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Changes in FMS™ Scores in a NCAA Division 1 Men's Collegiate Golf Team

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Changes in FMS™ Scores in a NCAA Division 1 Men's Collegiate Golf Team

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APPROVAL PAGE

Master of Science Thesis

Changes in FMS™ Scores in a NCAA Division 1 Men's Collegiate Golf Team

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Chapter 2: Literature Review

Needs Analysis and Strength and Conditioning Recommendations for Golfers

Introduction

Golf is a sport played across the world by different ages and skill levels. According to the US Censes Department there are 29,000,000 people participating in golf throughout the United States as of 2012. Golf has been known as a sport comprised of skill, precision and accuracy (1). The golf swing itself is a highly complex skill that requires strength, power, flexibility and balance (22, 35, 51). As a result of these characteristics, physical training and fitness is becoming a crucial component of a golfers regimen at various levels.

For years, golfers have neglected an effective workout with the thought that they would reduce their range of movement and in turn decrease their performance (59). Wells and colleagues conducted a study that shows otherwise. Their results show significant associations between peripheral muscle tests, driver results, 5-iron ball measures, score and putting efficacy. This is suggesting an association between golf performance and core strength, stability, flexibility, balance and peripheral muscle strength. This ultimately illustrates that a training program that focuses on these areas may not decrease performance as commonly thought (57). Doan and colleagues also aimed to show the positive impact that a golf-conditioning program would have on golf performance. The study investigated the effects of a program on parameters such as club head speed, consistency and putting distance control. The program took place over 11 weeks with performance tests conducted before and after the duration of the period. Results showed an increase in club head speed by 1.6%, which increased driving distance by approximately 4.9-m. The improvement of club head speed allows the golfers to add approximately 5.3 yards onto their distance. As well as club head speed, the performance tests showed increases in strength, power and flexibility from the pre-test to the post-test. Strength,

power and flexibility increased an average of 12.6% after the training period was complete (15). Both studies show significant increases in several important aspects of golf. Current findings and research can dispute the common thought that working out will decrease a golfers performance (59). Current physiological profiles show that highly skilled golfers have superior physical fitness characteristics. These characteristics, such as hip, core and shoulder strength, elbow stability and spinal range of motion impact the golfers ability to produce the highly coordinated swing movement and produce force (26, 29, 51). These characteristics allow golfers to produce higher club head speeds, which will in turn produce longer, more accurate shots. To improve on these areas it is important to follow a strength and conditioning program that is created to improve strength, power, flexibility, and balance. Focusing on these areas while refining skill can be beneficial for the collegiate golfer.

Many studies use traditional strength and conditioning programs but recently Functional Movement Screening (FMS)[™] has become a popular and effective component in determining risk of injury as well as characteristics related to performance (9, 31, 32, 37, 55). Gray Cook and Lee Burton created the functional movement screen to assess several fundamental movements throughout the body (12, 13). FMS[™] allows strength and conditioning professionals to pinpoint weaknesses and create a corrective program to improve those areas. The FMS[™] screen is comprised of 7 different fundamental movement patterns. The patterns are deep squat, hurdle step, inline-lunge, shoulder mobility, active straight leg raise, stability push up, and rotary stability. Each category tests a certain movement to identify any asymmetries or weaknesses (12, 13). Research shows that FMS[™] is beneficial in decreasing the risk of injury (9, 31, 32, 37) as well as improving factors such as club head speed in older adults (55).

Golf is a physically demanding sport using highly coordinated skills (35, 51)

A golfer partaking in a strength and conditioning program may see increases in several aspects such as accuracy, driving distance, and club head speed (2, 15, 19, 35, 36, 59). Combining FMS™ screens with a strength and conditioning program may reduce the risk of injury as well as increase functional movement (9, 31, 32, 37). In order to create a beneficial program, the sport of golf must be broken down by the needs analysis and the five acute program variables. Once the sport and athlete is assessed the next step is to complete a baseline FMS™. From each athlete's scores an individualized component can be created and implemented along side a strength program. This will maximize an athletes potential and improve overall performance on and off the course.

Needs Analysis

As research suggests, a golf specific training program will improve overall performance. In order to optimize a strength and conditioning program it is important to conduct a needs analysis of the sport. The needs analysis will depend on several different factors such as current training status, weaknesses, and goals. Training goals should be individually developed to make certain that proper progression occurs for the athlete. Once the training goals are set the needs analysis will be completed to further analyze the metabolic demands. The needs analysis is broken in three different categories of a movement analysis, physiological analysis and injury analysis (3).

Movement Analysis

The movement analysis will assess the limb and muscular involvement during a golf swing. A golf swing is a rotational movement that occurs within the transverse plane. This means that it is important to not only train core movements but also rotational movements of the upper and lower body. The golf swing requires several different muscles throughout the body to create

a coordinated sequence of muscle activation. Essentially, the entire body is used during a golf swing to generate enough power to accurately hit a target that may be hundreds of yards away. A study conducted by McHardy and Pollard aimed to examine muscle activity during different phases of a golf swing. Each phase holds different muscle requirements and the phases are as follows; back swing, forward swing, acceleration, early follow through and late follow through. For example, during the back swing their study found that the upper trapezius was the dominant muscle. While the pectoralis major was responsible for 93% of the acceleration phase and 74% of the early follow through phase. The lower body/trunk muscles are activated during each of the phases as well. During the forward swing the upper and lower gluteus muscles are activated 100% and 98% respectively (40). Since certain muscles are used for specific movements it is important to train those muscles throughout a similar range of motion. Some studies use a general strength protocol (15, 58, 59). These protocols allow for neuromuscular adaptations as well as increases in strength and golf specific improvements (15, 58, 59). However, to break through to the next level and continue to improve the proper strength program should contain heavy lifting, power exercises, flexibility, and injury prevention (2, 19).

Physiological Analysis

The physiological analysis examines how the body responds to the stresses of a sport and how the body maintains efficiency during the exercise bouts. More specifically the physiological analysis evaluates which metabolic pathways will be used and at what point during the exercise. Golf is comprised of short, quick, powerful swings that total an average of 1.21 ± 0.14 seconds for PGA Tour players (7). It takes approximately 4 hours to complete a round of golf (17) and a golfer who chooses to walk will walk approximately 4.4 miles (48). The metabolic pathways within the body are utilized during different movements and durations. Golf is a unique sport.

Golfers repeat a movement that requires a quick burst of energy for a long period of time. This utilizes the ATP-Pc energy system. The ATP-Pc system is used for up to 10-12 seconds before it is depleted. As stated before Burden, Grimshaw, and Wallace analyzed the swings of 8 golfers with a handicap of 7 ± 1 . They found that the total swing time was $(1.21 \pm 0.14 \text{ s})$ (7), which is in fact slower than the average tour players swing time of (1.09 s) analyzed by McTeigue et al. (1994) (42). Regardless of the skill level of the player, it is found that the golf swing is a quick, powerful burst. To complete the golf swing the ATP-Pc system is engaged fully. Once the swing is completed there will be a varying amount of rest before another swing is taken. This repetition will continue for 4-5 hours (17). The glycolytic system is used as fuel for energy in between each swing. The intensity and energy expenditure in golf varies if the golfer is walking, has a caddy, uses a single strap golf bag, a double strap bag or riding in a cart. Oxygen consumption, heart rate and rate of perceived exertion are significantly higher when using a single strap bag as opposed to a double strap bag (27). However, regardless the means of transportation around the course both the ATP-Pc system and glycolytic system are activated. Since the ATP-Pc and glycolytic pathways are the dominant pathways it is important to train them off the course so they are used at the highest potential on the course.

