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Identifying relationships between upper extremity function and Army combat fitness test scores in the reserve 'officers' training corps population

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IDENTIFYING RELATIONSHIPS BETWEEN UPPER EXTREMITY FUNCTION AND ARMY COMBAT FITNESS TEST SCORES IN THE RESERVE 'OFFICERS' TRAINING CORPS POPULATION

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APPROVAL OF THESIS

We, the faculty supervising the work of Lianne Marie Shroba affirm that the thesis, *Identifying Relationships Between Upper Extremity Function and Army Combat Fitness Test Scores in the Reserve Officers Training Corps*, meets the high academic standards for original scholarship and creative work established by the Masters of Exercise Science concentration Athletic Training and the School of Kinesiology. This work also conforms to the editorial standards of our discipline and the Graduate College of Marshall University. With our signatures, we approve the manuscript for publication.

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ABSTRACT

Background: The United States Army is implementing the Holistic Health and Fitness program (H2F), intending to transform the Army's culture of health and fitness. It aims to optimize soldier readiness by improving physical and non-physical performance, decreasing injury rates, and improving rehabilitation after injury. A part of that program includes replacing the current Army Physical Fitness Test (APFT) with the new Army Combat Fitness Test (ACFT). The ACFT consists of six functional events that gauge combat readiness. There is already established literature regarding injury epidemiology as it relates to the previous APFT, but little published work on the ACFT and any potential relationships

Purpose: This study aimed to identify any potential relationships between upper extremity dysfunction and the Army Combat Fitness Test in the Reserve Officer Training Corps population. The hypothesis was that cadets who score higher on the ACFT would have better strength, range of motion measurements, and patient-reported outcome measurements.

Methods: 11 ROTC Cadets (173.1 ± 10.8cm, 80.1 ± 11.3 kg) participated in the study. Participants completed patient-reported outcome forms (PENN, DASH, FABQ) before testing. Cervical and shoulder range of motion measurements as well as shoulder strength measurements were recorded. Cadets completed an ACFT during scheduled physical training hours, and scores were collected. A group independent variable was created grouping Cadets above or below the mean ACFT score. One-way ANOVA was used to determine between-group differences.

Results: The mean ACFT score for the 11 total cadets was 434.34 ± 75.8 out of 600. Cadets scoring above the mean had greater right side strength measurements in External Rotation (mean difference = 3.8 kg, $p = 0.018$), Internal Rotation (mean difference = 2.2 kg, $p = 0.021$), and Abduction (mean difference = 2.8 kg, $p = 0.028$) and External Rotation (mean difference = 2.9

kg, $p = 0.006$), Internal Rotation (mean difference = 2.3 kg, $p = 0.039$) and Abduction (mean difference = 3.1 kg, $p = 0.023$) on the left. Serratus Anterior (mean difference = 2.4 kg, $p = 0.029$), Lower Trapezius (mean difference = 1.0 kg, $p = 0.028$), and Middle Trapezius (mean difference = 1.1 kg, $p = 0.031$) on their right sides and Serratus Anterior (mean difference = 3.0 kg, $p = 0.007$), Lower Trapezius (mean difference = 1.3 kg, $p = 0.026$) and Middle Trapezius (mean difference = 1.1kg, $p = 0.039$) on their left. There was especially high correlation between External Rotation Strength ($r = 0.606$). Statistical significance between group differences was not found in range of motion measurements or in the patient reported outcome measure scores.

Conclusion and Practical Relevance: Cadets who scored above the mean on the ACFT had greater strength measures, with External Rotation showing a strong positive correlation with ACFT scores. Range of motion measurements and patient-reported outcome measure scores had little impact on ACFT performance. The results establish a link between shoulder strength and ACFT scores outcomes and create a foundation for future research regarding soldier fitness and strength training, leading to increased combat readiness, decreased injury rate, and improved overall effectiveness of the H2F program.

CHAPTER 1
INTRODUCTION

The Practical Problem

The United States Army is transitioning to a new standard in physical fitness testing as part of the Holistic Health and Fitness (H2F) program.[1]The Army Combat Fitness Test (ACFT) is replacing the current Army Physical Fitness Test with more functional and combat-related movements. Compared to the recent test, grading will not be based upon gender but on their military occupation specialty (MOS) and age. This drive to eliminate gender differences aims to ensure complete combat and functional readiness and comes when the equality of the sexes is a progressive movement within the military. The ACFT aims to create a well-rounded physical soldier by incorporating exercises that mimic daily military activities and test the individual's overall fitness rather than a specific movement set. Additionally, the Army aims to transform its culture of fitness and reduce the risk of injury. The previous APFT consisted of 2 minutes of sit-ups and push-ups followed by a 2-mile run. The ACFT replaces this with three repetition max deadlifts, overhead ball throws, sprint-drag-carry, leg tucks, 2 mile-run, and hand-release pushups. The ACFT has slowly been implemented in select groups over the last 2 years and will become the standard in October of 2020. These more functional testing events assess a soldier's overall combat readiness and are a more accurate portrayal of physical activities that are specific to the military.

Ninety-six percent of Army soldiers deployed to Iraq or Afghanistan during 2003-4 reported musculoskeletal complaints.[2] The low back, hands/fingers, and shoulders are three of the most common sites of non-battle injuries. Musculoskeletal injury rates within the Army vary depending on training type, duration, intensity, and gender, with reports of their incidence being as high as 62% in women and 42% in men.[3] MOS can play a role in the type of injury sustained as well. In an Infantry Brigade Combat Team deployed to Afghanistan, Engineer and Maintenance MOSs reported higher percentages of shoulder injury to the upper extremity related tasks required of their jobs, with a total prevalence of 10.1%.[4] This high rate of shoulder injury may have a negative impact on soldier readiness and is not without financial cost. The total cost for treatment of shoulder pain within the United States in 2000 was approximately 7 billion dollars.[5] The various technical and physical aspects involved in the ACFT can have a role in identifying dysfunction and impairments in soldiers.

The physical demands required of members of the US Military increase the service member's risk of musculoskeletal injury. The reported shoulder injuries may result from the compressive forces of ruck sacks and increased loads applied during long-duration ruck marches.[6] Common shoulder pathologies reported by service members include glenohumeral instability,[7-9] glenoid labral tears, and rotator cuff pathologies.[8] Many of these injuries occur during day-to-day training rather than in combat activities.

The ACFT mimics the duties required of Army soldiers. The components of the ACFT simulate the complex upper extremity movement patterns of military training and battlefield activities.[10] As it has many components relying on upper extremity function, the ACFT may identify possible links in overall shoulder function. Identifying potential relationships will aid in preventing possible injuries that can affect soldier readiness.

Often, a clear relationship between physical impairment, injury, and function does not exist. Impairments may be a direct result of injury but are not exclusive to a trauma occurring. Impairments may be assessed through objective measures to determine how it affects an individual's function. Objective measures such as pain, do not necessarily play an important role in identifying and treating impairments. While pain may indicate anatomical defects and injury, it does not always point to impairment, as the body may adapt and compensate for the impairment without loss of function. It was stated that it often appears to an observer that the affected organ or body part is capable of functioning but that the claimant does not use it normally because of pain.[11] Injury does not always have a causation link to impairment, and impairment is not result of injury, but each can influence the other. In assessing the function and readiness of soldiers, identifying potential impairments and direct care can prevent future injury and reduce duty profiles. It is possible to identify impairments and risk of injury by measuring strength, range motion and patient reported outcome measures. Identifying and understanding potentional relationships between physical impairment, injury, and the ACFT may improve the test's utility as an assessment of physical fitness and potentially increase the ACFT's utility to aid in predicting injury.

In this study, the ACFT scores patient-assessed function, physical, clinical test results, range of motion and strength measurements will be compared to find the relationship between the ACFT and physical impairment. Using this information and comparing it with specific ACFT scores will help develop prevention strategies that clinicians can implement to prevent possible or further injury and improve overall function and physical fitness test scores. The ACFT was designed to mimic the various physical demands of military duty. The events have specific functional foundations that assess whether a soldier will maintain a combat-ready status. By identifying soldiers who perform poorly on the ACFT and comparing them to clinical measurement data, clinicians can potentially highlight sources that contribute to poor performance.

The Research Problem

The ACFT involves exercises and movements requiring a great deal of upper extremity function. Following injuries of the lower extremity, upper extremity injuries are the most common, specifically within the shoulder.[12] Identifying a link between shoulder impairments and ACFT test scores can provide information on reducing injury and ensuring soldier readiness. Measuring shoulder impairment and assessing dysfunction with patient-reported outcomes, along with objective measures such as range of motion and strength, and comparing that to individual ACFT scores, potential relationships can be identified.

Research Question

What is the relationship between ACFT scores and upper extremity impairment and dysfunction within Marshall University ROTC Cadets?

Null Hypothesis

H_0:There will be no relationship between ACFT scores and shoulder impairments and shoulder function scores.

Alternative Hypothesis

H_1: Cadets that score higher on the ACFT will have better patient-reported function scores, strength, and range of motion measures

H_2: Cadets that score lower on the ACFT will have lower shoulder strength than cadets with higher shoulder strength scores. There will be a positive correlation between shoulder strength and ACFT score.

H_3: Cadets that score lower on the ACFT will have restricted shoulder motion than cadets with higher scores. There will be a positive correlation between shoulder range of motion and ACFT score.

CHAPTER 2

LITERATURE REVIEW

Introduction

The Army Reserve Officer Training Corps (ROTC) began with the signing of the Defense Act of 1916 (Pub. L. 64-85). There are approximately 260 ROTC programs in all 50 states, including Guam, American Samoa, Puerto Rico, Virgin Islands, and the District of Columbia [13]. Students enrolled in ROTC can pursue a baccalaureate degree at their chosen college while learning military knowledge, procedures, and regulations. Within the American Military, the Army ROTC is the largest producer of officers, commissioning approximately 600,000 men and women. The ROTC is subject to the same physical requirements as soldiers who enlist outside the program. The US Army regularly administer physical fitness tests to maintain and assess physical and combat readiness. The physical fitness tests are administered and graded according to the standards set forth by the United States Army.[1]

The United States Army is currently in a physical fitness transition period. To better measure combat readiness and overall physical capacity, the Army is phasing out the traditional Army Physical Fitness Test in favor of the Army Combat Fitness Test.[10] The previous test included 3 different assessments consisting of push-ups and sit-ups for two minutes, respectively, and a timed 2-mile run.[10] Soldiers are scored based on their repetitions, gender, timed run, and age, which is totaled on a standard table. This testing procedure and training regime created cause for concern over how soldiers train for the test.[14] By training for specific movements, there is a risk for lack of combat readiness in addition to overuse injuries. The Army seeks to remedy this by refining the test, using a full fitness approach, and overhauling the testing procedures.

Still, there is little information on the ACFT and potential relationship to functionality scores in the ROTC population.

This literature review will examine upper extremity functional outcome measures, shoulder dysfunction, and impairments that can impact ACFT scores and soldier readiness. This data will aid in predicting the outcomes of the implementation of the ACFT within the ROTC population. The current relationship between the ACFT and upper extremity dysfunction is not known. It can be hypothesized that cadets with poor patient-reported outcome measures and strength assessments will be related to low ACFT scores. The following sections will examine musculoskeletal injuries in various patient populations, how shoulder injury and impairment can affect those patients and functional measurement tools that can capture how much overall daily function is affected. This information will provide background and reasoning as to how the ACFT can become a clinical measure of shoulder impairment and dysfunction. This is because the events are created to mimic functional activities required by a soldier. Poor scores on specific ACFT components can highlight issues due to poor mechanics, lack of range of motion, or decreased strength.

Musculoskeletal Injury in the Military

About one-quarter of new male trainees within the Army and approximately half of female trainees will experience a musculoskeletal injury during an 8-week basic training period.[15] An issue commonly found is a general lack of physical fitness within the Army. Individuals who were over body fat standards were more likely to experience a musculoskeletal type injury than those who met the weight standards.[16] During basic training, women also have been found to visit a clinic for an injury or more than men as women tend to report injury occurrences more than men, leading to an increase in sustained injury numbers during basic training.[17] Injury at basic training can also lead to discharge from the Army. Discharge factors for both men and women included medical recommendations for removal from training to recover from an injury, lower performance on any of the three APFT events, and lower educational level.[18] Many studies aimed to identify risk factors that may lead to injury during basic training and examine how different prevention protocols affected those factors.

Financial Cost of Injury in the Military Population

With the introduction of the ACFT and the push to have a more physically fit soldier within the U.S Army, the plan to maximize injury prevention strategies is important. In 2012, musculoskeletal injuries were the leading cause of medical visits across military services, totaling approximately 2.2 million encounters.[19] They also account for the highest number of disability charges, with the Army being the branch with the most occurrences annually. Previously published literature states that physical training-related injury risk is the highest for basic combat training in the Army.[20] These injuries can affect a wide range of body parts, including knee, ankle, foot, lumbar spine, cervical spine, hand, or shoulder.[4] The cost of delivering medical treatment to 703 soldiers over a year in 2018 reportedly cost the U.S government $1,337,000.[21] Not only does care cost the government but there is expense associated with time lost due to injury. This can add approximately one and a half million dollars to that overall expenditure.[22] Direct expenses associated with the treatment of shoulder dysfunction and pain over two years during military training are approximately $4,711,845. Indirectly, it can add an additional $18,353,146.[22] If the ACFT can be utilized as a functional assessment and aid in identifying shoulder dysfunctions and impairments, clinicians can use that information to implement rehabilitation and preventative programs that can decrease injury occurrence. By working on the problem before it can manifest further, costs related to treatment and time loss can be reduced. Not only will spending be decreased overall, but the readiness and availability of soldiers will increase and improve.

