing the viewer's body. Arms are slightly away from the body (abduction) with palms facing the viewer (supination). Legs are hip width apart with the hips, knees, and toes pointing towards the viewer/forward.

*Antagonist*: The muscle in which is in opposition of the primary mover when an action is occurring. This is the muscle involved in the eccentric movement of an action.

*Anterior*: The front side of the human body when referring to anatomical position. Also known as ventral.

*Bicep femoris*: A muscle that originates from the ischial tuberosity (long head) or the lower half of the linea aspera, and lateral condyloid ridge (short head) and inserts at the head of the fibula and lateral condyle of the tibia. The function of the biceps femoris is to flex the knee, extend the hip, posterior pelvic rotation, external rotation of the knee, and externally rotate the hip (Floyd, 2015, p. 281).

*Biomechanics* :The mechanisms through which the musculoskeletal components interact to create movement (Haff & Triplett, 2016, p. 20).

*Cervical spine*: The upper spine near the neck. The cervical spine has seven vertebrae including five cervical vertebrae, the atlas, and the axis. The cervical spine articulates with the skull and the thoracic spine.

*Cleans*: An Olympic exercise which is a multi-joint movement requiring multiple joints and muscles to be involved with the movement. An example of an Olympic lift is the clean and jerk. An exercise that is known to help develop power.

*Co-activation*: Activation of two muscles at a single recruitment time during an exercise.

*Concentric*: The contraction of a muscle that results in shortening of the muscle. (i.e., in a bicep curl, the weight is brought upward towards the shoulder). Similar to that of flexion.

*Contraction*: The shortening of a muscle. Muscles are activated by being contracted. An exercise occurs because muscles contract to create movement.

*Chronic*: A long-term state in which a disease or condition has been present, condition must be present for longer than six months.

*Eccentric*: The contraction of a muscle that results in lengthening of the muscle (i.e., in a bicep curl, the weight is returned downward to the starting position). Similar to that of extension.

*Energy/fuel substrate I:* Often referred to a nutritional element such as macronutrients (carbohydrates, protein, and fats) that can be converted into glucose, which then can be created into ATP, which is the body's source of energy.

*Energy utilization*: The use of energy or fuel. Energy is needed for muscular contractions and movement.

*Eversion*: Rotation of the ankle to make the lateral side (outside) of the foot closer to the ground than in anatomical (or neutral) position.

*Exercise physiology*: The application of physiological occurrences in relationship to exercise. In this lab manual, the focus of exercise physiology is within the human body.

*Extend, extension*: The change of movement in a joint that increases the joint angle or two body parts.

*Flexed, flexion*: The change of movement in a joint that decreases the joint angle or two body parts.

*Frontal view*: When comparing the front (anterior) and back (posterior) of the body.

*Functional movement screen (FMS)*: A pre-participation screening tool to assess an individual's risk to injury due to the inability of properly moving the body.

*Functional anatomy*: The study of the functional movement when referring to anatomy (muscles and bones predominately).

*Glenohumeral joint*: The shoulder joint that is made up of the humerus and the scapula. The glenohumeral joint can rotate, abduct, and adduct.

*Gluteus medius*: A muscle that originates at the ilium and inserts on the greater trochanter of the femur. The function of the gluteus medius is to abduct and medially rotate the thigh.

*Ground contact time*: The amount of time the foot is in contact with the ground.

*Ground reaction forces*: The force exerted by the ground on a body in contact with it.

*Hamstrings*: A group of muscles consisting of the semitendinosus, bicep femoris, and the semimembranosus. The primary functions of these muscles are to flex the knee, extend the hip, posteriorly rotate the pelvic, internally and externally rotate the hip and knee (Floyd, 2015, p. 281).

*High intensity interval training*: A form of exercise which is in intervals of high workloads and rest periods. The workloads are to be intense, approximately >85% of max workload. The talk test is an indicator of whether one is in a high intense state, if an individual can talk, more than likely the individual is not in the high intensity state.

*Hypertrophy*: The increase in growth, hypertrophy for the terms of this paper is referred to the growth of a muscle or a cycle in a SC program which should promote muscle growth.

*Inversion*: Rotation of the ankle to make the medial side (inside) of the foot closer to the ground than in anatomical (or neutral) position.

*Isokinetic assessment*: Equipment that can determine muscular strength and fatigue factors during an isolated exercise.

*Kyphosis*: Rounding of the thoracic spine creating a “hunch back.”

*Lordosis*: Hyperextension of the lumbar spine. Commonly found with pregnant women.

*Lower extremities*: The lower extremities are composed of the lower appendicular bones. The extremities include the leg (femur), the shin (tibia, fibula, and patella), and the foot.

*Lumbar spine*: The lower back region. The lumbar spine has five vertebrae which articulate with the thoracic spine and the sacrum.

*Macrocycle*: The entire periodized exercise program. The program can be as little as a year to a couple years in length.

*Mesocycle*: A phase of a periodized exercise program. The phase lasts two weeks to several months.

*Microcycle*: A phase of a periodized exercise program. The phase lasts one week.

*Mobility*: The ability to move.

*Muscle activation*: To actively recruit contraction in a muscle during an exercise.

*Muscle recruitment*: The muscles that are required to work during an exercise or movement.

*Muscular fatigue*: A state in which the muscles become weak or tired. This can be due to a decreased amount of energy supply, increased concentration of hydrogen ions, or excessive training on the muscles with little recovery time.