Injury Analysis

Golf is a sport that focuses on repetition and muscle memory. This is a crucial part of the last section of the needs analysis. Every sport must be analyzed for an injury assessment. According to the American Orthopedic Society for Sports Medicine the average golfer plays an estimated 37 rounds per year, with many hours of practice. Due to the repetitive nature of golf many overuse injuries are seen. A study conducted by Gosheger and colleagues aimed to examine the musculoskeletal injuries that occur in golfers of different skill levels. 703 randomly

selected golfers were interviewed to analyze injury data. A total of 82.6% reported an overuse injury, with 21.7% sustaining a major injury (23). Although overuse injuries are more common, other injuries caused by the swing can occur as well. The most common injuries are injuries sustained to the lower back, elbow and shoulder. A current epidemiological study conducted by McHardy found that the most common injury site is the lower back. Results showed that 25% of all golf related injuries were sustained to the lower back. Many of the injuries occurred during the follow through when the core and trunk muscles are most activated (41). Despite the severity of an injury it still causes a decrease in performance to the athlete. Injury prevention programs can be implemented along side an appropriate strength program. Some general injury prevention tips are ensuring your body is properly warmed up before you begin a round of golf. Studies suggest completing an active golf specific warm up previous to any practice or competition. This will aid in reducing and preventing injuries as well as increasing athletic performance (20, 46, 56).

Acute Program Variables

The effectiveness of a training program relies on the understanding of the five acute program variables. The variables are choice of exercise, order of exercise, number of sets, rest period and resistance used (18). The acute program variables will be chosen based off of the results of the needs analysis. Each sport, athlete and workout will be different depending on the noted demands. The training status, weaknesses, and goals of the athlete will also have an impact on the program variables.

Choice of Exercise

As discussed earlier, a golf swing essentially uses the entire body and several different muscles at once (40). This allows for the use of a wide variety of exercises during training. Strength and power have a crucial effect on a golfer's performance. Exercises such as bench press, parallel squat, low cable row and dumbbell lunges have been found to significantly improve strength, power, flexibility and increases in club head speed as well as driving distances (15). Athletes with weaknesses in the upper body will want to focus on exercises such as dumbbell flies, dips, shoulder press, low-seated row, and bench press. These exercises will work several different muscles but especially the pectoralis major and trapezius, which are dominantly used in the back swing, forward swing, acceleration and early follow through phases of the golf swing (40). The core and trunk will benefit from exercises such as the back squat, forward step lunge, good morning, and planks. These exercises train muscles such as the gluteus, bicep femoris, semimembranosus and erector spinae. The gluteus muscle is used in all five phases of the golf swing (40). The exercises needed to improve performance will be different between each golfer, and ultimately, it will be more beneficial to create a program tailored to each individual athlete. The focal point to each workout will be based off of weaknesses to improve strength and power in that area.

Order of Exercise

Once the exercises are chosen it is important to implement them in the proper order. This program variable is otherwise known as order of exercise. Although different exercise arrangements can be used, research suggests completing the exercises where maximal force will be used first. Performing large muscle groups before small groups and multiple joint before single joint exercises (33). Exercise order effects program design and an array of exercises can

be used for a golf specific program (53). A sample sequence for a golf specific work out may be as follows; bench press, lat pull down, and bicep curl in that order.

Exercise sequence is not the only determinant of the exercises that are chosen. A workout routine may follow one of three different workout structures. The three basic workout routines are total body workouts, split workouts, or muscle group workouts (33). The main goals of a golf program should be to increase strength and power to improve distance and accuracy on the course. Day 1 of a lower body golf specific workout may go as follows; squat, dumbbell lunge, and leg curl. Day 2 will focus on the upper body using exercises such as bench press, lat pull-down and bicep curl, in that order. The decision between a split routine and a total body workout may be decided by the athlete's season as well as time in the weight room. During pre-season the golfer should follow a program 3-4 times per week. However, during in-season due to competitions and travel time there may only be time for 1-3 workouts per week (3). In-season is when a total body workout would be most beneficial. This ensures that the athlete is working on all of the targeted muscles each workout.

Number of Sets

The training load and repetitions differ depending on the training goals of the sport and program. The main goals for a golf specific training program will be to improve strength, power, and flexibility. The recommended amount of sets for strength is usually 3 to 6 sets. This will ensure optimal strength gains (3). The optimal range for power exercises is 1-3 sets due to the maximal efforts needed to complete the exercise. The number of sets is a significant factor in determining exercise volume (sets x repetitions x weight lifted). Exercise volume is crucial in ensuring proper program progression. Continually using the same exercise volume may cause the athlete to plateau and ultimately decrease performance. The most advantageous results will be

seen when exercise volumes are varied throughout a training program (45). This will also allow for adequate rest and recovery between workouts. Another important factor is the amount of rest between sets. Rest varies depending on the training goal as well. For a golf program that is focusing on strength and power, 3-5 minutes of rest between each set is recommended (3). Exercises using maximal or near maximal loads will need more rest as opposed to small muscle exercises (50). To improve strength and power it is recommended to use 1-6 sets with 3-5 minutes of rest between each exercise. This will maximize training benefits and increase muscular strength and power for an explosive swing (2, 19).

Rest Period Length (Frequency)

The frequency of a training program varies throughout the year and golf season. Frequency is also affected by intensity, choice of exercise and training status. Recovery time between workouts will increase as loads increase. Heavy load training sessions require the most recovery time, while light days require the least amount of recovery time (3). Some heavy load training sessions may require up to 72 hours of recovery time to maximize benefits. The season in which the athlete is in will also dictate how many training sessions will occur during the week. During in-season a golfer may only strength train 1-3 times per week due to time constraints with competitions and traveling. The remainder of their time will be spent refining and maintaining skill level during practice. The typical golf professional in Germany will play four rounds of 18 holes weekly and hits an average of 200 balls in practice (23). Golf and shot practice occurs throughout all seasons to continually improve technique. However, pre-season is the most important time when it comes to physical fitness levels. This time period should prepare the golfer for tournament play. This will allow them to increase strength and power before the maintenance period occurs during the in-season (3).

Resistance Used (Intensity)

Using a RM target or zone for a golf specific training program will be the most beneficial. The resistance used for a golf program should remain in the 1-6 RM range. The speeds at which the repetitions are completed are also a key factor. Force production is highest at slower speeds and decreases as speed decreases. Strength enhancement is increased when slow velocities and maximal tension is used (18). On the opposite side of the spectrum, power and speed improvements will be seen when high velocities are used (18). Using a combination of the two paradigms will be most effective in increasing the overall strength and explosive power needed for golf (2, 15, 19). Previous research suggests using a protocol for general strength with resistance at 3 sets of 10-12 (15), 3 x 8-12 (59), and 3 x 10-15 (36). Each of these studies produced significant results and improvements in strength, club head speed and driving distances. These programs lasted 11 weeks (15) and 8 weeks (36, 59). In order to continue to progress, a golf specific program should utilize several different exercise prescriptions to improve strength and power. The National Strength and Conditioning Association set recommendations to use 2-6 sets of 1-6 repetitions to maximize strength and 1-5 sets of 3-5 repetitions for power exercises (3). Power can also be completed using plyometric exercises with body weight, using a RM target to perform a movement quickly such as the jump squat, or even Olympic lifts using maximal loads (3). Using a protocol that combines strength and power has been shown to improve club head speed as well as driving distances (19). An 18-week program conducted by Alvarez and colleagues used a maximal strength training protocol with 3 sets of 5 repetitions at 85% with 4-minute rest in between. In conjunction with the strength program they used explosive power training performed with 3 sets of 6 repetitions at 70% in an explosive manner followed by 4 minutes of rest. The explosive power training was followed by golf

specific plyometrics to mimic the stretch shortening cycle as well as the golf swing. Increases were found in maximal strength, explosive strength and club head speed (2). It is concluded that a 6-week maximal strength-training program will improve strength and driving performance (19). However, in order to maximize and maintain gains a minimum of a 12-week program should be implemented with a combination of strength training and explosive power movements specific to the golf swing (2). Including such programs with a golf specific practice regimen may show beneficial effects on several aspects such as strength and golf performance.