Army Physical Fitness Test

The United States Army is currently in a physical fitness transition period. To better measure combat readiness and overall physical capacity, the Army is phasing out the traditional Army Physical Fitness test in favor of the Army Combat Fitness Test.[10] The previous test included three different assessments consisting of push-ups and sit-ups for two minutes, and a timed two-mile run.[1] Soldiers are scored based on their repetitions, gender, timed run, and age, totaled on a standard table. This testing procedure and training regime created cause for concern over how soldiers train for the test.[14] By training for specific movements, there is a risk for lack of combat readiness and overuse injuries. The Army seeks to remedy this by refining the test, using a robust fitness approach, and overhauling the testing procedures. Still, there is little collected data on the ACFT and potential relationship to functionality scores in the ROTC population.

The new physical test will replace the traditional 2-2-2 testing format of the APFT. In addition to replacing the tasks, the ACFT also modifies the grading structure. The scoring standard is no longer based on gender. Instead, soldiers are held to the same standard, and gender has no influence. Scores correlate with a soldier's military occupational specialty (MOS) and unit type.[10]

Historically, physical fitness testing in the Army has varied. Efforts to create a formal test developed at the United States Military academy in 1858. The first test, named "Individual Efficiency Test" involved a wall climb, hand grenade throw, obstacle course, running broad jump and a 100-yard run.[23] Colonel Herman J. Koehler is credited with being the first to implement a program of physical education systemically at the academy. His program focused on strengths tests and human body movements in addition to gymnastics, equestrianism, and swimming.[24] Since then, the test has been modified, women have been included, and age adjustments have been implemented. The APFT of today has been in practice since 1980.

Injury and the Physical Fitness Test

Not only is full fitness integration a focus of the new ACFT, but decreasing the number of profiles amassed within the Army is as well. A profile in the U.S. Army is a duty-restriction and limitation of P.T.[14] An article titled *Incidence of Acute Injury Related to Fitness Testing of U.S Army Personnel* by LTC Rachel Evans examined the incidence of self-reported acute injuries related to the APFT. It identified possible risk factors of military rank, APFT scores and years of service along with previous injuries sustained during the administration of a P.T. test. It was found that most knee pathologies can be traced back to training for the running portion of the test and that sit-up-related issues make up for most injuries relating to the APFT due to the loading on the spine. Overall the number of profile days recorded for 11 soldiers citing 15 different injuries was 271 days. This is time lost for the soldier and the Army. Injuries occur for many reasons in the Army. A study done with the 101st Airborne Division (Air Assault) found that tactical training only amounted for 6.8 percent of injuries during 1 year while physical training injuries accounted for 29.3 percent of all injuries and 65.4 percent of preventable injuries in the population, the 2nd most frequent activity after an unknown etiology.[25] Running was the most frequent cause of injury during 1 year with 13.5 percent of all injuries and 34.6 percent of preventable injuries. More data collection on injury epidemiology and military fitness tests need to occur to further assess its impact on soldier readiness and ultimate financial cost.

Overuse Injuries

Overuse injuries can include muscle strains, bursitis, tendinopathy, tears, joint pathologies, bone stress fractures, and various stress reactions.[26] Factors such as lack of overall physical fitness and weight can increase the military population's risk of injury. The low physical activity of many civilians before transitioning into military life can potentially create issues that can result in musculoskeletal injuries. Lack of practice and education on proper exercise form and recovery techniques can result in poor adaptation to intense exercises required in basic training camps. Those who exhibit decreased physical fitness are predisposed to over-use injuries.[27] Lower levels of physical activity decrease exposure to stressors that develop bone density, further increasing the risk of injury with the military training rigor. Very little information on upper extremity injury in the military has been recorded. Despite the lack of literature relating to work-related upper extremity injuries, potential risk factors have been identified and can be broken down into individual, psychological and physical factors.[28]

Upper Extremity Injuries

The military population, because of its unique and specific physical characters, experiences higher incidences of injury. Shoulder instability is one of the most commonly recorded, showing an incidence in the military at 1.69 per 1,000 person-years, approximately 20 times more than that in the general U.S population.[7] Additionally, the incidence of shoulder instability has been found to be even higher among the young and highly active population of service academy cadets.[9] Glenohumeral instability has been found to be very common in this population, with subluxations comprising approximately 85 percent of instability events.[7] Other common conditions include tendonitis, bursitis, rotator cuff tears, adhesive capsulitis, avascular necrosis, and impingement syndrome.[29] Depending on MOS, certain soldiers are more susceptible to upper extremity injury. A study that was done examining the specific body regions injured and their associations to different MOS in a Brigade Combat Team found that at 12 percent, shoulder injuries were most prevalent in Engineers.[4]

Grip Strength and Injury

Grip strength can be used as an accurate measure of physical health and can be used to predict the presence of disability.[30,31] It also reflects the functional status of the upper extremity and has been used multiple times in clinical studies regarding upper extremity disease, fracture, dysfunction and treatment.[32] Having adequate grip strength can be important for cadets taking the ACFT as it is incorporated in several events. It also varies across the sexes. When compared to females, males had 40 percent greater grip strength, and a significant correlation between body weight and grip strength was also found in men.[33]

Impairments

Understanding the definitions of function, impairment, and injury is fundamental in creating effective treatment and preventative programs. Impairment can describe problems at the tissue level and can result from disease or injury, but not exclusively. Impairment can occur because of injury, and can additionally result in injury. Various clinical measures of impairments include a range of motion, strength and pain, and special clinical tests and physical assessments. The World Health Organization (WHO) created the International Classification of Functioning, Disability, and Health (ICF) to define disability as a multidimensional construct that involves a dynamic interaction between body functions and structures, activity limitations, and participation restrictions.[34] It also incorporates environmental and personal factors that are associated with the health condition into this model. This model defines impairments as problems in body function and structure such as significant deviation or loss.

The ICF has two main classification components. Part 1 involves Functioning and Disability, whereas Part 2 incorporates Contextual Factors, and within each part, there are two components. In Part 1, there is a focus on the body systems and structures within the body, and an Activities and Participation component, which covers a range of functional aspects from an individual and societal perspective. The components within this part can be used to indicate impairments or activity limitations that fall under the term of disability, which WHO defines as an umbrella term for impairments, activity limitations, and participation restrictions. It denotes the negative aspects of the interaction between a person's health condition(s) and that individual's contextual factors (environmental and personal factors). It can also indicate neutral aspects of health that can be summarized within the definition of functioning. The ICF defines functioning as an umbrella term for body function, body structures, activities and participation. It denotes the positive or neutral aspects of the interaction between a person's health condition(s) and that individual's contextual factors (environmental and personal factors).[34]

It is important to distinguish the difference between disability and impairment further. If two individuals sustain the same injury (i.e., loss of motion at the knee, amputation of a finger, etc.), they are impaired. Disability arises when one individual is no longer able to carry out activities of daily living due to that specific impairment. The American Medical Association created *Guides to the Evaluation of Permanent Impairment* to have a system that rates the severity of an impairment and the degree to which that impairment affects an individual's ability to perform common activities of daily living. The AMA's guides define impairment as a loss, loss of use or derangement of any body part, organ system or organ function."[35] These guides are commonly used in workman's compensation cases to identify and rate the severity of the impairment and not to determine treatment plans.

The Kinesiopathologic (KPM) model is built upon the premise that repetitive movement and sustained alignments can produce pathology. Rather than diagnosing individuals and creating treatment plans that focus on the pathoanatomical issues, the KPM classifies patients according to their impairments and alignments, as these are the issues being corrected in therapy, not the resulting pathology.[36] The key concept in this model is that the body, at the joint level, will follow the laws of physics and will take the path of least resistance for the movement. This occurs typically in a specific direction, such as extension and extension. Factors that influence that path are intra- and inter-joint relative flexibility and muscle and connective tissue stiffness. It is also influenced by the body's motor performance that becomes motor learning.[37] If a joint moves more readily in a specific plane or direction over time and develops hypermobility or accessory motion, this can result in micro-instability. This can cause micro-trauma due to the repetition, which can lead to macro-trauma. This can be found in athletes who experience varying pathologies due to repetitive, specific movements. Throwing athletes can experience altered shoulder and arm kinematics as a result to changes within the glenohumeral joint capsule and rotator cuff .[38]

Shoulder Impairments

To identify shoulder impairments, it is important to understand shoulder mechanics and kinematics. The shoulder has a high degree of mobility due to its structure and motion of all segments of the shoulder girdle.[39] Key components of the shoulders anatomical and biomechanical systems pertain to its mobility, strength, and overall stability. Because of the glenohumeral (GH) joints mobility, stability is derived mainly from overall muscular control, with secondary assistance from the glenohumeral capsule, ligaments and labrum. Shoulder mobility is mainly the result of motion in both the GH joint and the scapulothoracic-gliding plane. The glenohumeral joint is a ball-and-socket type joint that articulates between the proximal humerus and glenoid of the scapula.[40] The shoulder is also comprised of multiple static and dynamic stabilizers that allow for extreme degrees of range of motion in the sagittal, vertical and coronal planes. Flexion and extension allow for the upper limb to move anterior and posteriorly in the sagittal plane. Typical shoulder range in flexion is 180° with the main flexors of the shoulder being pectoralis major, anterior deltoid and coracobrachialis. Extensor muscles of the shoulder include the deltoid, Teres major, and latissimus dorsi. These muscles allow for extension between 45° and 60°. Internal rotation from the glenohumeral joint ranges from 70° to 90°. Primary rotation muscles are the pectoralis major, Teres major, subscapularis, latissimus dorsi, and anterior deltoid. External rotation has a normal range of motion at 90° and primarily controlled by the infraspinatus and Teres minor muscles. Adduction and Abduction is bringing the upper limb towards (adduction) and away (abduction) from the midline. The muscles responsible for adduction include pectoralis major, latissimus dorsi and teres major. Shoulder abduction has a normal range of motion of approximately 150°.[41] Within abduction, the supraspinatus is responsible for the first 0° to 15° followed by the middle deltoid until about 90°, after which scapular rotation caused by trapezius and serratus anterior activation, allows for abduction of the shoulder past 90°.[42]

Another contributing factor to the shoulders overall mobility is the scapula. The contribution of scapular motion to arm elevation follows a general movement pattern where scapular motion is responsible for approximately one-third of total arm elevation.[39] There are multiple joints that make up the shoulder that also allow for its mobility. The sternoclavicular joint allows for clavicular elevation of 11° to 15°, retraction of 15°-20° during arm elevation and large axial rotation of up to 40°.[43] The wide range of mobility experiences by the glenohumeral joint is possibly due to the small articular surface area of the scapula, the glenoid surface and the loose connective tissue. Loss of range of motion in any direction can alter the function and movements of the various static and dynamic stabilizers of the shoulder. The upper extremity allows for tactile feedback from one's environment, so loss of function due to range of motion deficits can be detrimental.

Maintaining adequate shoulder range of motion is crucial for completing numerous activities of daily living (ADL). When such activities are impeded by loss of motion at the joint, the body will adapt with compensatory patterns and movements independently or assistance via other people or instruments.[44] While adaptations such as though can be a solution, it will not prove to sustainable to the overall function of the joint or limb in the long term. Secondary conditions may arise from the excessive use of compensatory motions, such as soft tissue and degenerative joint diseases.[45] In addition to ADL's being affected by a range of motion deficits, skill specific movements are also greatly affected. Many complex maneuvers are required daily to complete various training exercises and maintain combat readiness regarding the military. Loss of range of motion can impact a soldier's ability to complete tasks such as lifting, carrying, and dragging, all of which are involved within the new physical fitness test. As the ACFT seeks to gauge a soldier's overall fitness and readiness, having poor scores in events that rely heavily on upper extremity function potentially can be caused by impairments to the upper extremity caused by range of motion issues.