*Muscular imbalances*: To have a comparison of agonist versus antagonist muscle relationship. The ratio would display a set of muscles to be stronger than the opposing muscle (i.e., quadriceps would be stronger than the hamstrings).

*Nordic hamstring*: An exercise that has the individual kneeling on the ground or padded surface. The feet are anchored down with either a coach or equipment. The individual will lower their entire body from the knees to the head closer to the ground. The body is kept in a straight line or neutral spine. The individual can either end the exercise at the ground or pull themselves back up towards the starting position.

*Passive recovery*: A period of time where the body recovers with a lack of activity.

*Patellofemoral joint*: A joint that is made up of the femur, tibia, patella, and fibula. This joint is also known as the knee. Ligaments and tendons are included in this joint to keep the patella tracking with the femur and tibia.

*Pelvic girdle*: Includes the bones that make up the pelvis (ischium, ilium, and pubis). The pelvis girdle includes innominate bones (ossa coxae) only. The ossa coxae are made up from the ischium, ilium, and pubis. The pelvic girdle articulates with the sacrum and coccyx.

*Periodization*: A program which is divided into periods which promote physiological adaptations for athletic performance. Periodization allows for progression within the exercise program.

*Plyometrics*: Exercises which exert maximum forces within a short period of time with phases with concentric, amortization, and eccentric phases.

*Posterior*: The backside of the human body when referring to anatomical position. Also known as dorsal.

*Prehabilitation*: A form of programming which is to promote prevention of injuries prior to onset of an injury. Prehab can be found in performing assistive exercises, corrective exercises, and exercises to improve muscular imbalances.

*Prone*: When an individual lie facing down or facing the table they lie on.

*Protraction*: In reference to the scapula. The scapula is abducting away from the vertebral column.

*Quadriceps*: A group of muscles consisting of the rectus femoris, vastus lateralis, vastus intermedius, and the vastus medialis (internus). The primary function of these muscles are to extend the knee with the rectus femoris also flexing the hip and anteriorly rotating the pelvic.

*Range of motion*: The range of which a joint can move.

*Recovery time*: The time required to have the body recovery to full potential and recovery of energy substrates. This can be seen in interval times (i.e., 30 seconds) or can be seen in relationship to the days of rest when working muscle groups having a minimum of 2-3 days in between large muscle groups.

*Rectus femoris*: A muscle that originates at the anterior inferior iliac spine of the ilium and groove above the acetabulum and inserts superior aspect of the patella and patellar tendon to tibial tuberosity. The function of the muscle is to extend the knee, flex the hip, and anterior pelvic rotation (Floyd, 2015, p. 280).

*Registered dietician*: An individual who possess a license to oversee an individual's nutrition intake.

*Reliability*: A measurement/calculation to the degree of which a concept, theory, application can be depended upon.

*Repetitions (reps)*: The number of times the movement is performed in a set/duration of time.

*Resistance training*: Utilizing weight training as a form of exercise. Applying resistance to the body, the muscles, and the bones.

*Rest-to-work ratio*: The ratio in which the duration of exercise and rest is performed. Typical rest to work ratios would be 1:1 or 1:2, meaning the athlete works for 30 seconds and rests for one minute (1:2 ratio) or rests for 30 seconds (1:1 ratio).

*Retraction*: In reference to the scapula. The scapula is adducting towards the vertebral column.

*Running economy*: Determined by physiological occurrences such as the oxygen consumption and respiratory exchange ratio. This term is the energy demanded for a given velocity of submaxim running (Saunders, Pyne, Telford, & Hawley, 2004).

*Sagittal view*: When viewing the body from the side. This is in reference to anatomical position.

*Sets*: A group of consecutive repetitions.

*Snatch*: An Olympic exercise which is a multi-joint movement requiring multiple joints and muscles to be involved with the movement. An exercise that is known to help develop power.

*Sport specific*: Exercises that support or align with movements found within the sport.

*Strength training*: A form of training to produce strength. This is typically found in the form of resistance or weight training.

*Talocrural joint*: Also known as the ankle joint. This is made up of the talus and calcaneus.

*Thoracic spine*: The middle of the back. There are 12 thoracic vertebrae that makes up the thoracic spine. The thoracic spine articulates with all of the ribs, the cervical spine, and the lumbar spine.

*Valgus*: Adduction of the knee. The patellofemoral joint moves medially or towards the midline of the body.

*Validity*: The state of which the concept, subject, or application is of quality. If an experiment has statistically valid data then the correlations between the variables are very strong. Measures what is intended to measure.

*Varus*: Abduction of the knee. The patellofemoral joint moves laterally or away from the midline of the body.

*Volume*: Number of exercises, sets, and reps performed during a single training session.

# CHAPTER II

# LITERATURE REVIEW

## Introduction

The field of SC is typically viewed as a single direction of athletic performance involving exercise and lifting heavy weights. However, the science of SC is much greater than throwing around iron in a weight room. SC involves, but is not limited to, biomechanics, functional anatomy, exercise physiology, and motor control. A SC coach needs to be well versed in these areas. These topics are well connected in the workings of functional movements especially in athletics. This proposal for a lab manual includes peer review evidence-based results on biomechanics, functional anatomy, and athletic performance. Having knowledge in these subject matters will help future SC professionals so that they may better assist athletes.