Functional Movement Systems

Functional Movement Systems are becoming more popular among athletes, fitness settings and rehabilitation settings as a means of determining the risk of injury (9, 31, 32, 37). Gray Cook has created a functional movement screen (FMS™), which grades movement patterns throughout the body. By completing these screens, an athletes weaknesses and limitations are identified. This allows professionals to target specific areas and track progress after implementing a corrective program. FMS™ is especially important in golf because it allows the strength and conditional professional to see any weaknesses or imbalances, which can be used to create an individualized program. FMS™ is broken into 7 different fundamental movement patterns. Each pattern is scored separately then added to give a total FMS™ score. The 7 patterns are as follows; 1) deep squat which assesses mobility of the ankles, knees, and hips, 2) hurdle step which assesses stride mechanics throughout the stepping motion, 3) inline-lunge which examines hip and trunk mobility and stability, quadriceps flexibility and knee and ankle stability, 4) shoulder mobility which assesses range of motion throughout the shoulder, scapular mobility and thoracic spine extension, 5) active straight leg raise examines hamstring and gastroc-soleus flexibility, 6) stability push-up measures trunk and core stability and 7) rotator stability examines

multi-plane stability throughout the pelvis, core and shoulder girdle. Each pattern has 4 scoring possibilities ranging from 0-3 with an overall total of 21. 0 represents a complete limitation due to pain, while 3 represents proper movement. The standard for scoring as well as the testing protocol can be found in the Functional Movement Screening Manual that is used for FMS™ certification (11-13). In golf, this screen can be very beneficial. A golfer who scores anything below a 3 in any category will work to improve those weaknesses. The low scoring categories will become the priority for a FMS™ component of a strength program. This allows each golfer to follow an individualized weakness oriented portion of the strength program to correct imbalances and increase performance. Thompson and colleagues recently examined the effects of functional training on club head speed in older male golfers. An 8-week functional training program was created that included flexibility, core stability, balance, and resistance exercises. Results showed that club head speed significantly increased following the 8-week training program (55). FMS™ can also be a crucial tool in decreasing the risk of injury. Golfers are susceptible to several different injuries due to overuse and imbalances (4, 8, 23, 38, 39, 60). By completing a functional movement screen the imbalances found can be corrected before an injury occurs. Rita Chorbha and colleagues studied the use of FMS™ to determine injury risk in female collegiate athletes. They tested 38 NCAA Division II female athletes previous to their competitive season. The risk of injury to the lower extremities was increased by 4-fold if the FMS™ score was 14 or less. They concluded that a score of 14/21 was significantly correlated to injury risk (9). Other research suggests that scoring below a 17 on the FMS puts athletes at a 4.7 times greater risk for injury (37). With this data the FMS™ screening can be used as a valuable tool to decrease the risk of injury and increase functional movement. The FMS™ screen used in conjunction with a strength program will prove to be very beneficial in several different aspects.

To make certain that the athlete is progressing, regular testing should occur. This will allow the strength and conditioning coach to track improvements and make adjustments if necessary.

Practical Application

Using the knowledge gained from the needs analysis, movement analysis, injury analysis and acute program variables in conjunction with FMS™ may be beneficial on several different aspects of a golfer's performance. It is important to create a program that effectively trains strength, power, and flexibility. As noted earlier, to maintain maximal strength and power gains it is crucial to properly train those areas. Research suggests using resistance and plyometric exercises such as found in Table 1 (2, 15, 19). Previous studies found benefits in strength as well as club head speed and driving distance when using a general strength protocol for sets and repetitions (15, 36, 59). However, to maximize strength it is recommended to use 2-6 sets of 1-6 repetitions. Using 1-5 sets of 3-5 will activate explosive movements during power exercises. Rest period length should remain between 2-5 minutes for both strength and power exercises (3). Since RM testing is not appropriate for every exercise a certified strength and conditioning specialist will determine the loads. The loads should be prescribed so that the sets and repetitions can be completed using the maximal amount of weight lifted with proper form. If technical failure occurs then the certified strength and conditioning specialist should decrease the loads and continue to monitor the lifts. When additional repetitions can be completed then the certified strength and conditioning specialist can add weight at their discretion. The strength program should be implemented in conjunction with an individualized FMS™ component. Using these corrective exercises may improve imbalances and limitations as well as increase stability. Sample corrective exercises for ASLR, shoulder mobility, and hurdle step are displayed in Figure 1, 2, and 3.

*** Table 1 about here ***

*** Figure 1 about here ***

*** Figure 2 about here ***

*** Figure 3 about here ***

Conclusion

Golf is becoming more popular and it is imperative to dispute the myths that working out will decrease performance. The golf swing requires the coordinated activation of several muscles in a short period of time. Training these muscles and movements with a strength and conditioning program proves to be an effective aspect of a collegiate golfers daily regimen. Based on the current research and findings we can conclude that a strength and conditioning program focusing on strength and explosive power will be beneficial in several different areas such as club head speed and driving distance. Benefits can be maximized when combined with a FMSTM screen and corrective program. Creating an individualized program using the players weaknesses from the FMSTM scores will have benefits such as decreased risk of injury, improved strength and power, and increased flexibility while correcting limitations throughout the body. These increases will allow improvements in driving distance, accuracy, and consistency. Creating an effective program will be valuable during the pre-season and competitive season due to practice time constraints.

Tables and Figures

Table 1: Sample upper body, lower body and plyometric exercises.

Upper body exercises

Bench Press
Low cable row
Triceps cable push-down
Shoulder press
Upright row

Lower body exercises

Squat
Dumbbell lunges
Leg curl
Dumbbell step-ups
Leg extensions

Plyometrics

Explosive pull-downs
Plyometric push-ups
Medicine ball horizontal twists
Golf swing
Standing back extensions
Medicine ball speed rotations

Figure 1: Example ASLR corrective exercise. Single leg (SL) glute bridge with lowering is depicted below.



Figure 2: Example shoulder mobility corrective exercise. Seated rotation with foam roller is depicted below.



Figure 3: Example hurdle step corrective exercise. Supine SL hip flexion is depicted below.



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INTRODUCTION:

In 2012 the National Golf Association recorded approximately 25.3 million golfers who played 489.5 million rounds of golf throughout the United States. With such enormous popularity, golf is a successful business as players are always looking for ways to develop their game. Many players invest time and money into equipment and coaching to improve on the course. Golf technology is continuing to change and expand as researchers produce the newest equipment to add distance and accuracy to each shot. While some players are spending their time finding the perfect club, others are gaining that competitive edge by developing their physical fitness. Despite the interest in developing physical fitness many golfers continue to overlook an effective strength program due to the thought that it may reduce their range of motion and ultimately decrease performance (43). However, some of the most important aspects of a golfer's success may be determined by physical fitness characteristics such as strength, power, flexibility and balance (22, 38, 41).

Strength and conditioning programs have been widely accepted as an integral component of an athlete's daily regimen for years. Golfers have not always thought about strength but have instead focused largely on skill and technical aspects (27). However, golfers need strength and explosive power to produce club head velocities that can exceed 160 km/h (41). Club head velocity is an important determinant for a powerful shot (20, 28). Recent golf research has concluded that improving strength, power, flexibility and balance through a strength program may improve factors such as club head speed, driving distance, and accuracy (1, 11, 13, 16, 26, 28, 33, 41-43). These characteristics play an effective role in a golfer's level of performance. Strength training programs should be implemented to optimize golf specific movements and swing mechanics to improve performance and reduce the risk of injury.