Muscular strength plays a large role in shoulder impairments as well. The primary muscle group that provides support for the shoulder joint is the rotator cuff muscles. The four muscles that create this group are the subscapularis, supraspinatus, infraspinatus, and Teres minor. [40] The rotator cuff muscles attach to the proximal humerus anteriorly on the greater tuberosity and provide structural support to the GH joint and maintain the humeral head firmly in position by articulating with the scapula within the glenoid cavity.[40] Their primary role is to stabilize and center the head of the humerus on the glenoid during upper extremity movements.[39] The lower trapezius muscle contributes to shoulder movement primarily in external rotation, posterior tilt, and scapular upward rotation. Serratus anterior is mainly involved in generation muscle torque during the elevation of the arm, while the trapezius directs the clavicle and scapula towards the plane of elevation.[43] Serratus anterior and the rhomboids press the scapula onto the thorax and provide a stable base for humeral motions. This is known as the Scapulohumeral Rhythm (SHR). Clinical assessment of strength measures can highlight strength deficits that have either caused impairments or have been the result of one. Isometric strength testing has been shown to be an efficient and inexpensive way to perform strength measurements.[46] A study aimed at identifying baseline reference data was conducted at the United States Military Academy at West Point with freshman cadets aged 17-21 years. The subject's bilateral isometric strength was measured using a handheld dynamometer. It included external and internal rotation, abduction, external and internal rotation at 45°, as well as prone lower trap strength measures.[47] Having normative data for comparison after an injury or surgery is crucial in determining how to direct care.

With a high degree and range of mobility, there is a required amount of stability needed. In the shoulder, many dynamic and static stabilizers work together to prevent instability and injury. The glenohumeral, coracoclavicular, and coracohumeral ligaments and the glenoid labrum and joint capsule work to stabilize the glenohumeral joint. In addition to the rotator cuff muscles, the long head of the biceps tendon and periscapular muscles provide dynamic stabilization.[48] Instability issues can lead to subluxations and potentially dislocations. Weak internal and external rotators have been found to be associated with recurrent anterior instability.[49] Maintaining adequate strength and stability allows for a great deal of mobility required of the shoulder. Deficits in any of these components can lead to functional impairments and possible injury.

As the body experiences impairments, it will adapt to various secondary movement patterns. Over time, this can cause different pathologies to develop and kinetically have a negative impact on other joints. An example of shoulder dysfunction and impairment is scapular dyskinesia. This is an alteration of the normal position or motion of the scapula during coupled Scapulohumeral movements.[50] It appears to be a non-specific response to shoulder dysfunction as there is no specific pattern of dyskinesis associated with a particular shoulder diagnosis.[50] Scapular dyskinesis has an observable alteration in the position of the scape and the practices it exhibits in relation to the thoracic cage.[51] One of the primary roles of the scapula is involved in glenohumeral articulation, which kinematically is a ball and socket configuration. For this configuration to be maintained within the joint, the scapula must move in coordination with the moving humerus. This is so the instant center of rotation is constrained with a physiologic pattern throughout the full range of motion.[50] Impairments due to strength deficits, range of motion decreased, and compensatory movement patterns are not exclusive to athletes and active individuals. Impairment is not always caused by injury, but age, genetics, and environment can all contribute. Various populations are affected by impairments of the upper extremity.

General and Athletic Population Shoulder Impairments

Traditionally, impairment refers to the problem related to a specific structure or tissue within the body. Various trauma, including fracture, rupture, contusion, minor instability, and joint displacement, can contribute to overall shoulder pain. When movement becomes painful, is the pain typically associated with entrapment of the sub acromial soft tissue under the coracoacromial complex, fibrosis and adhesions of the glenohumeral joint capsule and surrounding soft tissues which leads to range of motion deficits, and muscle strength loss due to tears in the rotator cuff and biceps tendon.[52] The most prevalent shoulder disorders found in working adults were adhesive capsulitis and rotator cuff tendonitis. Many overlap with other diagnosis such as bicipital tendonitis, sub acromial bursitis and acromioclavicular joint disorder (walker-bone). Primary Adhesive capsulitis has a reported prevalence of 2-5.3 percent, mainly affecting women over 40 years of age with sedentary jobs in their non-dominant shoulder.[53]

Overhead-throwing athletes have a high risk of developing injury due to high loads and forces found during certain upper extremity biomechanics.[54] Chronic issues are typically due to sport specific adaptations and alterations in strength, posture and flexibility. These are not exclusive to just the glenohumeral joint but in other links within the kinetic chain of the shoulder and arm.[55] Certain impairments within the athlete's upper extremity can change their biomechanics and movements during activity. Glenohumeral internal-rotation deficit (GIRD), scapular dyskinesia, rotator cuff imbalance, hyper kyphosis and range of motion deficits can possibly lead to the "cascade of injury."[38] Muscle strength imbalances create impairments within the overhead throwing athletic population as well. Regarding rotator cuff strength, overhead athletes exhibit sport specific adaptations leading to a relative decrease in the strength of the external rotators, thus creates the muscular imbalance within the rotator cuff. The most common shoulder pathologies in overhead athletes consist of rotator cuff lesions, rotator cuff tears, G.H. joint capsular lesions, SLAP tears, Osseous lesions and Biceps Tendon lesions.[56]

Patient Reported Outcome Measures

Patient reported outcomes are the goals that the patient has and wishes to meet throughout treatment. These outcomes can fall across a spectrum of simple daily activities to highly specific functional skills. Patient reported outcome measures (PROMs) are the tools or instruments that measure their progress.[57] These various questionnaires can range in question specificity, with disease-specific PROM's focusing mainly on identifying symptoms and the impact those symptoms have on function.[58] This study employs the use of the Penn Shoulder Score (PSS), Disabilities of the Arm, Shoulder and Hand Questionnaire (DASH) and the Fear Avoidance Belief Questionnaire (FABQ). The Penn Shoulder Score is a questionnaire of 100 items divided into three subscales that pertain to pain, satisfaction and function. Within the pain subscale, pain at rest, with normal activities, and strenuous exercise is addressed. Patients can rate their pain on a 10-point scale with ending points of "no pain" and "worst possible pain." When grading, points are given to each item, or question, by subtracting the number the patient circled, from the maximum of 10. An example being, if the patient has complete absence of pain, they will be rewarded 30 points. The patient’s shoulder function satisfaction is also scored on a 10-point numeric system. Its end points are "not satisfied" and "very satisfied." The function sub section deviates slightly in design due to qualitative and numeral combination responses rather than purely numerical. Its grading is based on 20 items, and each item has a four-point Likert scale. The options for patient response include 0: cannot do at all, 1: much difficulty, 2: with some difficulty, 3: no difficulty. The PSS has been shown to be a reliable and valid measure to assess the outcomes of individuals as well as groups of patients dealing with shoulder disorders. The PSS has an MCID of 11.4 points and MDC (based on a 90% CI) ranging from 1.8 to 8.6 points. Another PROM tool used within this study was the Disability of the Arm, Shoulder, and Hand questionnaire (DASH). This is a shorter questionnaire consisting of 30 questions concerning physical function and symptoms.[59] Similar to the Penn Shoulder Score, the DASH is designed with 3 sections. They consist of physical, social or role functions and symptoms.

Additionally, it contains two sections that create scores for participation regarding work activities, sports, and music. Within each section, the items are scored on a 5-point Likert scale. The scale ranges from "no difficulty" to "unable", "no impact" to "high impact" and "none" to "extreme." All items in the questionnaire reference situations that the patient has possibly experiences in the week leading up to the questionnaire.[60] Both PROMs utilize subjective, patient-derived data to observe progress. In addition to patient reported outcome measures, there are other tools used to obtain information regarding patient function. Clinicians use various physical and functional assessments and use that data to direct proper care as well.

The Fear Avoidance Belief Questionnaire is used to measure what is called fear avoidance behaviors. It was developed based on the Fear Avoidance Model of Exaggerated Pain Perception, a model that tries to explain why certain patients with acute pain can recover while other patients will develop chronic pain from the same conditions[61]. Individuals, especially those dealing with chronic issues, exhibit anxiety avoidance of certain activities that are perceived to cause further pain [62]. The FABQ has 16 items and consists of two subscales that are related to those fear avoidance beliefs concerning work (FABQ-W) and physical activity (FABQ-PA). The FABQ-W has 7 items (score scale range = 0-42) and the FABQ-PA has 4 (score scale range = 0-24). The responses range from 0, meaning strongly disagree, to 6, which is completely agree, on a total seven-point scale. Higher scores are representative of the presence of fear avoidance beliefs.[63] The test-retest reliability of scores for the physical activity and work subscales have been reported to by high (ICC 0.90 = FABQ-W, ICC 0.77 = FABQ-PA). This measurement tool allows for psychosocial measures related to pain, impairment, and injury to be collected.

Clinical Assessments

The shoulder dysfunction screen exam utilized within this study involves several shoulder provocative tests. These special tests include Painful Arc, Drop Sign, Sulcus Sign, Hawkins, Neer, Apprehension & Relocation tests, External Rotation Lag sign, Liftoff test, Serratus Anterior Flexion Test. These all are used clinically for the detection of various shoulder pathologies. In the ACFT, the overhead throw, leg tuck, and Hand-Release pushups put a great deal of stress on the shoulder complex. Understanding the biomechanics and anatomy involved with these events and the clinical reasoning behind these special tests, it is possible to understand the specific effects each event can have on a soldier.

The clinical tests most commonly used in identifying impingement syndrome are the Painful Arc, Neer, Hawkins-Kennedy, Drop Arm and Liftoff tests.[64-66] Neer states that impingement occurs against the anterior edge and undersurface of the anterior third of the acromion, the coracoacromial ligament and occasionally, at the AC joint. When the arm is raised, the supraspinatus passes under the anterior edge of the acromion and the AC joint. There are three stages to impingement; edema and hemorrhage (Stage I), fibrosis and tendinitis (Stage II), and bone spurs and tendon rupture (Stage III).[67]

The Painful Arc test is used for detecting subacromial impingement syndrome (SAIS) and is performed by asking the subject to actively abduct, or raise, their shoulder and report any pain during that movement. If the subject identifies pain between 60° and 120° of abduction, the test is considered positive. A painful arc within the 60° to 120° range is indicative of a disorder of the sub acromial region. If the pain occurs past 120° towards full elevation of the arm at 180°, this indicates an issue with the acromio-clavicular (A.C.) joint.[68]

Neer's test is another clinical test used to determine the presence of SAIS. It is performed with the clinician stabilizing the subject's scapula with a downward force while fully flexing the humerus overhead maximally while applying an overpressure. The scapular rotation is prevented with the clinician's hand, and as the subject's arm is forced into forward flexion, this causes the greater tuberosity to impinge against the acromion.[67]

Hawkins-Kennedy is performed by the examiner flexing the subjects humerus and elbow to 90° and then maximally internally rotating the subjects shoulder and applying an overpressure. This test is positive if there is a recreation of pain in the superior shoulder. [65] The Hawkins-Kennedy is another exam that is used in the clinical diagnosis of SAIS.

Drop Arm sign, or Drop Arm test, is simple and is performed by having the clinician abducting the subjects arm to 90°, releasing the arm, and asking the patient to slowly lower their arm to their side following the same path of movement. A positive test occurs if the patient is unable to return their arm to their side slowly or if they experience severe pain when they try to do so.[66] It was determined that the drop arm sign is best used to diagnose full thickness rotator cuff tears when combined with the painful arc test and weakness in external rotation.[69]

Apprehension and Relocation tests are used for determining anterior instability. There is a high rate of recurrent dislocations and subluxations in young patients that have a history of previous anterior dislocation and instability can increase the chance of further damage to the glenohumeral (G.H.) joint.[70] Having adequate G.H. stabilization is important as it is the most mobile joint in the body. ACFT upper extremity focused events require movement of the shoulder in virtually every anatomical plane and maintaining proper stability throughout will ensure low injury risk. The Apprehension/Relocation tests can help in identifying the presence of instability and, if found, how it can potentially affect a cadets' ability to perform. Anterior apprehension can be identified by bringing the subjects shoulder into 90° of abduction and 90° of external rotation. A positive test occurs when the subject feels a potential subluxation or dislocation and displays apprehension and recoils from the position.[70] The relocation test stems as a progression from the previous, and looks to relieve the apprehension exhibited by the subject after the clinician manually stabilizes the shoulder by applying a posterior force on the anterior portion of the shoulder. Another test of glenohumeral instability is the Sulcus sign. This test allows for visible representation of shoulder laxity in the glenohumeral joint capsule. The lift off test, or Gerber's test, is used to identify subscapular weakness and damage to the subscapularis tendon.[64,71] The subscapularis is one of four muscles that make up the rotator cuff, which is responsible for providing stability and strength to the shoulder during motion. This test is done while the subject is in a standing position with the clinician standing behind them. The subject is asked to place the back of their hand in the small of their back, and then instructed to 'lift off' their hand against resistance provided by the clinician. It is considered positive if the subject cannot resist against the clinician, lift their hand off their back, or if they rely on compensatory movements to complete the task.[72]

ACFT Events

For this study, emphasis will be on scores earned from the leg tuck, standing power throw, and Hand Release push-ups. Biomechanically these events contain various upper extremity movements. Proper shoulder stabilization, strength, motion, and coordination are needed to execute the tasks correctly, and these movements translate to specific functional activities soldiers will experience daily.