## Assessments, Biomechanics, and Injury Prevention

It is necessary that the athlete adheres to periodic assessments and a proper training program in order for athletic performance to be optimal. Preventative measures for injury reduction should be heavily considered when working with athletes. Injury reduction programs are necessary when evaluating programming readiness, sport readiness, and muscle development. Reduction of risk injury is applied in the form of assessments and corrective exercises to help maintain muscular balance.

Training implications are important to factor in when putting an athlete through a SC program. A professional must be aware of the biomechanics one will go through during the exercises prescribed. Athletes face additional risks of injury without proper exercise and lifting techniques. Therefore, it is crucial for the professional to be aware of the participants' lifting forms, sprint, jumping, landing, and changing direction mechanics to ensure each athlete is moving properly. Knowledge of potential risks that lie within each exercise is crucial. Application of powerlifting exercises such as squat, deadlift, and bench press are commonly incorporated into SC programs. The injuries resulted from squat, deadlift, and bench press are found in competitors of sports such as powerlifting, weightlifting, body-building, and CrossFit (Keogh & Winwood, 2017). The squat exercise was associated with 22-32% injuries, bench press associated with 18-46% injuries, and 12-31% to the deadlift exercise from sub-elite to elite lifters (Keogh, Hume, & Pearson, 2006; Strömbäck, Aasa, Gilenstam, & Bergland, 2018). It is important to be aware of the risk of injury rates among exercises. The risk-to-benefit ratio needs to be evaluated when programming exercises for athletes. The physical demands, volume an athlete would be lifting, movements and joints involved, and rest should be taken into consideration (Bengtsson, Berglund, & Aasa, 2018).

SC professionals should be assessing the strengths and weaknesses of athletes. Muscular imbalances, limited range of motion, compromised mobility, and compensation of muscle activation can be detected through running a battery of tests. For example, patellofemoral pain syndrome can be detected with single leg triple hop test in women. Patellofemoral pain syndrome in women may be influenced by stress placed on the patellofemoral joint. Stress can be increased when having greater activity in the bicep femoris and vastus lateralis as well the patterns found in the hip, knee, and ankle with extension movements (Bley, Correa, Reis, Rabelo, Marchetti, & Lucareli, 2014). SC specialists can help reduce patellofemoral pain thereby enhancing movement with recognition of a potential pattern of muscular imbalances.

Movement tests and screens are a tool to detect muscular imbalances and poor mobility or movement mechanics. The FMS is a battery of seven tests that attempt to detect muscular imbalances and immobility in the body. Reported findings have indicated to use caution when implementing the FMS, as using it may lead to unnecessary time and testing for athletes who do not require any biomechanical or motor pattern corrections (Bushman et al., 2015). However, this screening can be used as a baseline in which professionals can identify muscular imbalances. Utilizing an array of tests can be beneficial as detections of muscular weakness can be absent in some movements compared to others. For example, an athlete may show gluteus medius strength when testing the isolated muscle with a resistance test. Further investigation is needed on the glutes if an athlete performs a drop landing and valgus movement occurs in the knee. Assuming results of one test stand for all tests can be a disservice to the athlete.

Injury prevention is a large portion of a SC program. It would be advantageous for a strength coach to begin with the functional movement screen and detect possible risk of injury and limited range of mobility. Coaches should then follow up with more specific assessments and progress towards sport-specific tests. These results can then influence the programming of planned exercises and periodization of phases for the macrocycle.

An array of tests and movement screens can be performed, dependent on the sport, athlete, and prescribed exercises. Information provided in this lab manual proposal is both specific and nonspecific towards particular sports. However, the greater understanding of this information can be applicable across all sports and movements.

## Spine

### Functional Anatomy

The spine has five distinct regions: cervical, thoracic, lumbar, sacral, and coccyx. The cervical spine can flex and extend 45°, rotate 60°, and laterally flex 45°. The thoracic spine is limited in its mobility due to the anatomical structure of the ribs. Therefore, the lumbar spine does the majority of the movements in the spine. The lumbar spine can flex up to 80°, extend 20-30°, rotate 45°, and laterally flex 35° (Floyd, 2015). The degrees of movement and mobility are crucial in assessing the biomechanics of lifts and movements. Most injuries commonly occur in the L4, L5, and S1 (lumbar = L, S = sacral). Olympic and power lifts can be dangerous with high volume and loading. Therefore, professionals should always address mechanics of the lift to reduce the risk of injury.

### Rates of Injury

Weightlifting, including power and Olympic lifts, puts high demands and stress on the body. Additional stress is put on the body when larger volumes of weight are being lifted. Olympic lifts, such as the snatch, require large range of motions in order to successfully complete the lift. These demands may be related to injuries that occur in these sports and trainings. Having poor technique and limited amount of rest can increase that rate of injury (Bengtsson et al., 2018). The lumbar spine is reported to be the region of highest frequency for injury. Injury to the low back was reported the second highest frequency of injury among powerlifters and highest injury frequency in weightlifters (Aasa, Svartholm, Andersson, & Berglund, 2016). Injuries to the vertebral column are not uncommon. Reports show that injuries in the cervical spine account of 55%, thoracic spine 33%, and lumbar spine 68% (Jonasson, Halldin, Karlsson, Thoreson, Hvannberg, Sward, & Baranto, 2011). SC specialists should focus on loading volumes, mechanics, rest periods, and mobility due to the high prevalence of spinal injury reports.