Due to golf's repetitive nature, overuse injuries are very common in professional, amateur, and recreational golfers (2, 17, 30, 32, 33). It has been reported that swing biomechanics, improper warm-up, and lack of physical fitness may affect injury risk (4, 6, 15, 20, 30). In recent years functional movement screening (FMS™) has gained popularity as a tool to assess fundamental movement patterns and determine potential injury risk (5, 24, 25, 29). The FMS™ examines seven different movement patterns to identify limitations and weaknesses throughout the body (8, 9). Once identified, these deficits can be corrected and improved with the use of individualized corrective exercises (3, 10, 18, 23). The use of the FMS™ may be helpful in highlighting faulty movement patterns that may result in poor swing mechanics due to the weaknesses and range of motion limitations. Correcting these movements may decrease the incidence of the various injuries seen in golf and improve overall FMS™ score.

In recent years very little research has examined the changes in FMS™ scores after an intervention program has been implemented (3, 10, 18, 23). Kiesel et al. conducted a study examining the effect of an off season strength and conditioning and corrective program in professional football players and concluded that the FMS™ significantly improved following the intervention (23). However, little research has examined changes in FMS™ scores in collegiate athletes, especially golfers. With the possibility of injury in golf, the FMS™ could be a useful tool when implemented with an intervention program. Improving weaknesses and limitations may decrease the risk of injury and may ultimately improve performance. The main purpose of this investigation was therefore to examine the effects of a strength-training program with individualized weakness oriented corrective exercises on collegiate golfers FMS™ scores. We hypothesized that the strength-training program in conjunction with the corrective exercises would improve overall FMS™ scores.

METHODS:

Experimental Approach to the Problem

Nine NCAA Division 1 Men's Collegiate Golfers were assessed using the FMS™ by a FMS™ Certified Exercise Professional. Subjects completed the screen seven times from September 2012 to March 2014. The initial FMS™ screen completed in September of 2012 was used as the baseline time point. The final time point consisted of data collected in March 2014. The Certified Strength and Conditioning Specialist (CSCS) who was also the FMS™ Certified Exercise Professional remained the same throughout the time frame. The FMS™ testing and training protocols implemented remained the same throughout the time frame as well.

Subjects

Data from nine NCAA Division 1 Men's Collegiate golfers (age = 19 ± 1.0 years, height = 180.3 ± 3.6 cm, weight = 76.2 ± 6.8 kg) were retrospectively analyzed from September 2012 to March 2014. The FMS™ component was completed as part of the subject's normal conditioning. All subjects completed the FMS™ portion during the 18-month time frame. The Institutional Review Board at the University of Connecticut approved the use of human subjects for research. All subjects successfully completed each FMS™ screen and their respective assigned workouts.

Procedures

Each subject underwent seven FMS™ screens from September 2012 to March 2014. Baseline measures were collected in the beginning of preseason in September of 2012, followed by another screen at the end of preseason in December 2012. Because of the university holiday break the subjects workouts for four weeks were conducted away from campus and unsupervised. During this time all subjects followed their prescribed workouts. The next FMS™ screen was performed at the beginning of the competitive season in February of 2013. The

screens for the next year were completed at the start of preseason, the end of preseason, and the beginning of the competitive season just as the 2012 screens. The final time point was conducted during the competitive season in March of 2014. Data were analyzed to assess the changes in FMS™ scores in each subject as well as the interactions between time and focus.

Functional Movement Screen Protocols

A FMS™ Certified Exercise Professional evaluated the Functional Movement Screens. The FMS™ protocol was implemented (7). The Functional Movement Screen consists of 7 different fundamental movements. The FMS™ tests are as follows: deep squat, hurdle step, inline lunge, shoulder mobility, active straight-leg raise, trunk stability push-up, and rotary stability. Each pattern has 4 scoring possibilities ranging from 0-3. 0 represents a complete limitation due to pain, while 3 represents proper movement. A score of 1 is given if the subject cannot complete the movement and a score of 2 is given the subject can complete the movement but compensates to perform properly. The highest overall score that can be attained is a 21. A 21 represents proper movement for all seven fundamental movements.

Deep Squat: Subject starts by placing feet in vertical alignment with the outside of the shoulders. There should be no lateral outturn of the toes or heels. Next the subject rests the four-foot dowel rod on top of their head and adjusts the hand position to create a 90° angle at the elbow. Once the position is attained the subject presses the dowel overhead while the shoulders are abducted and flexed and elbows are fully extended. As the subject descends into the squat position ensuring that the head and chest are facing forward with heels on the floor and the dowel remaining pressed overhead (7, 8).

Hurdle Step: The subject begins with the feet together and the toes touching the base of the hurdle. The hurdle is then adjusted to align with the height of the tibial tuberosity. The dowel

rod is placed across the shoulders below the subject's neck. While keeping the position of the dowel the subject is instructed to step over the hurdle and touch their heel to the floor then return to the starting position. During this time the stance leg must remain in an extended position and the hips, knees and ankles should remain aligned (7, 8).

Inline Lunge: The inline lunge will use the measurement of the tibial tuberosity acquired in the hurdle step. The tester applies the measurement from the end of the subject's toes and a mark is made. The subject then places the heel of the leading foot at the appropriate mark made by the tibial tuberosity measurement. Next the subject places the dowel behind the back so that it is touching the head, thoracic spine, and sacrum. The hand that is opposite the leading leg should grasp the dowel at the cervical spine. The other hand grasps the dowel at the point of the lumbar spine and must remain vertical position throughout the movement. The subject then lowers their back knee to touch behind the heel of the leading foot and then returns to the starting position (7, 8).

Shoulder Mobility: The tester first establishes hand length by measuring the distance from the distal wrist crease to the tip of the third finger. The subject then stands with their feet together and makes a fist with each hand with the thumbs inside of the fist. The subject then reaches behind the neck with one fist and reaches the other behind the back. The fist behind the neck should have the shoulder in a maximally abducted, flexed and externally rotated position. The fist behind the back should have the shoulder in a maximally adducted, extended and internally rotated position. The hands should remain in a fist and should move behind the neck and back in one smooth motion. The tester measures the distance between the two closest points of the hands (7, 9).

Shoulder Mobility Clearing Test: The subject must then complete the shoulder mobility clearing test after finishing the shoulder mobility test. The clearing test is assessing the subject for pain and this portion is not scored. If pain is produced during this movement then a positive (+) mark is recorded on the score sheet. In this case, the subject would receive a 0 for the shoulder mobility test. To complete this clearing test the subject places their palm on the opposite shoulder and continues to lift their shoulder. They should lift their elbow as high as possible while maintaining contact between the palm and shoulder. This test should be completed bilaterally. The purpose of this clearing test is to detect shoulder impingement, which may not be identified during the shoulder mobility test (7, 9).

Active Straight Leg Raise: The subject begins by lying supine with the arms in anatomical position and ensuring the head stays flat on the floor. The tester identifies the midpoint between the anterior superior iliac spine (ASIS) and the center of the patella. Next, the dowel is placed perpendicular to the ground at the midpoint. With the ankle dorsi-flexed and the knee in extended position the subject lifts the test leg, while maintaining contact with the ground with the opposite knee (7, 9).

Trunk Stability Push-Up: The subject positions themselves in prone position with their feet together and hands shoulder width apart. The knees are fully extended while the ankles are dorsi-flexed. The subject is instructed to perform a push-up in this position and the body should be lifted in one smooth motion. Initially males will perform the push-up with thumbs aligned with the top of the forehead while females will have their thumbs aligned with their chin (7, 9).