The standing power throw (SPT) is a backward overhead throw measured for the distance that assesses explosive power.[73] Tasks related to this event include executing a buddy drag, throwing equipment over an obstacle, throwing hand grenades, jumping over a ditch, loading equipment and using progressive forces in hand-to-hand combat. The SPT incorporates multidirectional movements that generate lower body power and involve upper extremity explosiveness.[74]

The Leg Tuck (LTK) is used to assess a soldier's muscular strength and endurance. This event incorporates grip strength, shoulder flexion and adduction, elbow flexion and trunk/hip flexion. This test simulates climbing tasks and surmounting obstacles such as walls or climbing rope in the practical military application. Grip strength ability in individuals has been a biomarker in identifying those who exhibit weakness-associated mobility limitations.[75] Poor scores on the LTK can indicate mobility impairments due to decreased grip strength, mostly identified in women.[75]

The Hand-Release pushups (HRP) are a modified version of the already well-established push-ups from the APFT. They aim to measure upper body muscular endurance and relate to repetitive and sustained pushing used in various combat tasks. This can include pushing an opponent away in hand-to-hand combat, pushing a disabled vehicle, and pushing oneself off the ground during maneuver techniques.[76] Compared to standard push-ups as a test of muscular endurance, hand-release push-ups were apparently less difficult due to the musculature involved in standard push-ups being under constant tension throughout the test. In contrast, hand-release pushups allow for a brief pause in movement, alleviating stress upon the shoulders.[77] Glenohumeral instability is important as anterior and posterior forces upon the shoulder joint occur and external and internal rotation of the arm.

ACFT Scoring

For soldiers to pass the ACFT, they must obtain a score of at least 60 points in each of the events and an overall score of at least 360 points. The maximum score a soldier can receive is 600.[73] Scoring is categorized into 3 different sections, depending on how physically demanding a soldier's unit or MOS will be. A minimum score in each event in the "Heavy" or Black standard is 70, 65 for soldiers in "Significant" or Grey. For those in the "Moderate" or gold category, the overall minimum score for each event is 60. Cadets at Marshall University are required to reach the minimum Gold Standard. (See Appensdix G)

Black Scoring Standards: In units and specialties that require heavy physical activity, a soldier must lift 200lbs in the three repetition max deadlift (MDL), 8.0 meters in standing power throw (SPT), 30 hand-release push-ups (HRP), 2:10 in the sprint drag carry (SDC), a minimum of five leg tucks (LTK) and a two-mile run (2MR) time of 18:00.[78]

Grey Scoring Standards: In units and specialties requiring significant physical activity, a soldier must lift at least 180lbs in the MDL, 6.5 meters for the SPT, 20 HRP, 2:30 time for the SDC, three leg tuck and a 2MR time of 19:00.[78]

Gold Scoring Standards: In units and specialty's that require moderate physical activity, a soldier must lift at least 140 lbs. during the MDL, 4.5 meters for the SPT, 10 hand-release push-ups, 3:00 overall spring drag carry time, at least 1 leg tuck, and a 2MR time of 21:00.[78]

Conclusion

Examining how shoulder impairment and dysfunction are measured and identified is important during the transition of the health and fitness model in the U.S Army. As the upper extremity is an extremely functional unit, maintaining its overall integrity can be beneficial holistically for an individual soldier and the branch as a whole. The ACFT requires a great deal of upper extremity function. These events were created to mimic functional tasks and ensuring that soldiers do not have impairments or dysfunctions that can affect their performance is important in preventing time lost due to injury and poor test score outcomes. Transitioning the traditional physical fitness test to one that is more combat readiness-based presents with its challenges. Forgoing age and gender score requirements in favor of more equal standards will undoubtedly be met with injury, function, attrition and overall effectiveness. The logistics of implementing and administering the test across the entire Army, from active duty and national guard to reserves and ROTC programs, can prove to be difficult. Data collection on how the test affects the passing rates and upper extremity function can be beneficial. The ACFT can be used as another functional assessment tool by clinicians based on score outcomes individually and collectively. These specific scores can highlight weakness, loss of function, and other impairments because the ACFT may be an effective way to test shoulder function in movement that is closer to military activity rather than information collected from outcome measures. In this study, by gathering data related to upper extremity function and disability, and comparing it to ACFT scores, it is possible to identify possible relationships that can then be addressed and resolved. The treatment of these impairments can lead to lower injury rates, improved attrition rates, and decreased overall costs associated with long-term musculoskeletal injury treatment.

CHAPTER 3

Methods

Purpose

The purpose of this study is to identify any potential relationships between ACFT scores and the functional outcome measure scores from the PENN and DASH in an ROTC population.

Research Question

What is the relationship between ACFT scores and functional outcome measurement scores within the Marshall University ROTC population?

Null Hypothesis

The ACFT will have no significant effect or relationship on functionality scores.

Alternative Hypothesis

H_1: Cadets that score higher on the ACFT will have better patient-reported function scores, strength, and range of motion measures

H_2: Cadets that score lower on the ACFT will have lower shoulder strength than cadets with higher shoulder strength scores. There will be a positive correlation between shoulder strength and ACFT score.

H_3: Cadets that score lower on the ACFT will have restricted shoulder motion than cadets with higher scores. There will be a positive correlation between shoulder range of motion and ACFT score.

Research Design

This is a cross-sectional study.

Participants and Setting

Participants were recruited from the ARMY ROTC program. Participants were recruited through emails and announcements via the athletic trainers, and Google forms was used utilized to collect participants and provide volunteering instructions. Testing and documentation occurred at Marshall University's recreational field and Gullickson Hall.

Inclusion Criteria:

1. At least 18 years of age

2. No current shoulder or arm pain (pain < 2/10)

3. An ROTC student

Exclusion Criteria:

Exclusion criteria (any one excludes):

1. Active or passive cervical spine range produces shoulder symptoms

2. Is not enrolled in the Marshall University ROTC program

3. Systemic musculoskeletal disease

4. Not able to elevate either shoulder to 120°.

5. Shoulder range of motion restricted ≥ 50% in any plane of motion.

6. Shoulder pain ≥7/10

7. Greater than 30 years of age

IRB Approval

The project received approval by the Marshall University Institutional Review Board (IRBNet ID# 1654309-1). (Appendix A) All participants provided written informed consent prior to data collection. (Appendix B)

Instrumentation

- Handheld dynamometer (microFET2, Hoggan Scientific LLC, Salt Lake City, UT)
- Grip strength dynamometer – Jamar Hand Dynamometer (Lafayette Instruments, Lafayette, IN, USA)
- Digital inclinometer (The Saunders Group Inc., Chaska, MN.)
- PENN
- *Quick*DASH
- FABQ

Protocol

Participants were asked to complete three patient-reported outcome measures, the PENN, QDASH, and FABQ before physical measurements were collected. A physical examination was performed, which includes special tests for known shoulder pathologies. Shoulder and cervical range of motion was also measured. Shoulder girdle muscle strength measurements were recorded and repeated before and after thirty repetitions of weighted overhead shoulder motion in the frontal plane are completed. Additionally, throughout the semester, study participants participated in ACFT testing.

Participants were recruited through emails, and scheduled to complete lab testing through google forms and screened for exclusion and inclusion criteria prior to testing. They arrived at the lab during their designated times and filled out demographics information including sex, age, birthdate and completed patient reported outcome measures (PENN, QDASH, FABQ). The clinician recorded height and weight measurements. The participant's cervical and shoulder range of motion was recorded along with upper extremity strength, postural measures, and grip strength. Several special tests that asses glenohumeral stability, rotator cuff pathology and glenoid labrum pathology were performed. This includes the load shift test, apprehension location, anterior release and sulcus tests for glenohumeral stability. For rotator cuff pathologies, the painful arc test, Neer Test, Hawkins Kennedy tests were administered. The muscles being tested for strength via clinician as well as with electromyography were the upper trapezium, lower trapezium, serratus anterior as well as the middle deltoid and infraspinatus. Manual muscle test assessments of shoulder adduction and internal/external rotation were also completed. The subject then will complete a fatigue protocol consisting of 30 arm elevations with 3lb or 5lb weight depending on the subject's mass. After the fatigue exercise was completed, strength measurements will be again.

ACFT Testing Protocol

The new Army Combat Fitness Test includes six events; three repetition maximum deadlift, standing power throw, two minutes of Hand-Release push-ups, sprint-drag-carry, leg tucks and a timed two mile run.[79]

3 Rep Max Deadlift- Strength deadlift: With a proposed weight range of 120 to 420 pounds, the deadlift event is similar to the one found in the Occupational Physical Assessment Test, or OPAT, which is given to new recruits to assess lower-body strength before they are placed into a best-fit career field. The ACFT will require soldiers to perform a three-repetition maximum deadlift (only one in OPAT) and the weights will be increased. The event replicates picking up ammunition boxes, a wounded battle buddy, supplies or other heavy equipment.

Standing power throw: The participants will start this exercise facing backwards with their heels close to the line on the ground without touching. They will hold a 10-pound medicine ball with a nine-inch diameter. For proper form the participants will have to hold the ball with their hands tucked under the bottom of it. The exercise will be performed by throwing the ball backwards over their head. The throw will not count if they step backwards over the line. The goal for this exercise is to throw the ball as far as they could. Each participant has one practice throw and then two throws that count. Participants must throw the ball at 6.5 meters or further to pass

Hand Release-push-ups: The participants will start this exercise in normal push-up position with their chest on the ground. From there they will push up and then return to down at the starting position. At the bottom of the push-up they will have to extend their arms out into a T position and then bring them back to the start. The push-ups will not count if the participants could not keep their body in a straight line as they pushed up and down. The goal for this exercise is to perform as many push-ups as they can within two minutes. Participants must perform thirty push-ups to pass.

Sprint Drag Carry: As they dash 25 meters five times up and down a lane, soldiers will perform sprints, drag a sled weighing 90-pounds, and then hand-carry two 40-pound kettlebell weights. This can simulate pulling a battle buddy out of harm's way, moving quickly to take cover, or carrying ammunition to a fighting position or vehicle.

Leg Tucks: The participants will start this exercise in a dead hang on a bar with their hands in front of each other from either hand touching to six inches apart. Participants will then have to bring both knees up to touch the left and right elbows, respectively. The tuck will not count if both knees are not touching the triceps at the same time. The goal for this exercise is to perform as many leg tucks as they could within two minutes. Participants must perform at least one leg tuck to pass.

Two Mile Run: Same event as on the current test. The overall passing times have increased due to the overall intensity of the test.

Patient Recorded Outcome Measures

Participants completed the PENN to identify the participant shoulder specific level of pain and function. A 25-item questionnaire, the PENN assesses the level of pain, satisfaction, and function of the shoulder in the participant.[92] The total score of the PENN is the total of the pain, satisfaction, and function scores. The PENN is scored 0-100, a score of 100 represents no pain, maximum satisfaction, and no disability of the shoulder. A score of 0 represents total shoulder disability/function.[92] The PENN minimum clinically important difference is reported as 11.4 and the minimum detectable change as 12.1.[92] The PENN has been found to be valid and reliable; the test-retest reliability of $ICC_{2,1} = 0.94$.[92]

Participants completed the Disability of the Arm Shoulder and Hand (DASH). The *Quick*DASH is a 11-item questionnaire that evaluates symptoms and the level of disability of the upper extremity. The DASH is also scored on a scale of 0-100, with a score of 0 meaning no disability and a score of 100 meaning total disability.[58] The minimum detectable change is reported as 10.81 and the minimum clinically important difference is reported as 10.83. The DASH was found to be a valid and reliable; the test-retest reliability of $ICC_{2,1} = 0.96$.

The participants also completed the Fear Avoidance Belief Questionnaire (FABQ). It is a 16-item survey that assessed fear avoidance beliefs concerning work (FABQ-W) and physical activity (FABQ-PA). The responses range from 0, meaning strongly disagree, to 6, which is completely agree, on a total seven-point scale. Higher scores are representative of the presence of FAB.[63] The test-retest reliability of scores for the physical activity and work subscales have been reported to by high (ICC 0.90 = FABQ-W, ICC 0.77 = FABQ-PA).

Shoulder Range of Motion

Shoulder range of motion measurements were performed to determine scapular position using a digital inclinometer (The Saunders Group Inc., Chaska, MN). Digital inclinometer intrarater reliability showed excellent reliability with $ICC_{3,k}$ = 0.94-0.98 and a standard error of measurement of 2°. The range of motion techniques implemented by Kendalwere utilized for the following motions:

External rotation:. External rotation was performed with the participant sitting. The shoulder was abducted to 90°, and the elbow was flexed to 90°. The participant was instructed to rotate their forearm towards the ceiling while keeping their humerus parallel to the floor. The measurement was taken at maximum external rotation and recorded.

Internal rotation: Internal rotation was performed with the participant sitting. The shoulder was abducted to 90°, and the elbow was flexed to 90°. The participant was then asked to rotate the forearm towards the floor. The measurement was taken at maximum internal rotation and recorded.

Shoulder Abduction: Shoulder abduction was performed with the participant standing. The participant was then asked to abduct their arm to side of the body with palms facing forward. A measurement of 180° was recorded if participant could elevate arm to ear.

Shoulder flexion: Shoulder flexion was performed with the participant standing. The participant was then instructed to raise their arm forward and overhead. A measurement of 180° was recorded if participant could elevate arm to ear.