Assessments

Postural assessments should be done prior to any movement. Points of contact to be assessed are the cervical spine, positioning of glenohumeral joints, thoracic spine, lumbar spine, and positioning of the posterior superior iliac spines. Strength coaches should ask the athletes to stand in normal stance as well as athletic stance for assessments. Theoretically, a line could be drawn through the ear, glenohumeral joint, the acetabulofemoral joint, patellofemoral, and talocrural joint. There should not be any rounding of the glenohumeral joints, anteriorly or posteriorly. The glenohumeral joints should also be linear and parallel to the ground. Excessive rounding, an increased flexion, in the thoracic spine is called kyphosis. The cervical spine typically will have hyperflexion with the presence of kyphosis. Extreme rounding upward, or hyperextension, of the lumbar spine indicates lordosis. Lordosis is also known as anterior pelvic tilt. There is also greater flexion of the acetabulofemoral joints, tilting the anterior superior iliac spine forward. A posterior pelvic tilt is excessive rounding downward of the lumbar spine. Extension of the acetabulofemoral joint and concentric contraction of hamstrings occur with a posterior pelvic tilt. The positioning of the posterior superior iliac spine should be linear and parallel to the ground. Possible muscular imbalances and previous injuries may be present should there be a "hike" of one of the posterior superior iliac spines. Performing static posture assessment and athletic assessment can give the first indications of possible muscular weaknesses and immobile joints and regions.

The overhead squat or deep squat test in the functional movement screening tests thoracic spine mobility in conjunction with mobility of the hips, knees, ankles, and shoulders (Cook, 2001). The athlete will compensate in form to position the body in an overhead squat if there is limited mobility in the thoracic spine or other regions mentioned. One indicator of lack of thoracic mobility is the direction in which the torso is positioned. The torso can drift parallel to the ground with thoracic immobility. This test will not only help assess the mobility of the thoracic but also the cervical and lumbar spine. Athletes should be able to flex the cervical spine anteriorly when positioned in the deep squat. If there is a lack of ability to "poke the head through" then cervical spine immobility is present. Assessment of the lumbar spine in the deep squat would indicate if there is lordosis.

Assessments can be done throughout the mesocycles. Coaches can continuously assess movements when an athlete performs a lift. For example, the Olympic lift snatch mechanics can occasionally be altered due to the large volume of weight being lifted. The athlete should move in a linear plane as he or she passes the knees and extends into triple extension. In triple extension the athlete should be perpendicular to the ground. However, hyperextension in the lumbar spine is commonly seen into triple extension. Assessing the mechanics of the movement will allow the coach to monitor the risk of injury for an athlete. Performing a lift properly will not only decrease the risk of injury but also increase athletic performance. Coaches should pay close attention to movements of high-risk lifts such as the Olympic and power lifts as well as corrective and assistive exercises.

## Knee

### Functional Anatomy

The knee is made up of the femur, tibia, fibula, and patella. There are three major ligaments that hold the knee joint together: the anterior cruciate ligament (ACL), the medial cruciate ligament (MCL), and the posterior cruciate ligament (PCL). The knee joint can flex up to 150°, extend 180°, internally rotate 30° and externally rotate 45° if the knee is flexed 30° (Floyd, 2015). The knee is between the two longest levers in the body. The knee is at an increased risk of injury due to the anatomical structure, collisions, and movements such as cutting, change of direction, and jumping/landing.

### Valgus and Varus Movements

Two movements that indicate improper movements in the knee are valgus and varus movements. Valgus movement is when the knees adduct towards the midline of the body. Internal rotation of the acetabulofemoral joint and inversion of the talocrural joint tends to occur simultaneously with the valgus movement. Gluteus medius weakness is commonly found with valgus movement along with greater risk of ACL tears. Varus movement in the knees is when the knees abduct away from the midline of the body. External rotation of the acetabulofemoral joint and eversion of the talocrural joint commonly occur with the varus movement. Varus movement can be associated with tight hip flexors causing restricted movements such as flexion of the acetabulofemoral joints.

Rates of Injury

ACL injuries occur more than 120,000 times annually (Gornitzky, Lott, Yellin, Fabricant, Lawrence, & Ganley, 2015). Most of these injuries result in surgery which is followed up with physical therapy or rehabilitation (Paterno, 2015). Females have a greater risk of ACL tears due to their anatomical features. The pelvic girdle of the female body tends to be wider than males for childbearing purposes. This greater pelvic girdle also increases the “Q angle.” The Q angle is the angle between two lines drawn from anatomical features on the body. The first line starts at the anterior superior iliac spine (ASIS) of the pelvic girdle. The line continues to the midline of the patella. A second line is drawn from the center of the tibial tuberosity to the center of the patella. The intersection of these two lines produces the Q angle. A normal Q angle for males is less than or equal to 15°. Yet for a female, a normal Q angle is less than or equal to 20°. Q angles greater than 20° are known to predispose people with knee problems (Floyd, 2015).

Females have a greater risk of injury to the ACL compared to their male counterparts. The ACL in females is smaller due to the “V” shape space in between the intercondylar notches. Males have a “U” shape space and therefore has more room for the

ACL to be larger. In combination with the smaller ACL and the greater Q angle, females have a greater risk of ACL injuries than males.