Trunk Stability Clearing Exam: This exam is completed at the end of the trunk stability push-up test. This movement is performed to determine pain and does not receive a score. A positive (+) mark is given on the score sheet if pain is produced and a 0 will be given for the

trunk stability push-up exam. The subject is instructed to lie in the prone position and perform a press-up to create spinal extension (7, 9).

Rotary Stability: The subject begins in quadruped position with shoulders and hips at 90° to the torso. The knees should be at 90° while the ankles are dorsi-flexed. The subject then flexes the shoulder while extending the hip and knee of the same side. The leg and hand should be raised approximately 6 inches off of the floor. The same shoulder is then extended while the knee is flexed so that the knee and elbow touch (7, 9).

Rotary Stability Clearing Test: The clearing test is completed at the end of the rotary stability exam. This movement is performed to determine pain and does not receive a score. If pain is produced during this movement the subject should immediately be referred out for a thorough evaluation and a 0 will be given for the rotary stability exam. The subject is instructed to begin in the quadruped position. The subject then rocks back to touch the buttocks to the heels as well as the chest to the thighs. The hands should remain as far out as possible in front of the body. The purpose of this exam is to examine spinal flexion (7, 9).

Golf Strength and Conditioning Program Protocols

A Certified Strength and Conditioning Specialist (CSCS) by the National Strength and Conditioning Association (NSCA) created a strength and conditioning program with individualized weakness oriented corrective exercises. The individualized portion was based off of the focus determined from the results of each FMS screen. Due to competition schedules and traveling the programs varied throughout the seasons. All subjects begin with a foam roll and band stretch followed by mobility/activation, mini-bands, and general core before starting their individualized corrective portion followed by the strength program. Loads were prescribed and supervised by the Certified Strength and Conditioning Specialist. Since testing the subjects 1RM

was not always appropriate for certain exercises the loads were prescribed to correspond with the repetition range. The subjects would lift the maximal amount of weight for the given set and repetition range. If technical failure occurred the certified strength and conditioning specialist properly lowered the weights at their discretion. As the program progressed loads were also increased at the discretion of the certified strength and conditioning specialist. A sample intervention strength program that all subjects completed is shown in table 1.

*** Table 1 about here ***

The FMSTTM portion of the program is individualized and varies depending on the specific focus. The FMSTTM component is performed during the warm up and before the strength program. A total of 2-3 exercises are completed each day totaling 5-10 minutes. The corrective exercises for ASLR, shoulder mobility, and rotary stability as well as purpose, protocol, and sets and reps are shown in tables 2, 3, and 4.

*** Table 2 about here ***

*** Table 3 about here ***

*** Table 4 about here ***

Examples of a single leg (SL) glute bridge with lowering, seated T-spine, and landmine rotation can be found in figures 1, 2, and 3.

*** Figure 1 about here ***

*** Figure 2 about here ***

*** Figure 3 about here ***

Statistical Analyses

Data are presented as means \pm *SD* unless otherwise noted. All data sets met the assumption for linear statistics. Data were retrospectively analyzed using a repeated measures ANOVA with time (BL, 2, 3, 4, 5, 6, 7) as the within subject variable. Data were also analyzed using a between subject ANOVA (focus group: ASLR, shoulder mobility, rotary stability) on change in FMS™ score (post-pre). When the ANOVA indicated significance an appropriate post-hoc analysis was used to make a pairwise comparison. For the purpose of this investigation, significance was set at ($p \leq 0.05$).

RESULTS:

The primary findings of this investigation were that the nine subjects saw significant ($p \leq 0.05$) improvement in FMS™ scores over time as shown in figure 4. The mean baseline score was (15 ± 2.3) and the final time point mean was ($19.7 \pm .83$). Subjects improved their FMS™ score over the 18-month period as hypothesized. Each subject's individual FMS™ scores over time can be seen in figure 5. Significant changes were seen in FMS™ score over time.

Focus groups were analyzed to determine a potential interaction on change in FMS™ score. A focus was identified for each subject after each FMS™ test. The most common foci were ASLR, shoulder mobility, rotary stability and hurdle step. However, a focus in hurdle step only occurred once, therefore lacking statistical power. The individual foci that had adequate statistical power (ASLR, shoulder mobility, and rotary stability) for analysis are shown in figure 6. The score for each category was compared with the previous score in the respective category to determine change in score. The overall change in score shown in figure 6 is represented as the

mean change for each main focus. Shoulder mobility significantly improved from a score of 2 to 3 for all six times the area of concern was addressed. However, ASLR and rotary stability did not change as significantly. ASLR became a priority a total of 20 times and improved twice from a score of 1 to 2, and improved 4 times from a score of 2 to 3. Rotary stability became a priority 15 times and was only corrected once from a score of 2 to 3.

*** Figure 4 about here ***

*** Figure 5 about here ***

*** Figure 6 about here ***

DISCUSSION:

Currently, little research exists that examines the ability to change FMS™ scores in collegiate golfers with the use of weakness oriented corrective exercises. The primary findings of this investigation support that FMS™ scores can significantly improve with the use of weakness oriented corrective exercises. Improvements in FMS™ scores demonstrate a reduction in weaknesses and limitations throughout the body. Correcting the areas of concern in conjunction with a traditional strength and conditioning program may possibly improve golf performance. Regular FMS™ testing over the 18-month period ensured that the subjects were continuing to improve with the use of the supervised intervention program. Improvements in FMS™ score may suggest a reduced risk of injury, which is especially important for collegiate golfers.

Golfers are prone to several different injuries due to improper swing mechanics, lack of warm-up and physical characteristics. Golf relies greatly on repetition and because of that golfers are highly susceptible to overuse injuries (17). Several studies have reported the back as the most common site of injury followed by injuries to the shoulder and elbow (17, 21, 31, 32). Gosheger

examined 703 randomly selected golfers and found that 82.6% sustained an overuse injury with 21.7% resulting in a major injury (17). With many common injuries in golf it may be beneficial to use a tool to reduce the predisposition to injury. FMS™ scores have been observed to determine potential injury in various athletes (5, 24, 25, 29, 35). Improving these scores may lower the risk for injury by correcting weaknesses and limitations. The FMS™ overall scores in this investigation significantly ($p \leq 0.05$) improved over the 18-month period. This suggests a decrease in the risk of injury, which would be beneficial in reducing the amount of injuries that golfers are susceptible to. Increases in overall FMS™ scores also suggest improvements in the areas of concern.

During the current investigation a weakness and limitation focus was identified using specific criteria. This criterion concluded that the three main weaknesses were ASLR, shoulder mobility and rotary stability. As stated earlier, golfers are more susceptible to injuries to the back, shoulder, and elbow (17, 21, 31, 32). However, weaknesses and limitations in the ASLR suggests that golfers may be susceptible to hip and leg injuries as well. Further research should be warranted to examine the risk of injury based on highlighted weaknesses. If an association exists, golfers may ultimately decrease the rate of injuries that are caused by overuse and poor biomechanics. This suggests that fewer injuries might be seen in the highlighted areas of concern if they are properly corrected.

Of the three main foci we saw that shoulder mobility weaknesses were improved to a score of 3 each time. This suggests that shoulder mobility is easily trainable and functional mobility can be improved with the use of individual exercises. However, ASLR and rotary stability were found to be more difficult areas to improve. It is noted in the FMS™ manual that it is challenging to score a 3 in the rotary stability movement and only some can complete the

movement without error (7). The rotary stability movement requires trunk stability during a combined upper and lower extremity movement. Errors in this movement make it difficult to properly complete other movements as well. Shoulder mobility, rotary stability and ASLR are the hierarchy of the FMS™ tests. Improvements in these areas are crucial to improve the remaining areas. Subjects in this study showed improvements in the rotary stability movement, but not enough to meet the criteria for a score of 3. However, improvements in ASLR, shoulder mobility and rotary stability suggest that these movements are trainable and may aid in improving other movements as well.