Horizontal adduction: Horizontal adduction was performed with the participant lying on a table. The participant was then asked to move their arm across their body towards the opposite shoulder. The measurement was taken at the point of maximum horizontal adduction and recorded.

Manual Muscle Strength

For this study, strength of the following muscles, and shoulder motion was assessed; serratus anterior, lower and middle trapezius, external rotation, internal rotation, and shoulder abduction. A hand-held dynamometer was used to grade the force produced and the participant was asked to grade their pain on a scale of 0-10.

Serratus anterior: The strength of the serratus anterior muscle is assessed by having the subject stand upright with the arm abducted to 120° in the plane of the scapula. The examiner stands to the side of the subject and places their hand at the level of the subject's elbow and applies a downward directed force, forcing the subject into adduction.

Lower Trapezius: The strength of the lower trapezium muscle is assessed by having the subject lay prone with their arm abducted to 120° and internally rotated. The examiner places their hand at the level of the subject's elbow and applies an anterior directed force.

Middle Trapezius: The strength of the middle trapezium muscle is assessed by having the subject lay prone with their arm abducted to 90° and in a position mid-way between internal and external rotation. The examiner places their hand at the level of the subject's elbow and applies an anterior directed force.

External rotation: External rotation strength is assessed by having the subject stand upright with their arm hanging in a relaxed slightly abducted position at with the elbow flexed to 90°. The examiner stands to the side of the subject with one hand stabilizing the subject's elbow, the examiner grasps the subject's wrist with their other hand. The subject is instructed to externally rotate their shoulder. The examiner resists their motion.

Internal rotation: External rotation strength is assessed by having the subject stand upright with their arm hanging in a relaxed slightly abducted position at with the elbow flexed to 90°. The examiner stands to the side of the subject with one hand stabilizing the subject's elbow, the examiner grasps the subject's wrist with their other hand. The subject is instructed to internally rotate their shoulder. The examiner resists their motion.

Shoulder adduction: Shoulder abduction strength is assessed by having the subject stand with their arm at their side. The examiner stands in front of the subject, grasps the subject's wrist and passively abducts the subject's arm. The examiner places their other hand at the level of the subject's elbow. The subject is instructed to abduct their arm. The examiner applies a force that resists the subject's motion.

Shoulder Provocative Tests

Shoulder provocative tests were performed to rule out specific shoulder pathologies (i.e., full thickness rotator cuff tear, anterior and multidirectional instability, and glenoid labial tear). The shoulder provocative tests that will be performed include:

Painful Arc Test: The painful arc test was performed by having the participant actively elevate their arm in the plane of the scapula through a complete range of motion. A positive test will be recorded if the participant complained of pain in the 60°-120° arc of motion. The painful arc test sensitivity = 0.57 and specificity = 0.66.

Drop Arm: The drop arm test was performed with the participant standing. The examiner passively abducted the shoulder to 90°. The examiner will then release the arm with instructions to hold the arm in starting position. A positive test was recorded if the participant was unable to hold their arm in 90° of shoulder abduction. The drop arm test sensitivity = 0.27 and specificity = 0.88.

Sulcus Sign: The sulcus sign test was performed by having the participant sit upright with the arm in a relaxed position at their side. The examiner placed one hand on the participant's shoulder over the acromioclavicular joint, while the other hand of the examiner grasped the participant proximal to the elbow. The examiner applied a traction force to the participant's shoulder. A positive test was documented if a sulcus is developed over the glenohumeral joint lateral to the acromioclavicular joint. Sulcus sign sensitivity = 0.17 and specificity = 0.93.

Hawkins-Kennedy Test: The Hawkins-Kennedy test was performed by having the participant elevate their arm to 90° in the sagittal plane with their elbow flexed to 90°. The examiner then passively internally rotated the participant's arm. A positive test was recorded if the participant experienced pain on the anterior portion of the shoulder at the end range of motion. Hawkins-Kennedy test sensitivity = 0.72 and specificity = 0.66.

Neer Test: The Neer test was performed by having the participant internally rotate their arm. From this position, the participant elevated their arm in the sagittal plane. A positive test was recorded if the participant experienced pain at the end range of motion. Neer test sensitivity = 0.88.7 and specificity = 0.31.

Apprehension Test: The apprehension test was performed by having the participant lay supine with their arm abducted to 90° with the elbow flexed to 90°. From this position, the Examiner passively externally rotated the participant's arm. A positive apprehension test was recorded if the participant reported a feeling of apprehension or discomfort during the test. The apprehension test sensitivity = 0.30-0.53 and specificity = 0.63-0.99.

Relocation Test: The relocation test was performed by having the participant lay supine with their arm abducted to 90° with the elbow flexed to 90°. A posterior force was then placed over the humeral head as the examiner passively externally rotates the participant's arm. A positive relocation test was documented if there is an increase in the range of external rotation motion before symptoms/apprehension is reproduced. The relocation test sensitivity = 0.36-0.75 and specificity = 0.40-0.87.

External Rotation (E.R.) Lag Sign: The E.R. lag sign was performed with the participant standing. The examiner passively flexed the participant's elbow to 90°, bringing their shoulder into 20° of abduction, and externally rotating their shoulder. The examiner then released the arm with instructions to hold the position. A positive test was reported if the participant could not maintain the position. ER lag sign sensitivity = 0.56 and specificity = 0.98.

Lift-Off Test: The lift-off test was performed with the participant standing, and the dorsum of their hand placed in the mid-lumbar region of their back. From this position, the participant “lifted" their hand off their back through humeral internal rotation and shoulder extension. A positive test was reported if the participant was unable to lift their hand off their back. The lift-off test sensitivity = 0.92 and specificity = 1.0.

Delimitations

Participants were male and female cadets in the Army ROTC from a single collegiate institution. Participates were at least 18 years of age to ensure no minors were involved and no older than 30 years to include all cadets within the ROTC program.

Limitations

Participants who did not report injury occurrence or activity type and participants that were de-enrolled before the test could be administered

Demographics

Information including height (cm), weight (kg), sex, current age and academic year was collected.

Statistical Analysis

All subject and clinician-generated data will be recorded on paper documents and then entered into an electronic database for analysis. All statistical analyses were performed with SPSS 24.0 (SPSS, Chicago, Il), statistical significance was determined at $P < 0.05$. Descriptive means and standard deviations were calculated for all demographic variables. Pearson correlation analysis was used to explore the relationship between ACFT scores and shoulder strength and range of motion measures. A correlation coefficient of, 0.25 represent a weak relationship, 0.26 – 0.50 fair relationship , 0.51 -0.75 moderate relationship and < 0.75 excellent a relationship. Between-group differences were explored in the patient-reported measures (PENN, QDASH, FABQ), shoulder range of motion, and strength using student t-test and analysis of variance (ANOVA) where appropriate.

CHAPTER 4

RESULTS

Demographics

Information regarding strength, range of motion, patient-reported outcome measures, and pathology tests were gathered from 11 participants (N = 11). Specific data pertaining to demographics can be found in Table 1. Participants had a mean age of 22.7 ± 4.9 years, the mean height of participants was 173.1 ± 10.8 cm, and the mean weight was 80.1 ± 11.3 kg. The mean ACFT total score from the 11 participants was 434.45 ± 75.8 out of 600 possible points. For ACFT events that focused on the Upper Extremity function (leg tuck, hand release push up, overhead ball toss), the mean score was 216.09 ± 54.8 out of 300 possible points. Cadets were categorized based on their score relative to the mean. The above and Below mean categories were generated for Total ACFT and UE test scores.

Cadet Demographics	Min	Max	Mean±SD
Age (yrs)	20	37	22.7±4.9
Height (cm)	157	185	173.1±10.8
Weight (kg)	64	105	80.1±11.3

Table 1. Cadet Demographics.

Demographic information regarding cadets age (yrs.), height (cm), and weight with minimum and maximum range as well as mean ± standard Deviation

Strength Measures

Correlation analysis (Table 3) revealed strong relationships between shoulder external rotation and the ACFT total score and the ACFT upper extremity score on both the right and left side. Moderate correlation was found for the remaining strength measures and the ACFT total and upper extremity scores but these correlations did not reach statistical significance. Specific muscle joint measurements can be found on Table 2. An ANOVA test was preformed to determine the statistical significant differences in muscle strength measurements between cadets who scored above and below the mean ACFT score. All Cadets who scored above the mean in the ACFT test were found to have greater strength with External Rotation (mean difference = 3.8 kg; $F_{(10,1)} = 8.412$; $p = 0.018$), Internal Rotation (mean difference = 2.2 kg; $F_{(10,1)} = 8.023$; $p = 0.021$), and Abduction (mean difference = 2.8 kg; $F_{(10,1)} = 6.855$; $p = 0.028$) on the right side. Similar trends can be found on the left side in cadets who scored above the mean in the ACFT with greater strength measures recorded in External Rotation (mean difference = 2.9 kg; $F_{(10,1)} = 12.870$; $p = 0.006$), Internal Rotation (mean difference = 2.3 kg; $F_{(10,1)} = 5.791$; $p = 0.039$) and Abduction (mean difference = 3.1 kg; $F_{(10,1)} = 7.469$; $p = 0.023$)

In specific muscle strength testing (Table 2), it was found that cadets who scored above the mean ACFT score had greater force output for Serratus Anterior (mean difference = 2.4 kg; $F_{(10,1)} = 6.742$; $p = 0.029$), Lower Trapezius (mean difference = 1.0 kg; $F_{(10,1)} = 6.893$; $p =0.028$), and Middle Trapezius (mean difference = 1.1 kg; $F_{(10,1)} = 6.525$; $p = 0.031$) on their right sides. This pattern was found in the left side as well with significant differences found with the Serratus Anterior (mean difference = 3.0 kg; $F_{(10,1)} = 12.349$; $p = 0.007$), Lower Trapezius (mean difference = 1.3 kg; $F_{(10,1)} = 7.053$; $p = 0.026$) and Middle Trapezius (mean difference = 1.1kg; $F_{(10,1)} = 5.839$; $p = 0.039$)

Grip Strength Testing yielded similar trends, cadets who scored above the mean ACFT score, had higher grip strength measurements in Grip position 2 (mean difference = 7.1 kg; $F_{(10,1)} = 16.286$; $p = 0.003$) and Grip Position 3 (mean difference = 6.5 kg; $F_{(10,1)} = 9.501$; $p = 0.013$) on the right side with similar results on the left with Grip Position 2 (mean difference = 7.7 kg;

$F_{(10,1)}$ = 26.557; p = 0.001) and Grip Position 3 (mean difference = 8.0 kg; $F_{(10,1)}$ = 15.399; p = 0.003)

	All Participants		ACFT Grouping				Upper Extermity Grouping			
			Above		Below		Above		Below	
	Right	**Left**	**Right**	**Left**	**Right**	**Left**	**Right**	**Left**	**Right**	**Left**
External Rotation	11.7 kg ± 2.9 kg	12.3 kg ± 3.6 kg	13.9 kg ± 1.4 kg	15.3 kg ± 2.6 kg	10.0 kg ± 2.6 kg	9.9 kg ± 2.3 kg	13.9 kg ± 1.4 kg	15.3 kg ± 2.2 kg	10.0 kg ± 2.6 kg	9.9 kg ± 2.3 kg
Internal Rotation	13.1 kg ± 3.2 kg	12.5 kg ± 3.5 kg	15.4 kg ± 3.2 kg	14.9 kg ± 3.6 kg	11.2 kg ± 1.5 kg	10.6 kg ± 2.1 kg	15.4 kg ± 3.2 kg	14.8 kg ± 3.6 kg	11.2 kg ± 1.5 kg	10.0 kg ± 2.1 kg
Abduction	11.8 kg ± 4.1 kg	11.6 kg ± 4.4 kg	14.6 kg ± 3.3 kg	14.8 kg ± 3.8 kg	9.4 kg ± 3.1 kg	8.9 kg ± 3.1 kg	14.6 kg ± 3.3 kg	14.8 kg ± 3.8 kg	9.4 kg ± 3.1 kg	8.9 kg ± 3.1 kg
Serratus Anterior	211.5 kg ± 3.6 kg	11.5 kg ± 3.8 kg	13.9 kg ± 3.0 kg	14.6 kg ± 2.7 kg	9.4 kg ± 2.7 kg	9.0 kg ± 2.4 kg	13.9 kg ± 3.0 kg	14.6 kg ± 2.7 kg	9.4 kg ± 2.7 kg	9.0 kg ± 2.4 kg
Lower Trapezius	6.2 kg ± 1.5 kg	6.9 kg ± 1.9 kg	7.6 kg ± 1.3 kg	8.2 kg ± 1.7 kg	5.7 kg ± 1.0 kg	5.8 kg ± 1.2 kg	7.6 kg ± 1.3 kg	8.2 kg ± 1.7 kg	5.7 kg ± 1.0 kg	5.8 kg ± 1.6 kg
Middle Trapezius	6.3 kg ± 1.6 kg	6.6 kg ± 1.7 kg	7.4 kg ± 1.4 kg	7.7 kg ± 1.4 kg	5.3 kg ± 1.2 kg	5.6 kg ± 1.4 kg	7.4 kg ±. 14 kg	7.7 kg ± 1.4 kg	5.4 kg ± 1.2 kg	5.6 kg ± 1.4 kg
Grip Strength 2	44.8 kg ± 8.5 kg	43.2 kg ± 8.6 kg	51.9 kg ± 3.1kg	51.0 kg ± 3.9 kg	38.8 kg ± 6.6 kg	36.7 kg ± 4.9 kg	51.9 kg ± 3.1 kg	51.0 kg ± 3.9 kg	38.8 kg ± 6.6 kg	36.7 kg ± 4.9 kg
Grip strength 3	41.6 kg ± 8.7 kg	40.3 kg ± 9.6 kg	48.1 kg ± 6.1 kg	48.4 kg ± 4.3 kg	36.1 kg ± 6.6 kg	33.6 kg ± 7.3 kg	48.1 kg ± 6.1 kg	48.4 kg ± 4.3 kg	36.1 kg ± 6.6 kg	33.6 kg ± 7.3 kg

Table 2. Mean Cadet Strength Measures.