Assessments

Assessments of the functional anatomy need to be performed by SC coaches. Movement screens can possibly detect muscular weaknesses that can impact knee movements. Performing a series of jump tests can help detect possible gluteus medius weakness and knee valgus movements. Taking still photos or videos of an athlete jumping and landing can improve the visual detection of improper movements. The athlete can jump with both feet as well as single foot. Photos should be taken during the preparatory phase of the jump, take off, and the landing phase. These images can inform a coach of inversion/eversion of the talocrural joint, valgus or varus of the knee joint, as well as abduction/adduction/rotation of the acetabulofemoral joint. Alterations in these joints can then affect the positioning of the spine and glenohumeral joints. A test of this sort can help pinpoint weak muscles for known associations: weak glute medius and valgus movement (Ford, Nguyen, Dischiavi, Hegedus, Zuk, & Taylor, 2015). To detect hip muscle dysfunction, coaches can incorporate the single-leg squat task into assessments and programming to detect valgus movement and hip muscle dysfunction (Crossley, Zhang, Schache, Bryant, & Cowman, 2011; Kianifar, Lee, Raina, & Kulic, 2017).

Conducting these assessments can be initially done with the naked eye. However, still images and videotaping can serve a purpose when reviewing the degree of movements between the joints. Still photos and video taping allow coaches to slowly watch the mechanics that occur during the tests. These images should be done in the frontal and sagittal view. Additionally, two-dimensional measurements of the positioning of joints can add reliability to the test (Rabin, Einstein, & Kozol, 2018).

Interventions/Exercises—Muscle Activation

There are various ways of implementation techniques to provide athletes with feedback to change mechanics. As mentioned previously, training weak muscles is helpful in aiding mechanical changes. Additionally, coaches can videotape or take still images as visual feedback. Providing a source for individuals to see what is being done improperly can enhance the learning of the athlete. Verbal instructions during an exercise is an additional technique that can be used. Coaches can use verbal augmented feedback during exercises in rehabilitative forms to help improve biomechanics of the lower extremities (Storberget, Grodahl, Snodgrass, Vliet, & Heneghan, 2017).

The gluteus muscles can be a key part in healthy knee movements. Weak gluteus muscles (specifically the gluteus medius) are known to influence knee valgus movements. The functions of the gluteus medius is to extend, internally rotate, and abduct the acetabulofemoral joint. The gluteus maximus functions are to extend and externally rotate the acetabulofemoral joint. Strengthening these gluteus muscles are a critical part knee rehabilitation. More specifically, pain reduction and increase functional use will occur if patients with patellofemoral pain strengthen the hip abductor muscles (Rogan, Haehni, Luijckx, Dealer, Reuteler, & Taeymans, 2018).

Exercises that focus on strengthening hip abductor muscles are barbell hip thrusts, monster walks, clam shell exercises, resistance bands, single leg deadlift, and much more. The barbell hip thrust is an exercise that should be highly considered for implementing into SC programs. The barbell hip thrust is an exercise that can be used as an assistive exercise to core lifts or a key integral piece to the program. The exercise activates the gluteus maximus, gluteus medius, bicep femoris, semitendinosus, rectus femoris, vastus lateralis, vastus medialis, and erector spinae. The barbell hip thrust recruited the largest amount of maximal voluntary isometric contraction (MVIC) of the gluteus maximus (Neto, Vieira, & Gama, 2019). It has been demonstrated that the gluteus maximus is able to produce a force greater than 100% MVIC while performing the barbell hip thrust exercise. The vastus lateralis produced a MVIC greater than 90%, the erector spinae an MVIC greater than 80%, and bicep femoris greater than 80% (Neto et al.). The barbell hip thrust is highly recommended for strengthening the gluteus maximus, erector spinae, biceps femoris, and vastus lateralis. The SC coach should focus on retraining sport-specific movements once strengthening the gluteus muscles.

## Hamstring

### Functional Anatomy

The hamstrings are a group of muscles located in the posterior chain of the upper leg. The group of muscles are composed of three muscles: bicep femoris, semimembranosus, and semitendinosus. The hamstrings are the antagonist muscles to the quadriceps. The quadriceps are the anterior group of muscles in the upper leg. The quadriceps are composed of the rectus femoris, vastus medialis, vastus intermedius, and vastus lateralis. Together the quadriceps and hamstrings allow the body to run, jump, and perform lift techniques like the squat and deadlift. The hamstrings are typically at a greater disadvantage with strength in comparison to the quadriceps. Given the anatomical nature, hamstrings have three muscles compared to the quadriceps which include four muscles. Due to biomechanical differences, hamstrings are at a greater risk of injury compared to the quadriceps. Additionally, the anterior cruciate ligament (ACL) can be at risk if the hamstrings are weak. Therefore, hamstring strength is a crucial part to healthy sport specific movements and injury reduction.

Assessments

Involving exercises and prevention programs focusing on the hamstrings can be beneficial for individuals and teams. Incorporating an isokinetic assessment and testing on muscular imbalances between quadriceps and hamstrings can be detected. The risk of hamstring injury increased with those athletes who have strength imbalances between the quadriceps and hamstrings. The rate of hamstring injury was reduced by implementing a concentric and eccentric isokinetic assessment and testing with soccer teams (Croisier, Ganteaume, Binet, Genty, & Ferret, 2008).