The current findings support the hypothesis that FMS™ scores will improve after an intervention program, which is observed in a limited amount of studies (3, 10, 18, 23). In this particular investigation an individualized FMS™ component was implemented with a traditional strength program. Using FMS™ alongside a strength program provides several other positive benefits as well. Several golf specific attributes are enhanced with the use of a properly conducted strength and conditioning program. Improving physical fitness characteristics such as strength, power, flexibility and balance have been shown to have positive effects on club head speed, driving distance, and accuracy (1, 11, 13, 16, 26, 28, 33, 41-43). Using FMS™ in conjunction with a strength program may prove to be beneficial on overall FMS™ scores as well as performance on the course. Properly certified professionals may use FMS™ as an effective tool to improve weaknesses and maximize sport specific qualities that are necessary for the collegiate golfer to succeed.

In the United States approximately 61% of golfers are over the age of 50 (14) and only approximately 5,215 men and women play on a NCAA Division 1 golf team (36). Golf is widely popular in older adults as a recreational sport. Although this study examined the effects of

weakness oriented corrective exercises on FMS™ score in collegiate golfers, we believe this information still pertains to all ages and skill levels. Despite age or skill level, golfers are susceptible to several injuries due to the nature of the swing. The amount of injuries increases as playing time and practice time increases (17). Professional golfers are more susceptible to injuries than an amateur golfer. Gosheger et al. found that golfers with previous musculoskeletal problems unrelated to golf were more prone to injury than a golfer who is considered healthy (17). This may put the older population more at risk for another injury. Using FMS™ in an older population may aid in reducing injury risk by correcting previous weaknesses and limitations as well as increasing activity level.

As hypothesized, FMS™ scores improved after the use of the weakness oriented corrective exercises, however, there are some limitations to this study. The study design was a pre and post comparison and a control group was not included. Therefore, the increases in FMS™ score may have been due to the use of the strength-training program as opposed to the use of the weakness oriented corrective exercises alone. The current investigation also lacked information on injury or changes in performance. Without this information the study cannot determine whether or not improving FMS™ score decreases the risk of injury or improves golf performance. However, this investigation added to the body of knowledge and to conclude that FMS™ scores can improve to correct weaknesses and limitations in collegiate golfers.

Although, FMS™ research is fairly new it has been examined and shown to have good inter-rater reliability, (12, 19, 34, 37, 39, 40) especially when using video analysis (34). This knowledge allows for greater use of the FMS™ screen throughout various health fields and clinical settings. The screen was created to grade movement patterns to identify weaknesses and limitations (8, 9). The seven fundamental categories allow professionals to target specific areas

as well as track progress by regularly testing. This investigation tracked changes in FMS™ scores over an 18-month period. As hypothesized, FMS™ scores improved over time with the use of an intervention program. This preliminary study provides insight on the changes in FMS™ scores in collegiate golfers after a strength program with an individualized component has been implemented. However, further research is needed to determine the effect of FMS™ on golf specific characteristics such as club head speed, driving distance and accuracy.

PRACTICAL APPLICATIONS:

Using FMS™ as a tool to determine asymmetries, imbalances and weaknesses is increasingly becoming more popular. The fundamental movement patterns highlight target areas to allow for improvement on and off the course. Time constraints due to travel and competition pose a problem for effective training protocols. Using the FMS™ screen to initially identify weaknesses allows strength and conditioning professionals to create an individualized FMS™ portion. Regular testing will ensure that the athletes are improving and progressing. These results indicate that implementing individualized weakness oriented corrective exercises in conjunction with a strength program will not only improve FMS™ scores but also specifically address the areas of concern. This study shows that FMS™ focus can be integrated into a comprehensive strength and conditioning program. With the use of 2-3 exercises taking approximately 5-10 minutes a day, FMS™ score can be substantially improved which has been associated with a reduced risk of injury.

Tables and Figures

Table 1. Strength program implemented with the individualized FMS™ component. This four-week program is an example of the strength programs conducted as an intervention program in between FMS™ testing sessions. The individualized FMS™ component varies based on the highlighted focus. FMS™ corrective exercises were performed during the warm up previous to the strength program.

Day 1					
		Foam roll - Band stretch			
Mobility/Activation		Stick Warm-up/SL RDL with scap, scap push-up, T-spine rotation, Opposite			
Mini-Bands		Side step, Monster walks, squats, glute bridge, clams, psoas			
General		1. Glute ham 2. Plank 3. Airex Balance			
FMS		Corrective exercises: Focus based individualization			
CNS		Med ball circuit: (lat stretch, core, slams), hurdle jumps			
		Week 1	Week 2	Week 3	Week 4
		Sets x reps	Sets x reps	Sets x reps	Sets x reps
Tall kneeling CC lift		2 x 10	2 x 8	2 x 6	2 x 6
Ankle Mobility		8 each toe up	3 x 3 each 3-way	3-way mobility	8 each toe elevated
DB goblet bulgarian squat		3 x 10 each	3 x 8 each	3 x 6 each	3 x 6 each
Chin-ups/Lat pulldown: Alt. weekly		3 x 8	3 x 10	To failure	3 x 6
BB upright row		3 x 8	3 x 8	3 x 10	3 x 8
BB elevation		3 x 10	3 x 10	3 x 10	3 x 10
DB bench press		3 x 8	3 x 6	3 x 10	3 x 8
CC pull through		3 x 8	3 x 10	3 x 8	3 x 6
POST WORK					
DB real row					3 x 8 each
Bretzel, hip internal rotation, supine hamstring					10 seconds each
Day 2					
		Foam roll - Band stretch			
Mobility/Activation		Inchworm, spiderman, side lunge, rev. atlas/SL RDL reach, split hold			
Mini-Bands		Pallof press, T's, Y's, high row, cuff rot, deep squat, cuff press, flys, press, tri extention			
General		1. Core board 2. T-spine mobility 3. SL squats			
FMS		Corrective exercises: Focus based individualization			
CNS		Jump rope, MB, bike TBD			
		Week 1	Week 2	Week 3	Week 4
		Sets x reps	Sets x reps	Sets x reps	Sets x reps
Tall kneeling CC chop		2 x 8	2 x 8	2 x 6	2 x 10
1/2 kneel elevated hip flex		5 each	5 each	5 each	5 each
CC seated iso-dynamic row		3 x 8 each	3 x 8 each	3 x 10 each	3 x 6 each
DB SL RDL		3 x 8 each	3 x 6 each	3 x 10 each	3 x 8 each
SL straight arm pulldown		3 x 8 each	3 x 6 each	3 x 10 each	3 x 8 each
DB SB reverse lunge		3 x 8 each	3 x 8 each	3 x 6 each	3 x 10 each
1/2 kneeling landmine press		3 x 8 each	3 x 8 each	3 x 6 each	3 x 5 each
POST WORK					
SB Core					TBD
Lat stretch, pec stretch, elevated hip flex stretch					10 seconds each

Table 2: Example ASLR corrective exercises as well the purpose, protocol, and sets and repetitions.