Measures shoulder strength (kg), figures represent mean ± SD for cadets above and below the mean ACFT total score and mean Upper Extremity ACFT Score.

	ACFT Total				ACFT UE			
	Right		Left		Right		Left	
	Correlation	p	Correlation	p	Correlation	p	Correlation	p
External Roation	0.606	0.048	0.587	0.058	0.671	0.024	0.607	0.048
Internal Rotation	0.472	0.143	0.459	0.155	0.481	0.134	0.514	0.106
Abduction	0.453	0.162	0.394	0.231	0.487	0.129	0.385	0.242
Serratus Anterior	0.255	0.45	0.376	0.355	0.318	0.341	0.41	0.21
Lower Trapzeius	0.375	0.256	0.427	0.19	0.372	0.259	0.402	0.22
Middle Trapzeius	0.318	0.341	0.427	0.19	304	0.363	0.427	0.191
Grip Stength 2	0.539	0.087	0.515	0.105	0.508	0.111	0.476	0.139
Grip Strength 3	0.44	0.175	0.514	0.106	0.421	0.198	0.466	0.148

Table 3. Correlation Analysis Table of Cadet's Strength Measures.

Correlation of ACFT total scores and Upper Extemity ACFT scores to recoreded strength measures.

Range of Motion Measurements

Correlation analysis found no statistically significant correlations between the ACFT total or upper extremity scores and all range of motion measures. An ANOVA test was preformed to determine the statistical significant differences in range of motion measurements between cadets who scored above and below the mean ACFT score. No statistically significant differences were found in range of motion measurements for Cervical Lateral Flexion ($p = 0.349$), Cervical Rotation ($p = 0.618$), Shoulder External Rotation ($p = 0$ .384), Shoulder Internal Rotation ($p = 0.154$), Shoulder Abduction ($p = 0.389$) and Shoulder Flexion ($p = 0.389$) on the right side. There were similar trends seen on the left side for Cervical Lateral Flexion ($p = 0.754$), Cervical Rotation ($p = 0.130$), Shoulder External Rotation ($p = 0.490$), Shoulder Internal Rotation ($p = 0.328$), Shoulder Abduction ($p = 0.389$) and Shoulder Flexion ($p = 0.389$). Additionally, no statistically significant differences were recorded in Cervical Flexion ($p = 0.190$) and Cervical Extension ($p = 0.446$).

	All Participants		ACFT Grouping				Upper Extermity Grouping			
			Above		Below		Above		Below	
	Right	Left	Right	Left	Right	Left	Right	Left	Right	Left
Cervical L. FLX	48.1°±11.5°	49.4°±9.4°	44.40°±14.0°	48.4°±9.2°	51.3°±9.0°	50.3°±10.3°	44.4°±14.0°	48.4°±9.2°	51.3°±9.0°	50.3°±10.3°
Cervical FLX	52.2°±12.3°		57.8°±5.8°		47.6°±14.9°		57.8°±5.8°		47.6°±14.9°	
Cervical EXT	72.1°±15.7°		76.4°±9.6°		68.6°±19.7°		76.4°±9.6°		68.6°±19.7°	
Cervical Rotation	63.2°±9.4°	59.9°±8.1°	61.6°±12.5°	55.8°-±5.84°	65.6°±6.7°	63.3°±8.5°	61.6°±12.6°	55.8°±5.8°	64.6°±6.7°	63.3°±8.5°
Shoulder ER	94.4°±16.2°	87.0°±10.6°	99.4°±13.4°	89.6°±12.7°	90.3°±18.3°	84.8°±9.2°	99.4°±13.4°	84.8°±9.2°	90.3°±18.3°	84.8°±9.2°
Shoulder IR	71.7°±14.4°	75.8°±11.2°	64.8°±13.0°	72.0°±15.5°	77.5°±18.8°	79.0°±5.5°	64.8°±13.0°	72.0°±15.5°	77.5°±13.8°	79.0°±5.5°
Shoulder ABD	176.5°±11.4°	176.0°±12.9°	180.0°±.0°	180.0°±.0°	173.6°±15.5°	172.8°±17.5°	180.0°±.0°	180.0°±.0°	173.6°±15.5°	172.8°±17.5°
Shoulder Flexion	117.0°±9.9°	176.3°±12.0°	180.0°±.0°	180.0°±.0°	174.5°±13.4°	173.3°±16.3°	180.0°±.0°	180.0°±.0°	174.5°±13.4°	173.3°±16.3°

Table 4. Mean Cadet Range of Motion Measurements.

Figures represent mean Range of Motion measurements (º = degrees) ± Standard Deviation cadets above and below the mean ACFT total score and mean Upper Extremity ACFT Score.

Patient-Reported Outcome Measures

Specific data regarding PENN outcome measure scores can be found in Table 5.. An ANOVA test was performed to determine the statistically significant differences in patient-reported outcome measurement scores between cadets who scored above and below the mean ACFT score. There were no statistically significant differences found between cadets who scored above the ACFT mean score and those who scored below the mean. Within the three sections, Pain ($p = 0.434$), Satisfaction ($p = 0.237$) and Function ($p = 0.065$), and the Total Score ($p = 0.176$) there is no recorded effect between ACFT scores and the PENN outcome measure.

Similar results were seen with the DASH outcome measurement tool. No statistically significant differences were found when an ANOVA test was performed on Shoulder function ($p = 0.297$), Elbow function ($p = 0.618$) on the right side, and with related results for left shoulder function ($p = 0.297$) and elbow function ($p = 0.900$) as well as neck function ($p = 0.093$). No variance was found within groups for left and right wrist function as statistics could not be computed. Both groups scores provided a 100% on their self-reported outcome for the wrist

FABQ scores followed a similar trend as the other outcome measures. Cadets within both above mean and below mean categories scored low in both work and activity-related sections. Mean scores for work were 4.3 ± 5.1 points, and recorded activity scores were 1.6 ± 2.0. Total FABQ scores between both groups was 6.6 ± 17.9 out of a maximum of 96. Low scores indicated less fear and avoidance behaviors within the total cadet sample population.

Special Tests for Shoulder Pathology

Positive results were elicited on the right side for the Sulcus Sign (n = 1), Hawkins Kennedy Test (n = 1) and Apprehension Test (n = 1). The singular positive observed on the left side was found in the Scapular Assist Test (n = 1). No clinical signs of pathology were identified. Also note that these positive tests were not found on the same individual.

		ACFT Grouping		UE Grouping	
PROM	Total	Above	Below	Above	Below
PENN - Pain	29.2±1.9	29.60±.54	29.0±1.5	29.6±.54	29.0±1.5
PENN - Satisfaction	9.3±1.5	10.0±.0	8.8±2.0	10.0±.0	8.8±2.0
PENN - Function	59.0±1.5	60.0±.0	58.3±1.7	60.0±.0	58.3±1.7
PENN - Total	97.7±4.0	99.6±.54	96.1±5.1	99.6±.54	96.1±5.1
FABQ- Work	4.3±5.1	2.0±4.3	2.0±2.0	2.0±4.3	2.0±2.0
FABQ - Activity	1.6±2.0	8.4±10.3	4.1±3.5	8.4±10.3	4.1±3.5
FABQ - Total	6.6±7.2	14.2±17.9	7.5±5.3	14.2±17.9	7.5±5.3
DASH Score	1.6±2.0	0.9±2.0	2.2±2.0	0.0±2.0	2.2±2.0

Table 5. Patient Reported Outcome Measure Scores.

Mean scores ± Standard Deviation of the PENN (Pain, Satisfaction, Function, Total), FABQ (Work, Activity, Total), and DASH outcome measures.

CHAPTER 5

DISCUSSION

The purpose of this study was to characterize the relationship between physical impairments of the shoulder (strength and range of motion) and ACFT scores. The US Army developed the ACFT to an assessment of physical ability related to functional combat activities. Physical impairment of the shoulder has been shown to have a relationship with decreased overall shoulder function.[44,45,49,50] The alternative hypothesis for the current study was that participants that score higher on the ACFT will have better patient-reported outcome measures and fewer strength or motion impairments. The hypotheses of the current study were supported in part. Cadets that scored higher on the ACFT had higher shoulder and grip strength measures than cadets that scored low on the ACFT (Table 2). However, there were no differences in shoulder range of motion measures between cadets that scored high or low on the ACFT. There seems to be no relationship between motion impairment and ACFT scores. Statistically significant differences were not observed in either patient outcome measures or special tests.

Strength measures were found to be higher in cadets that scored above the mean ACFT score. The current study found higher strength measures in cadets with high ACFT scores than low ACFT scores in all strength categories. Correlation analysis found that cadets scoring above the mean ACFT correlated very high to external rotation. While there was a moderate correlation found in grip strength measures, it was not statistically significant, likely due to small sample size. However, the stronger the cadets were in ER, they would probably score higher. Various literature examines the effect of internal and external rotation strength on injury risk with very little exploring the relationship between strength and performance, especially in a military population.[80-82] Given our results, we found that shoulder strength impairments in the cadet population are predictive of low scores on the ACFT. This finding does not mean that increasing shoulder strength within the population will increase ACFT scores, as that relationship needs to be explicitly studied.

The results of the current study are similar to the results of Šimenko et al.[83] Šimenko et al.[83] aimed to explore the relationship between the Slovenian Army Physical Fitness Test (APFT) to a functional testing battery that focused on functional military duties. The functional tests included countermovement jump testing, stork balance test, pull-ups, single leg hamstring bridge test, and loaded prone plank tests. They chose to substitute push-ups with pull-ups exercise. Previous studies report that the upper body "push" musculature is stronger rather than "pull" musculature.[84] Šimenko et al.[83] hypothesized that strength imbalances such as those might be even greater in soldiers. They theorized that soldiers are explicitly training for the standard APFT and targeting the push-up muscle groups during their exercise while rarely using musculature involved in pull-ups, which may have other associations with a soldier's risk of injury or performance. The association between shoulder strength and the risk of shoulder injury has been established in military injury epidemiology studies.[2-4,6-9,12,14-23,25,27,29] The soldiers scoring high on the Slovenian APFT, which included a push-up test, did not perform well on the pull-ups, confirming their assumption about weakness in muscle groups involved in pull-ups. The Slovenians created the functional testing battery to gauge whether a soldier who scored well on the traditional physical fitness test would have similar performance outcomes on a test that mimicked military duties. The reasoning behind the change in the Slovenians APTF is in keeping with the US Army's H2F transition and the creation of the US Army's ACFT to ensure that soldiers are prepared for combat and functional military duties holistically. Their findings can provide insight and comparison for this current study as well as future related studies.

Although all strength measures had a statistically significant difference between above and below mean groups, external rotation had the highest correlation (r = 0.606). Negrete et al. (2013) aimed to identify normative values for upper body pushing and pulling musculature for females and males. Participants completed two tests of upper body strength; push-ups for 3 sets of maximum repetitions in 15 seconds with a 45-second rest period between sets and modified pull-ups for 3 sets of maximum repetitions in 15 seconds with a 45-second rest between sets. The Negrete results suggest that the upper body pushing musculature was 1.5-2.7 times stronger than the musculature involved for pulling. Imbalances in strength between agonist/antagonist muscle groups may predispose an individual to injury and affect performance outcomes. Relative to the current study, this can explain why cadets scoring below the mean also had lower external rotation measures.

Another study by Kolber et al.[85] sought to examine shoulder joint, and muscle characteristics in the recreational weigh training (RWT) population and determine whether a significant difference in joint and muscle characteristics was present between trained and control groups. Similar to the current study, Kolber et al.[85] took abductor, external rotator, internal rotator, upper and lower trapezius strength measurements and found strength values for abductors, internal rotators, and upper trapezius muscle groups were significantly greater in the RWT group. However, Kolber[85] did not find significant differences in external rotation strength between their RWT and control groups (p = 0.18)[85]. Additional results found that the commonly trained muscle groups such as the upper trapezius, pectorals, and deltoids were greater in the RWT group. The external rotators and lower trapezius musculature were not significantly greater, which creates an imbalance of muscle groups that normally function synchronously. These results are like the current findings, as cadets had greater internal rotation strength than external strength in all but one category (left shoulder above mean cadets IR = 14.9kg and ER = 15.3kg). Previous literature has reported that individuals with shoulder disorders have greater deficits in external rotational strength than internal rotation or abduction strength.[80-82 86-88] This relationship between strength impairments can be due to training programs that emphasize deltoid muscles and neglect the rotator cuff, creating functional muscle imbalances. Imbalances in the shoulder can lead to altered kinematics, restricted ROM, and several shoulder pathologies. This information can create weight training programs for cadets that target the imbalances found in the current study.