Facilities may not have the resources to implement isokinetic training. Isokinetic assessments are costly and require specialized training to administer. Therefore, assessments for hamstring strain may need reconsideration towards more practical and accessible equipment (Green, Bourne, & Pizzari, 2018). A manual test can be administered if a facility lacks the resources for isokinetic training. The athlete can lie in a prone position on a stable surface. The knee should be flexed to a 90° angle. A coach applies pressure to the anterior surface of the anterior tibial crest region while the athlete should resist the applied pressure of the SC coach. A coach is to apply pressure against the concentric contraction of the hamstrings during hip extension. The knee will begin to extend if the athlete has weakness in the hamstrings. The greater the extension, the weaker the hamstring muscles are. The goal of the athlete is to resist as much applied pressure as possible, keeping the knee flexed.

Intervention/Exercises —Muscle Activation

An exercise that can aid in detection of quadricep to hamstring muscular imbalances is the use of the Nordic hamstring test. The Nordic hamstring is an exercise that greatly activates the hamstring muscles. Incorporating hamstring exercises, such as the Nordic hamstring curl, can help balance the quadricep to hamstring strength ratio. Ultimately this can reduce risk of injury in the hamstrings. Soccer players tend to be at an elevated risk of hamstring injury due to rapid changes of direction, length of exercise, and collision factors. It has been demonstrated that hamstring injuries were reduced by 51% for soccer teams that incorporated the Nordic hamstring exercise into their injury prevention program (Attar, Soomro, Sinclair, Pappas, & Sanders, 2017). Therefore, Attar, Soomro, Sinclair, Pappas, and Sanders (2017) concluded the Nordic hamstring exercises would be a viable exercise to mitigate the risk of injuring the hamstring in soccer athletes.

## Athletic Performance and Biomechanics

Assessing the athlete's biomechanics can play a vital part in efficiency of movements which impact the overall energy utilization, fatigue rates, speed, and ultimately athletic performance. Biomechanics is an important factor to consider in athletic performance. The biomechanics of how the athlete is running at the beginning and at the end of the race may expose poor running economy. Movements such as shorter or longer strides, rounded shoulders and lack of posture, as well as a multitude of other mechanical errors may be present. These crucial errors can alter muscle recruitment. Increased muscular fatigue can negatively influence their final race time and effect their position in the standings. Professionals can help well-trained runners reduce the oxygen cost. By assisting with greater knee stiffness during ground contact, greater co-activation between the rectus femoris and biceps femoris occurs. This can have results of shorter ground contact times and a higher stride frequency (Tam, Santos-Concejero, Tucker, & Lamberts, 2017).

## Conclusion

Biomechanics is an important component of athletic performance. Lack of mobility, range of motion, and muscular imbalances are deterrents in the success of athletes. Coaches can help reduce the risk of injury and increase the quality of play for an athlete. The manual should have assessments that will help highlight poor biomechanics within jumping, landing, change of direction, and movement screenings. The assessments are created from peer-reviewed research-based experiments. These assessments should be tested the efficacy and validity of the tests. These tests will help reduce the risk of injury and inefficient movements.

This proposal for a lab manual includes various training regimes to facilitate opportunities for optimal training scenarios and athletic performance. The lab manual should cover muscle activation, assessments, and movement screens. With an educational tool, coaches can be well equipped with the knowledge necessary for the best practices in SC.

Ultimately there are various components to be considered when working with athletes of any level. A SC coach should take a close look at the athlete’s movement patterns, biomechanics, assess muscular imbalances, and injury risk. Athlete's movements influence how efficient and inefficient an athlete is performing. SC coaches can promote healthier athletic performance and decrease the risk of injury.

The success of the athlete can be determined by the knowledge of the coach. With a multilayered approach, a SC coach can have a high impact on the influence of the athlete's performance. Therefore, the coach should be well versed in multiple subject matters, biomechanics, exercise physiology, muscle activation, and functional anatomy, as each topic integrates together for the inner workings of athletic function.

# CHAPTER III

# METHODOLOGY

## Research Databases

The materials used for this lab manual proposal are predominantly from published peer-reviewed research-based articles. The CSUC Library Advanced Search was used as the initial search engine to collect information for the proposed lab manual. Google Scholar was also used for general searches on topics. The search was redirected to journals such as *PubMed, SportDiscus, Journal of Strength & Conditioning, British Journal of Sports Medicine, American Journal of Sports Medicine*, *Frontiers in Physiology, Journal of Science and Medicine in Sport,* and *Journal of Athletic Training*. When researching peer-reviewed articles, the filter for date of publication was set from 2017-2019 for a number of research articles. Many of the searches focused on meta-analysis or synthesis of the previous findings for particular topics. This search approach has allowed the validity and reliability, or lack of, on previous methods for SC to be surfaced.

The key phrases used with these research databases were different combinations of the following terms: injury prevention; assessments; strength training; muscle activation; athletic performance; muscle adaptations; resistance training; concentric: isometric; muscle physiology; strength and conditioning; Olympic lifting; biomechanics; programming; meta-analysis; Nordic hamstring; injury risk reduction; preventative;

athletics; assessments; rehabilitation; running economy; gluteus maximus; gluteus medius; hip thrusts; hamstring rehabilitation; injury rates.

In addition, to the research databases, *Essentials of Strength Training and Conditioning* (2016) and *Manual of Structural Kinesiology* (2015) have contributed content to this SC lab manual proposal.

## Proposed Lab Manual Design

The lab manual should be designed to assist professionals in the SC field. Careful consideration of the design and structure for a lab manual should be taken. Chapters on assessments, mobility and stability limitations, injury reduction, exercises and muscle activation rates, coaching cues for weightlifting exercises, power lifts, and assistive/corrective exercises should be included. Each of these chapters should have descriptive directions on how to properly complete the exercises. The directions should be written in terminology used in the field and functional anatomical verbiage. Cues for proper mechanics would be prompted throughout the manual. Additionally, commonly seen mistakes should be highlighted.