Corrective Exercise	Purpose	Protocol	Sets x Reps
Leg lowering 2	Activates gastroc-soleus and hamstring flexibility, while improving core stability throughout the pelvis.	Instruct subject to lay on the floor in supine position and bring both legs up to create a 90° at the hips. Slowly bring one leg to the floor ensuring that both legs are extended and the ankles are dorsi-flexed. Once the active leg reaches the floor the subject raises the active leg back to start position and repeats.	8 each
Supported leg lowering	Improves hip mobility and stability.	Instruct subject to lie supine with one hip flexed against a wall. Tighten the core and ensure that the back is kept flat. Lower the opposite leg to the ground while keeping the hips down. Hold at the bottom of the movement before returning to starting position.	Hold for 20 seconds x 5 each
Single leg glute bridge with lowering	Improves hamstring flexibility while maintaining stability throughout the core and glutes.	Instruct the subject to lie supine with knees bent to 45°. Tighten the abdominals and glutes slowly to smoothly lift the hips in the air to create a straight line from the knees to shoulders. Raise and extend the active leg while ensuring dorsi-flexion in the ankles and the pelvis remains raised. Lower the active leg back to the starting position and repeat.	10 each
Wall single leg hip flexion	Improves hip flexion and ankle mobility.	Instruct the subject for stand in athletic position facing the wall. Place the hands on the wall by creating a 90° with the shoulder and arms. Place the toes of the active leg up against the wall and move the opposite leg about one foot length behind. Press on the wall while flexing the hips and pushing forward.	10 each
Band Psoas	Strengthens the psoas muscle and hip flexors as well as improves trunk stability.	Instruct the subject to lie in supine position with knees raised at a 90° at the knees and hips. Place the band around the middle of both of the feet. Pull the active leg into the chest and hold for 2-3 seconds before returning to the start position to repeat. Make sure both ankles remained dorsi-flexed and there is pressure on the band. This movement should be completed slowly and smoothly.	1 x 16

Table 3: Example shoulder mobility corrective exercises as well the purpose, protocol, and sets and repetitions.

Corrective Exercise	Purpose	Protocol	Sets x Reps
Seated rotation with foam roller	Isolates thoracic rotation while stabilizing the pelvis.	Instruct the subject to start seated on a box with feet off the ground and the foam roller between their legs. The hands should be crossed at the shoulders. Once in position the subject should “squeeze/crush” the roller to ensure stability of the pelvis. Once this is maintained the subject should rotate to one side while leading with the head/eyes. Hold at the end range for 2 seconds and return back to the starting position. Repeat the movement to the opposite side.	1 x 10 each
Prone T-spine rotation	Isolates thoracic rotation.	Instruct the subject to start in the prone position on the floor with the active hand behind the head and opposite hand behind the lumbar spine. Initiate the movement by rotating the head so the elbow of the arm behind the head lifts to the sky. Hold this position for the prescribed amount of time before returning to start position to repeat again.	1 x 10 each
Sleeper stretch	Improves internal rotation of the shoulder.	Instruct the subject to start by lying on their side with their shoulder packed and bent at 90°. The elbow should also be at 90°. Instruct the subject to push towards the floor by pushing just above the wrist and make certain that they never push on the hand. They should hold the stretch for the prescribed amount of time on each side.	1 x 10 each
Seated T-spine isometric hold	Improves thoracic mobility	Instruct the subject to sit against the wall with the hips, thoracic spine and head against the wall and ensure proper posture is maintained. The legs should be in “butterfly” stretch position. Begin by placing the hands against the wall with palms facing out and sliding them up the wall until the subject is about to lose contact with the wall. At this time the shoulder, hips, elbows, wrists, and hands should remain in contact with the wall at all times. Hold position for prescribed time. If contact is lost, instruct the subject to lower the arms back down to the floor until contact is regained.	2 x 20-30 seconds each

Table 4: Example rotary stability corrective exercises as well as the purpose, protocol, and sets and repetitions.

Corrective Exercise	Purpose	Protocol	Sets x Reps
Landmine rotation	Improve core stability through an anti-rotation/lateral flexion movement.	Instruct the subject to stand in an athletic position. Hold the barbell with arms straight and extended throughout the set. Rotate the arms from side to side in a smooth controlled manner ensuring that the torso and hips are square to the barbell's pivot point.	2-3 x 10 each
Half Turkish get up	Improve stability, strength, posture and symmetry.	The subject is instructed to lie in supine position with the active arm fully extended while holding the dumbbell. Raise the same side leg and maintain a 45° in the knee ensuring that the foot maintains full contact with the floor. After the starting position is gained the first movement is to press to the elbow. This occurs by rolling under the dumbbell while sitting up and raising the elbow. The elbow remains contact with the floor until the second movement, called elbow to post. This forms a continuation from the elbow to the hand. It is important to maintain posture as well as a packed shoulder. Return to the start position.	2-3 x 5 each
Hard roll	Improves inner core, thoracic mobility, and hip flexion/extension.	The subject should begin in supine position. While maintaining hip flexion on one side and hip extension on the other the subject should bring the active flexed leg to the opposite elbow and maintain contact. The roll should begin with the headfirst and continue by bringing the active side to the opposite side of the floor. Beginning with the headfirst, the subject should return to starting position. The subject should refrain from using the inactive arm or leg to assist with the roll.	1 x 8 each
Band resisted quad opposite	Activates the core while maintaining shoulder flexion and hip/knee extension.	Instruct the subject to begin in quadruped position and place the band on the active leg and opposite hand. While maintaining a tight core the subject should pull their belly button to their spine and raise the active hand and opposite active leg at the same time. The subject should maintain shoulder flexion and hip/knee extension. During this portion there should be a straight line from the active leg and opposite active arm. Return to the start position in a controlled manner.	1-2 x 10 each

Figure 1: Example of an ASLR corrective exercise. Single Leg (SL) Glute Bridge with lowering is depicted below.



Figure 2: Example of a shoulder mobility corrective exercise. Seated rotation with foam roller is depicted below.

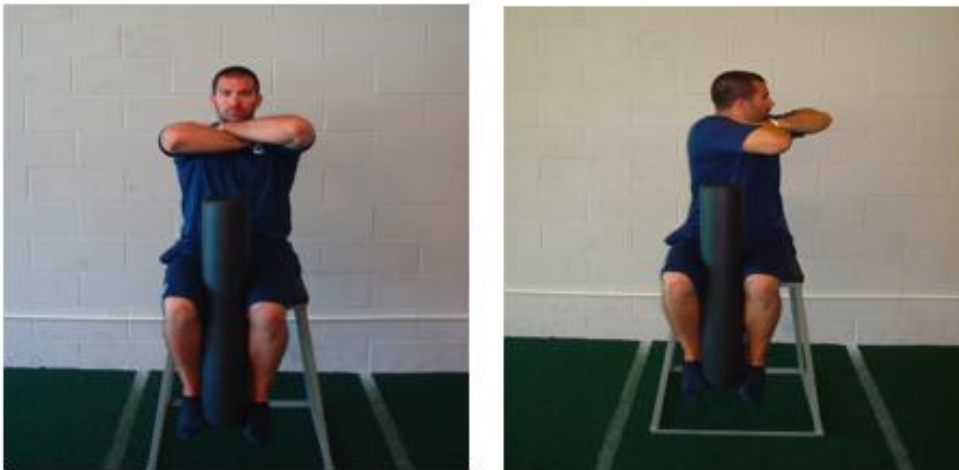


Figure 3: Example rotary stability corrective exercise. Landmine rotation is depicted below.



Figure 4: Means (\pm SD) FMSTTM overall score for each subject from September 2012 to March 2014. * = The mean at that respective time point is significantly ($p \leq 0.05$) greater than the time point that immediately preceded it.