Range of motion data relative to our study found no statistically significant correlations or differences between the ACFT total or upper extremity scores in all range of motion measures. Although there was no between-group range of motion impairments found, that does not necessarily equate to a lack of relationship between shoulder range of motion and the ACFT score. The mean range of motion measure fell within the range of generally acknowledged ranges of motion norms. No cadet in the current study had shoulder range of motion impairment. Mean External Rotation range of motion measurements in this study was 94.4º ± 16.2º and 87.0 ± 10.6 for left and right respectively, with general normative values of 93º ± 12.4º for males and 93º ± 13.2º for females.[89] Our study's internal rotation motion measurements were recorded as 71.7º ± 14.4 º for the right and 75.8º ± 11.2º for the left arm. Normative data have been recorded with a range of 58º± 12.0º to 102° ± 7.7°.[89,90] Mean difference values for shoulder abduction in a relevant age population (20-24 years) have been recorded as 158.6º in males and 156.2º in females.[91] Our current study found values that slightly exceed that at 176.5º ± 11.4º and 176.0º ±

12.9º for left and right, respectively. This can be due to varying measurement techniques or specific cadet measurements that can skew the data. A systematic review of cervical range of motion normative values using the CROM found values that were all within close range of our findings. Cervical flexion in the review was recorded as 59.7°, with our mean of 52.2°. Similar for cervical flexion (75.1°/72.1°), lateral flexion right (44.7°/48.1°), lateral flexion left (45.4°/49.4°), rotation left (73.4°/63.2°) and rotation left (75.1°/59.9°).[92] As the sample population consists of generally healthy, active, and young individuals, range of motion measurements fell within the accepted normal limits.

Patient-reported outcome measures also yielded non-statistically significant findings. Between the PENN, DASH, and FABQ scores, cadets reported low pain outcomes, high satisfaction and function, and low fear and avoidance behaviors. High scores on the PENN indicate high function, low pain, and high satisfaction.[93] The highest score attainable on the PENN is 100, and the mean score of the study participants totaling 97.7 ± 4.0, showing favorable outcomes. The QDASH, is scored from 0 to 100, with 0 equating to no disability. The cadets in this study recorded high percentages of functionality and low disability across the three categories. The scores on the FABQ outcome measure reflect little to no fear and avoidance behaviors. These scores reflect a generally healthy population not suffering from known shoulder pathologies, impairments, or disabilities and high physical activity functioning. Negative tests for specific shoulder pathology results also highlight the overall health and function of the sample population.

Moving forward, this information can be used to identify weaknesses in training programs and individual cadet strength measures. The decreased shoulder external rotation strength can contribute to muscular imbalances, impairments, and decreased physical performance. The findings from the current study will assist healthcare providers in creating physical training programs that holistically address the shoulder musculature. Improving shoulder strength could lead to improved ACFT scores and reduce the risk of a shoulder injury. As the U.S military spends millions of dollars per year on injury-related costs, creating training programs and identifying areas of significance can help in preventing chronic and long-term injuries from occurring.[4,19-22] The Holistic Health and Fitness initiative aims to improve combat readiness within the US Army. However, if a soldier cannot perform well on the ACFT, which is used to gauge that readiness due to strength deficits, impaired movements, or lack of function, issues leading to those factors must be addressed.

Limitations of the Study

There were several limitations of the current study. The collected sample population size was small compared to the total size of the battalion. This can be due to several factors. Many cadets do not live in the area. The cadets are unable to participate in testing and COVID-19 pandemic restrictions limiting the availability of the cadets and the authors of this study. Another limitation of the current study was the lack of literature regarding the new physical fitness test. As of Spring 2021, the ACFT is still being assessed and altered to suit the Army's needs. Although the individual components of the test have been studied, the combination of events has not, which is an area that needs additional study. Other limitations to the current study may include the specific utility of special tests for shoulder pathology, including sensitivity, specificity, and predictive values related to the singular test and clinical predictive rule combinations. Although this study has established that strength impairments can be predictive of a low score on the ACFT, which has been developed to predict combat readiness and overall fitness, the findings cannot answer the effect increasing strength will have on ACFT scores.

Recommendations for Future Research

Future research should focus on assessing the effect of a strengthening program, similar to the Throwers Ten, which upper extremity athletes commonly use, on total ACFT scores. Additionally, the collection of personal training program data from cadets can provide information on the current volume and intensity of exercise and highlight areas of improvement. Future research can also include collecting data on education level pertaining to exercise. Implementing educational programs that inform and instruct on proper exercise techniques and form can potentially decrease injury rates and increase performance outcomes. As the ACFT evolves, additional research should concentrate on collecting follow-up data on cadets to track how they develop through the program and include collaborative efforts from multiple ROTC programs to compare and identify relative factors.

Conclusion

Cadets who scored higher than the mean on the ACFT were found to have higher strength measures, most significantly in External Rotation strength. All recorded strength measures had statistical significance on total scores, while Range of Motion and Patient-Reported outcome measures had little impact on performance. By targeting strength imbalances with focused training programs, injury rate could decrease, and performance outcomes on the ACFT can improve along with greater combat readiness.

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APPENDIX A: OFFICE OF RESEARCH INTEGRITY APPROVAL LETTER

MARSHALL UNIVERSITY

www.marshall.edu

Office of Research Integrity
Institutional Review Board
One John Marshall Drive
Huntington, WV 25755

FWA 00002704

IRB1 #00002205
IRB2 #00003206

September 9, 2020

Mark Timmons, PhD
School of Kinesiology, Marshall University

RE: IRBNet ID# 1654309-1
At: Marshall University Institutional Review Board #1 (Medical)

Dear Dr. Timmons:

Protocol Title:	[1654309-1] The relationship between the ACFT and upper extremity pain and function.	
Site Location:	MU	
Submission Type:	New Project	APPROVED
Review Type:	Expedited	

In accordance with 45CFR46.110(a)(4), (6) and (7), the above study was granted Expedited approval today by the Marshall University Institutional Review Board #1 (Medical) Chair. An annual update will be required on September 9, 2021 for administrative review and approval. The update must include the Annual Update Form and current educational certificates for all investigators involved in the study. All amendments must be submitted for approval by the IRB Chair prior to implementation and a closure request is required upon completion of the study.

If you have any questions, please contact the Marshall University Institutional Review Board #1 (Medical) Coordinator Margaret Hardy at (304) 696-6322 or hardyma@marshall.edu. Please include your study title and reference number in all correspondence with this office.

Sincerely,

Bruce F. Day

Bruce F. Day, ThD, CIP
Director, Office of Research Integrity

APPENDIX B: INFORMED CONSENT

Informed Consent to Participate in a Research Study

The relationship between the ACFT and upper extremity pain and function.

Mark K Timmons PhD ATC, Principal Investigator

Marshall University IRB

Approved on:	9/9/20
Study number:	1654309

Key Information

You are invited to participate in a research study. Research studies are designed to gain scientific knowledge that may help other people in the future. You may or may not receive any benefit from being part of the study. Your participation is voluntary. Please take your time to make your decision and ask your research investigator or research staff to explain any words or information that you do not understand. The following is a short summary to help you decide why you may or may not want to be a part of this study. Information that is more detailed is listed later in this form.

The purpose of the study is to increase the understanding of the mechanisms that produce shoulder and upper extremity pain in ROTC students. This information will help healthcare providers develop better treatment plans for these individuals. You will be asked to complete the Army Combat Fitness Test and have the strength and motion of your shoulder measured. You will also have ultrasound images of your shoulder taken. We expect that you will be in this research study for about 90 minutes. The primary risk of participation is fatigue of your shoulder and arm muscles.

How Many People Will Take Part in The Study?

About 30 people will take part in this study. A total of 40 subjects are the most that would be able to enter the study.

What Is Involved in This Research Study?

You will take part in 2 testing sessions. First, you will complete the Army Combat Fitness Test as part of your participation in the ROTC program. At a time separate from the ACFT you will fill out questionnaires about your back, shoulder, and arm then the researcher will perform an examination of your shoulder and upper extremity and make several measurements of your shoulder strength and motion. The researchers will take pictures of your shoulder to help make some of the measurements. After the examination, the researcher will use an ultrasound machine to make several images of both of your shoulders. During the ultrasound imaging you will need to wear a sleeveless or tank top shirt. During the ultrasound imaging you will be asked to sit down, and your arm will be placed in several positions, you will also be asked to perform several contractions of your shoulder muscles. You will have several small sensors taped to your shoulder and arm. These sensors will measure your arm motion and muscle activity. During each testing session you will do several overhead arm motions that will fatigue your shoulder muscles. The questionnaires, shoulder examination, and ultrasound imaging will take about 90 minutes to complete.

What about Alternative Procedures?

There are no alternative procedures to this investigation; you do not have to participate in this study.

Subject's Initials ________

What Are Your Rights as A Research Study Participant?

You may choose not to take part, or you may leave the study at any time. Refusing to participate or leaving the study will not result in any penalty or loss of benefits to which you are entitled. If you decide to stop participating in the study, we encourage you to talk to the investigators or study staff first.

The study investigator may stop you from taking part in this study at any time if he/she believes it is in your best interest; if you do not follow the study rules; or if the study is stopped.

Detailed Risks of The Study

You might experience fatigue of your shoulder and arm muscles during the testing this fatigue feeling might last for a few hours following the testing. The feeling will be like the feelings you experience during exercise or prolonged walking. The sensors will be held in place with adhesive tape like the tape used to hold band aids in place. A few people might develop a mild allergic reaction to the tape.

What About Confidentiality?

We will do our best to make sure that your personal information is kept confidential. However, we cannot guarantee absolute confidentiality. Federal law says we must keep your study records private. Nevertheless, under unforeseen and rare circumstances, we may be required by law to allow certain agencies to view your records. Those agencies would include the Marshall University IRB, Office of Research Integrity (ORI) and the federal Office of Human Research Protection (OHRP). This is to make sure that we are protecting your rights and your safety. If we publish the information we learn from this study, you will not be identified by name or in any other way.

What Are the Costs of Taking Part in This Study?

There are no costs to you for taking part in this study. All the study costs, including any study tests, supplies and procedures related directly to the study, will be paid for by the study.

Will You Be Paid for Participating?

You will receive no payment or other compensation for taking part in this study.

What About Identifiable Private Information or Identifiable Biospecimens?

Your information or biospecimens collected as part of the research, even if identifiers are removed, will not be used or distributed for future research studies.

Subject's Initials ________

Whom Do You Call If You Have Questions or Problems?

For questions about the study or in the event of a research-related injury, contact the study investigator, **Mark K Timmons PhD at (304) 696-2925**. You should also call the investigator if you have a concern or complaint about the research.

For questions about your rights as a research participant, contact the Marshall University Office of Research Integrity (ORI) at (304) 696-4303. You may also call this number if:

- You have concerns or complaints about the research.
- The research staff cannot be reached.
- You want to talk to someone other than the research staff.

You will be given a signed and dated copy of this consent form.

SIGNATURES

You agree to take part in this study and confirm that you are 18 years of age or older. You have had a chance to ask questions about being in this study and have had those questions answered. By signing this consent form, you are not giving up any legal rights to which you are entitled.

____
Subject Name (Printed)

____ ______________
Subject Signature Date

____
Person Obtaining Consent (Printed)

____ ______________
Person Obtaining Consent Signature Date

Subject's Initials ________

APPENDIX C: FABQ INIITAL FORM

Subject number ______________________ Date _______________

Here are some of the things which <u>other</u> patients have told us about their pain. For each statement please circle any number from 0 to 6 to say how much physical activities such as bending, lifting, walking or driving affect or would affect <u>your</u> pain.

	COMPLETELY DISAGREE			UNSURE			COMPLETELY AGREE
1. My pain was caused by physical activity	0	1	2	3	4	5	6
2. Physical activity makes my pain worse	0	1	2	3	4	5	6
3. Physical activity might harm me	0	1	2	3	4	5	6
4. I should not do physical activities which (might) make my pain worse	0	1	2	3	4	5	6
5. I cannot do physical activities which (might) make my pain worse	0	1	2	3	4	5	6

The following statements are about how your normal work affects or would affect your pain.