The lab manual should include assignments that force the future coach to analyze lifting techniques. The assignments should include a series of questions to prompt the cognitive learning aspect. The author(s) of the lab manual should consider including questions that probe the coach to analyze movements, determine what is not working, and the why behind those decisions. These questions may force future professionals to seriously consider optimization of movements. This learn-by-doing approach gives responsibility to the future professional to be experts on proper mechanics and functional anatomy.

The lab manual should be set up in a clear, easy-to-follow structure. There should be distinctive chapters such as lifting techniques and assessments. References to additional pages may be necessary to encompass a global approach. For example, an indication of gluteus medius weakness refers to the corrective exercises chapter. This manual assists the student in assessment of what exercises to include in programming with a focus of strengthening the gluteus medius.

Overall, the design of the manual should be to aid the student and future professional in the learning process of becoming a SC coach. With the inclusion of coaching techniques and cues, lab assignments, and reflective questions, the student will be well-equipped to begin pursuing a SC career. The lab manual should prepare the student to embark on their SC career.

# CHAPTER IV

# CONCLUSIONS AND RECOMMENDATIONS

## Conclusions

This research project hoped to identify areas of weakness within the SC field. The SC field should be approached as a multifaceted occupation. The lab manual proposal was created to enhance the need for a SC tool. It should aid professionals in the SC field and athletes who compete in collegiate and professional sports. The purpose of creating this proposal document is to improve the sports performance capabilities among athletes. The information provided in the proposed lab manual should guides SC professionals through injury risk assessments, lifting techniques, sport specific movements, and corrective exercises. The resources made available will improve the approach of creating exercise programs for athletes.

## Recommendations

I recommend that a lab manual be created as a user friendly tool with the consumer in mind (predominately students). The lab manual can be used as a learning source for not only students but coaches, assistant coaches, and even athletes themselves. I suggest that SC professionals (future and current) use a lab manual as a general approach to their professional practice. All materials for every sport were not covered in this proposal due to the numerous sports offered at the collegiate and professional levels.

However, the material is general enough to cover multiple sports and sport-specific movements. SC professionals should use a lab manual to begin their development and enhancement of a multifaceted approach to coaching. Coaches should implement general assessments and exercises, as described in this proposal, as a baseline approach when working with their athletes. Research into this proposed lab manual should be utilized for the creation of future lab manuals. The research that supported this proposal encompassed a global approach to SC and can aid programming for new and returning athletes. The program needs to begin with assessments in movement and mobility. Corrective exercises should be assigned to athletes after recognition of the individual's mobility and stability limitations. Exercises and lifting mechanics should only advance when athletes are moving properly. Reassessments should be performed frequently to assure that athletes are continuously moving with full potential. There are various methods of putting together a lab manual, let alone one that includes a multifaceted approach. However, the connections between one chapter and another should be seamless. The lab manual should be written with the approach of a coach to be guided from intake of an athlete to taking assessments, analyzing results, administering exercises for risk reduction, to implementing programming (Appendix A illustrates an example of the proposed lab manual).The lab manual should provide coaches the tools to follow this progressive thinking and further embellish further upon the manual to craft their own techniques. The field of SC has the potential to advance by having a general baseline of applied knowledge and responsibility. The new expectations would cover coaching cues, mobility and stability assessments, and proper functional movement.

Researchers should pursue future research and lab manuals with the global strength conditioning approach. Studies should focus on the implications of assessments and corrective exercises on athletic performance. Researchers should incorporate findings from peer-reviewed, evidence-based research studies within the recent years of proposed publication. Areas to be taken into consideration for future lab manuals are athletic training, physical therapy, strength and conditioning, exercise physiology, biomechanics, sport psychology, and functional anatomy. Multiple lab manuals will have to be created in order to cover all topics that fall under the umbrella of SC.

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APPENDIX A

# SAMPLE OF PROPOSED LAB MANUAL

The manual should have assessments, corrective exercises for poor mechanics, and proper lifting techniques to follow. The example given is the progression of testing & resources for gluteus medius weakness. The following pages include an example of the format for the proposed lab manual. Within the format are sections which are labeled (A – I). After all examples have been given, sequential comments and suggestions are included for those sections indicated.

A

## SINGLE LEG SQUAT

The feet should be positioned as if the individual is ready to perform a vertical jump. Feet should be approximately hip width apart. Have the athlete lift one leg off the ground either as flexion or extension of the acetabulofemoral joint.

Direct the athlete to engage in a single leg squat to their best capability. Have the athlete perform the squat to approximately 20-30 degree bend. Be sure to switch sides. Look for the following markers of a single leg squat:

### MARKERS TO LOOK FOR:

- Toes or heels lifting,
- Feet moving medially or laterally,
- The knees internally rotating,
- The knee tracks beyond the toes,
- Abduction at the acetabulofemoral joint,
- Chest facing the ground,
- Or rounding of the back at any region.

### TESTING FOR:

B

- Glute Medius weakness or dysfunction
- Other Tests:
  - Glute medius test (pg. #)
  - Jump test (unilateral & bilateral) (pg. #)


## CORRECTIVE EXERCISES FOR DETECTION OF POOR SINGLE LEG SQUAT

C

EXERCISES
- Bridges
- Hip Thrusts
- Monster Walks
- Lateral Walks

MOBILITY
- Spine -lumbar/thoracic
- Talocrural joint
- Patellofemoral joint
- Acetabulofemoral joint

D.