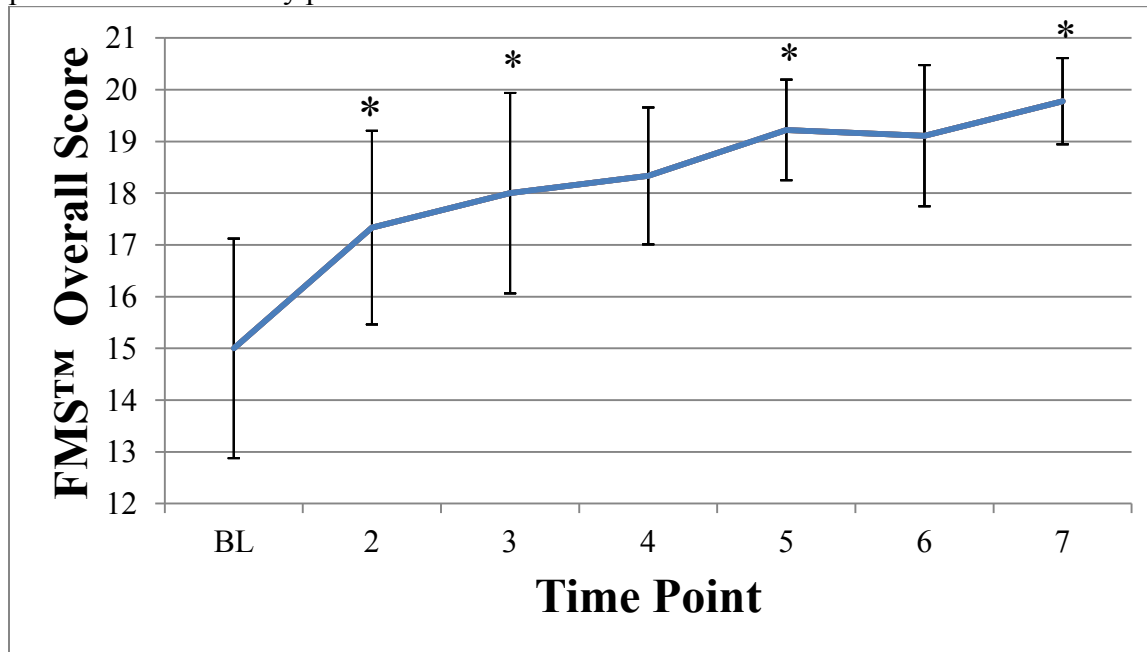


Figure 5: Individual FMSTTM score for each subject at each time point. Improvements from baseline to the final time point were observed for each subject.

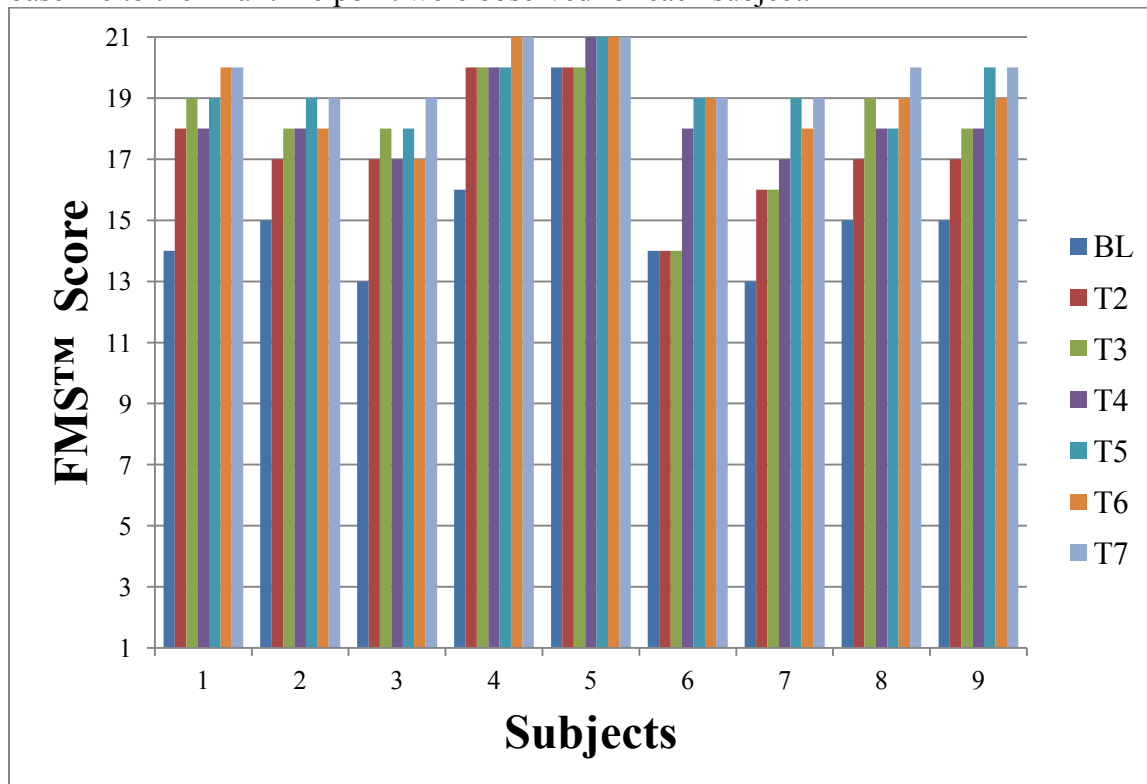
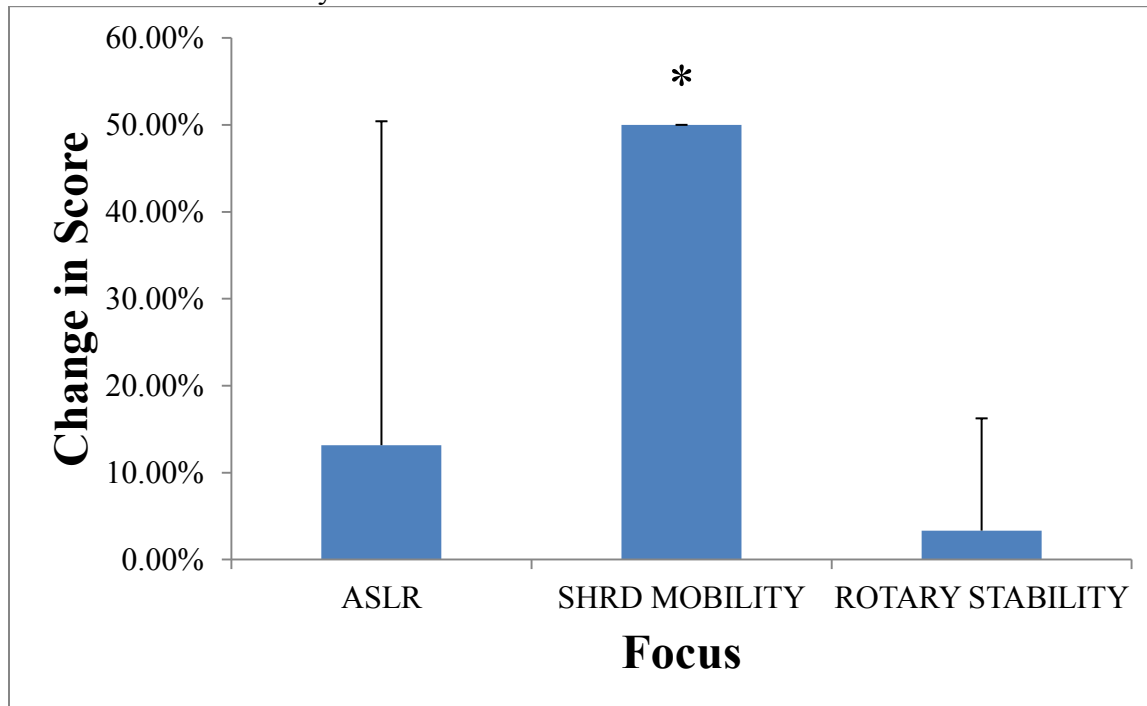


Figure 6: Means ($\pm SD$) change in FMS™ score. * = Significantly ($p \leq 0.05$) different from all other groups. No other significant ($p \leq 0.05$) differences were observed. Greatest increase was seen in shoulder mobility.



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