Crossley, K. M., Zhang, W.-J., Schache, A. G., Bryant, A., & Cowman, S. M. (2011). Performance on the single-leg squat task indicates hip abductor muscle function. The American Journal of Sports Medicine, 39(4) doi:10.1177/0363546510395456

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CORRECTIVE EXERCISES - BARBELL HIP THRUSTS

E.

## HIP THRUSTS - POSITIONING

Have athlete sit on the ground while leaning on a bench. The mid thoracic spine should be placed on the bench. The cervical spine will be flexed, tucking the chin into the chest. This will help keep the spine in neutral positioning throughout the exercise. If necessary place a pad around the barbell for comfort as the barbell will be near the anterior superior iliac crest of the pelvic bones.

The barbell will be rolled over the athletes legs towards the pelvic region. The athlete will have neutral talocrural joint positioning with flexion of the patellofemoral joints, causing greater flexion of the acetabulofemoral joints. The talocrural joints will be directly inferior to the patellofemoral joints when in an upward phase.

## UPWARD PHASE

The athlete will extend the acetabulofemoral joints, concentrically activating the gluteus and hamstring muscles. The torso being perpendicular to the ground and with movement will shift the torso to be parallel to the ground. When extending the acetabulofemoral joints, the positioning from the patellofemoral joints to the cervical spine will be neutral and in a straight line. Be sure to avoid hyperextension of the lumbar spine.

## DOWNWARD PHASE

The athlete will begin to flex the acetabulofemoral joints, controlling the eccentric contractions of the gluteus and hamstring muscles. The downward phase will bring the athlete back to a sitting position either fully sitting on the ground or for an increase level of difficulty, slightly raised off of the ground for the full set.

Starting Hip Thrust Position

End of Upward Phase Hip Thrust

CORRECTIVE EXERCISES - COMMON MISTAKES LOWER

## COMMON MISTAKES TO BE AWARE OF - HIP THRUSTS & BRIDGES

F

- Hyperextension of the lumbar spine
- Talocrural joint does not line up underneath the patellofemoral joint.
- Chin is not tucked in.
- Neutral spine is not kept.
- The back support is too high or too low.

LIFTING TECHNIQUES - CLEANS

G.

## 1ST PULL TO CLEAN CATCH

Have the dowel start at the talocrural joint or on the floor. Pull slowly to position two with keeping the bar close to the body. Simultaneously extend the patellofemoral and acetabulofemoral joints. Once getting to the second position the bar/dowel should move quickly. Keep the bar close to the quadriceps as the body extends into triple extension. As the body progresses into triple extension the hips will be driving the bar vertically requiring minor recruitment from the upper body. When catching the bar in the front squat position, the depth of the catch will vary dependent on the load of the weight lifted. Have the athlete hold the catch position until stable. Then the athlete will extend the acetabulofemoral and patellofemoral joints into a standing position.

H



LIFTING TECHNIQUES - CLEAN & JERK

## COMMON MISTAKES TO BE AWARE OF

- The bar travels too far away from the body.
- The individual uses all upper body to move the bar and does not incorporate the hips into the movement.
- The individual will bounce the bar off of position 3 region. This causes the bar to swing away from the body.
- The individual does not get into full triple extension.
- The individual will not have loud feet when in catch position.
- The start position will have the acetabulofemoral and patellofemoral joints linear to each other.
- The back leg will be directly extended posterior to the body in the jerk position.
- The front leg will be underneath the body, limiting the flexion of the acetabulofemoral joint in the jerk position.
- The athlete will reset their back leg first in the jerk position to finished position.

I

# SEQUENTIAL COMMENTS & SUGGESTIONS

*A.* Assessments should include how to conduct the test properly. It should also include what physical cues the coach should be looking for to indicate good or poor mechanics of the test

*B.* Indications of what the assessments are testing for should be included. Additional tests should also be provided to run multiple tests for confirmation of results.

*C*. The manual should have corrective exercises & stretches that can be administered with detection of poor mechanics, weak muscles, or limited range of mobility.

*D*. References should be included in the lab manual where appropriate. This is to help support the *why* behind administering exercises.

*E*. Corrective exercises should have descriptions on how to safely and properly perform the exercises. Authors should consider including research such as muscle involved and maximum voluntary isometric contraction (MVIC) percentages of the muscles. This can assist in coaches when deciding which exercises to include in programs and similar exercises for periodization purposes.

*F*. Common mistakes should be included highlighted for coaches to be aware of. Authors of a lab manual should consider including examples of effective verbal coaching cues to be given when seeing poor mechanics.

*G.* Authors should include the emphasis that athletes who are demonstrating poor mechanics, limited range of mobility and stability, or any muscle weakness should not progress to lifts that will increase their risk of injury. Authors should also consider highlighting the use of progression with lifts such as starting with a dowel, light weight, partial range of motion, and to program only towards the athlete's capabilities and limitations.

*H*. The lab manual should have a step by step progression of how to properly teach the lifts. Terminology in both functional anatomy and strength and conditioning language should be used.

*I.* Common mistakes should be highlighted in the lab manual. Authors should consider including reasonings for the mistakes or faults during lifts.