	COMPLETELY DISAGREE			UNSURE			COMPLETELY AGREE
6. My pain was caused by my work or by an accident at work	0	1	2	3	4	5	6
7. My work aggravated my pain	0	1	2	3	4	5	6
8. I have a claim for compensation for my pain	0	1	2	3	4	5	6
9. My work is too heavy for me	0	1	2	3	4	5	6
10. My work makes or would make my pain worse	0	1	2	3	4	5	6
11. My work might harm my back	0	1	2	3	4	5	6
12. I should not do my normal work with my present pain	0	1	2	3	4	5	6
13. I cannot do my normal work with my present pain	0	1	2	3	4	5	6
14. I cannot do my normal work until my pain is treated	0	1	2	3	4	5	6
15. I do not think that I will be back to my normal work within 3	0	1	2	3	4	5	6
16. I do not think that I will ever be able to go back to that work	0	1	2	3	4	5	6

APPENDIX D: QDASH FORM

*Quick*DASH

Please rate your ability to do the following activities in the last week by circling the number below the appropriate response.

	NO DIFFICULTY	MILD DIFFICULTY	MODERATE DIFFICULTY	SEVERE DIFFICULTY	UNABLE
1. Open a tight or new jar.	1	2	3	4	5
2. Do heavy household chores (e.g., wash walls, floors).	1	2	3	4	5
3. Carry a shopping bag or briefcase.	1	2	3	4	5
4. Wash your back.	1	2	3	4	5
5. Use a knife to cut food.	1	2	3	4	5
6. Recreational activities in which you take some force or impact through your arm, shoulder or hand (e.g., golf, hammering, tennis, etc.).	1	2	3	4	5

	NOT AT ALL	SLIGHTLY	MODERATELY	QUITE A BIT	EXTREMELY
7. During the past week, *to what extent* has your arm, shoulder or hand problem interfered with your normal social activities with family, friends, neighbours or groups?	1	2	3	4	5

	NOT LIMITED AT ALL	SLIGHTLY LIMITED	MODERATELY LIMITED	VERY LIMITED	UNABLE
8. During the past week, were you limited in your work or other regular daily activities as a result of your arm, shoulder or hand problem?	1	2	3	4	5

Please rate the severity of the following symptoms in the last week. *(circle number)*	NONE	MILD	MODERATE	SEVERE	EXTREME
9. Arm, shoulder or hand pain.	1	2	3	4	5
10. Tingling (pins and needles) in your arm, shoulder or hand.	1	2	3	4	5

	NO DIFFICULTY	MILD DIFFICULTY	MODERATE DIFFICULTY	SEVERE DIFFICULTY	SO MUCH DIFFICULTY THAT I CAN'T SLEEP
11. During the past week, how much difficulty have you had sleeping because of the pain in your arm, shoulder or hand? *(circle number)*	1	2	3	4	5

*Quick*DASH **DISABILITY/SYMPTOM SCORE** = $\left(\left[\frac{\text{sum of n responses}}{n}\right] - 1\right) \times 25$, where n is equal to the number of completed responses.

A *Quick*DASH score may not be calculated if there is greater than 1 missing item.

*Quick*DASH

WORK MODULE (OPTIONAL)

The following questions ask about the impact of your arm, shoulder or hand problem on your ability to work (including homemaking if that is your main work role).

Please indicate what your job/work is:____

❒ I do not work. (You may skip this section.)

Please circle the number that best describes your physical ability in the past week.

Did you have any difficulty:	**NO DIFFICULTY**	**MILD DIFFICULTY**	**MODERATE DIFFICULTY**	**SEVERE DIFFICULTY**	**UNABLE**
1. using your usual technique for your work?	1	2	3	4	5
2. doing your usual work because of arm, shoulder or hand pain?	1	2	3	4	5
3. doing your work as well as you would like?	1	2	3	4	5
4. spending your usual amount of time doing your work?	1	2	3	4	5

SPORTS/PERFORMING ARTS MODULE (OPTIONAL)

The following questions relate to the impact of your arm, shoulder or hand problem on playing *your musical instrument or sport or both*. If you play more than one sport or instrument (or play both), please answer with respect to that activity which is most important to you.

Please indicate the sport or instrument which is most important to you:________________________________

❒ I do not play a sport or an instrument. (You may skip this section.)

Please circle the number that best describes your physical ability in the past week.

Did you have any difficulty:	**NO DIFFICULTY**	**MILD DIFFICULTY**	**MODERATE DIFFICULTY**	**SEVERE DIFFICULTY**	**UNABLE**
1. using your usual technique for playing your instrument or sport?	1	2	3	4	5
2. playing your musical instrument or sport because of arm, shoulder or hand pain?	1	2	3	4	5
3. playing your musical instrument or sport as well as you would like?	1	2	3	4	5
4. spending your usual amount of time practising or playing your instrument or sport?	1	2	3	4	5

SCORING THE OPTIONAL MODULES: Add up assigned values for each response; divide by 4 (number of items); subtract 1; multiply by 25.

An optional module score may not be calculated if there are any missing items.

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APPENDIX E: PENN SHOULDER SCORE

Subject ID number: ____________________ **Date:** ___/___/___

Penn Shoulder Score

PENN SHOULDER SCORE **Part I: Pain & Satisfaction:** Please circle the number closest to your level of pain or satisfaction	
Pain at rest with your arm by your side: 0 1 2 3 4 5 6 7 8 9 10 No Pain Possible … Worst Pain	office use only _______ (10 - # circled)
Pain with normal activities (eating, dressing, bathing): 0 1 2 3 4 5 6 7 8 9 10 No Pain Possible … Worst Pain	_______ (10 - # circled)
Pain with strenuous activities (reaching, lifting, pushing, pulling, throwing): 0 1 2 3 4 5 6 7 8 9 10 No Pain Possible … Worst Pain	_______ (10 - # circled)
PAIN SCORE:	=____/**30**
How satisfied are you with the current level of function of your shoulder? 0 1 2 3 4 5 6 7 8 9 10 Not Satisfied … Very Satisfied	=____/**10** (# circled)

Page **5** of **11**

Subject ID number: ____________________ **Date:** ___/___/___

Part II: Function: Please circle the number that best describes the level of difficulty you might have performing each activity.	No difficulty	Some difficulty	Much difficulty	Can't do at all	Did not do before injury
1. Reach the small of your back to tuck in your shirt with your hand.	3	2	1	0	X
2. Wash the middle of your back/hook bra.	3	2	1	0	X
3. Perform necessary toileting activities.	3	2	1	0	X
4. Wash the back of opposite shoulder.	3	2	1	0	X
5. Comb hair.	3	2	1	0	X
6. Place hand behind head with elbow held straight out to the side.	3	2	1	0	X
7. Dress self (including put on coat and pull shirt on overhead.	3	2	1	0	X
8. Sleep on affected side.	3	2	1	0	X
9. Open a door with affected side.	3	2	1	0	X
10. Carry a bag of groceries with affected arm.	3	2	1	0	X
11. Carry a briefcase/small suitcase with affected arm.	3	2	1	0	X
12. Place a soup can (1-2 lbs.) on a shelf at shoulder level without bending elbow.	3	2	1	0	X
13. Place a one gallon container (8-10 lbs.) on a shelf at Shoulder level without bending elbow.	3	2	1	0	X
14. Reach a shelf above your head without bending your elbow.	3	2	1	0	X
15. Place a soup can (1-2 lbs.) on a shelf overhead without bending your elbow.	3	2	1	0	X
16. Place a one gallon container (8-10 lbs.) on a shelf Overhead without bending your elbow.	3	2	1	0	X
17. Perform usual sport/hobby.	3	2	1	0	X
18. Perform household chores (cleaning, laundry, cooking).	3	2	1	0	X
19. Throw overhand/swim/overhead raquet sports. (circle all that apply to you)	3	2	1	0	X
20. Work full-time at your regular job.	3	2	1	0	X
SCORING: Total of columns = (a) Number of "X's" x 3 = (b), 60 – (b) = (c) (if no "X's" are circled, function score = total of columns) Function Score = ___(a) / ___(c) = ___ x 60 = ___/60					

Stop Here. Remainder to be completed by study personnel. Thank you.

APPENDIX F: RESEARCH STUDY QUESTOINNAIRE PACKET

Subject ID number: ____________________ **Date: ___/___/___**

The relationship between the ACFT and upper extremity pain and function.

Initial Data Collection Forms

Procedure Checklist

1. Inclusion & exclusion criteria
   a. Eligibility Screening exam
2. Subject Informed Consent
   a. Read, discuss, ask questions, sign
3. General Questions- Eligibility and Screening
   a. Intake information
   b. Patient reported outcomes (Penn Shoulder Score, DASH)
   c. Physical activity assessment
   d. Height, Weight
   e. Arm length
4. Clinical Evaluation
5. Scapular Dyskinesis
6. Strength Procedure
   a. ER
   b. IR
   c. ABd
7. Posture assessment
8. Ultrasound Imaging- tendon thickness, AHD
9. Kinematics and EMG

Inclusion criteria:

__1. At least 18 years of age
__2. No current shoulder or arm pain (pain < 2/10)
__3. An ROTC student

Exclusion criteria (any 1 excludes):

__1. Active or passive cervical spine range produces shoulder symptoms
__2. Is not enrolled in the Marshall University ROTC program
__3. Systemic musculoskeletal disease
__4. Not able to elevate either shoulder to 120°.
__5. Shoulder range of motion restricted ≥ 50% in any plane of motion.
__6. Shoulder pain ≥7/10
__7. Greater than 30 years of age.

Subject meets inclusion/exclusion criteria (circle one): 1= Yes 2= No

Research Study Questionnaire
Participant completes:

DOB (mm/dd/yy): ____/___/____

Age: _____ (years) **Sex:** 1 = Female 2 = Male

1. **Do you have any systemic musculoskeletal disease (like Rheumatoid Arthritis)?**
   (Circle One) 1 = Yes If yes, please list__________________________
   2 = No

2. **Do you have shoulder pain or have had shoulder pain in the last 6 months?**
   (Circle One) 1 = Yes 2 = No

3. **Which shoulder is your dominant shoulder?**
   1 = Right
   2 = Left
   3 = Ambidextrous

4. **How would you rate your shoulders today (as "a percentage of normal")?**

   Right shoulder (0% - 100% with 100% being normal) = _______**%**

   Left shoulder (0% - 100% with 100% being normal) = _______**%**

5. **Do you have a known shoulder problem/ pathology?**

   1 = Yes 2 = No

   a. If yes, which shoulder? 1 = Right 2 = Left 3= Both

   b. If yes, have you sought treatment for this problem
      1 = Yes 2 = No

   c. If yes, when did your shoulder pain start?
      1 ____ Less than 6 weeks ago
      2 ____ 6-12 weeks ago
      3 ____ More than 12+ weeks ago
      4 ____ I do not have shoulder pain

   d. If yes, please describe: ____

Subject ID number: ____________________ **Date:** ___/___/___

6. How would you rate your elbow today as "a percentage of normal"?

Right elbow (0% - 100% with 100% being normal) = _______**%**

Left elbow (0% - 100% with 100% being normal) = _______**%**

7. Do you have a known elbow problem/ pathology?

1 = Yes 2 = No

a. If yes, which elbow? 1 = Right 2 = Left 3= Both

b. If yes, have you sought treatment for this problem

1 = Yes 2 = No

c. If yes, when did your elbow pain start?

1 ____ Less than 6 weeks ago
2 ____ 6-12 weeks ago
3 ____ More than 12+ weeks ago
4 ____ I do not have shoulder pain

d. If yes, please describe: ______________________________

____
____
____

8. How would you rate your wrist today as "a percentage of normal"?

Right wrist (0% - 100% with 100% being normal) = _______**%**

Left wrist (0% - 100% with 100% being normal) = _______**%**

9. Do you have a known wrist problem/ pathology?

1 = Yes 2 = No

a. If yes, which elbow? 1 = Right 2 = Left 3= Both

b. If yes, have you sought treatment for this problem

1 = Yes 2 = No

c. If yes, when did your wrist pain start?

1 ____ Less than 6 weeks ago
2 ____ 6-12 weeks ago
3 ____ More than 12+ weeks ago
4 ____ I do not have shoulder pain

d. If yes, please describe: ______________________________

____
____
____

Subject ID number: ____________________ **Date: ____/____/____**

10. How would you rate your neck / upper trunk today as "a percentage of normal"?

(0% - 100% with 100% being normal) = _______**%**

11. Do you have a known neck / upper trunk problem/ pathology?

1 = Yes 2 = No

a. If yes, which **neck / upper trunk**? 1 = Right 2 = Left 3= Both

b. If yes, have you sought treatment for this problem

1 = Yes 2 = No

c. If yes, when did your **extremity** pain start?

1 ____ Less than 6 weeks ago
2 ____ 6-12 weeks ago
3 ____ More than 12+ weeks ago
4 ____ I do not have shoulder pain

If yes, please describe: ____

____

____

____

Subject ID number: ____________________ **Date: ___/___/___**

Screening Exam
Research Team completes

Subject height: __________(cm) **Subject weight:**_______________(Kg)

Cervical motion reproduces shoulder pain: Yes No

Right lateral flex	___________
Left lateral flex	___________
Flexion	___________
Extension	___________
Right rotation	___________
Left rotation	___________

Shoulder AROM:

	Right Shoulder	**Left Shoulder**
ER	___________	___________
IR	___________	___________
Abduction	___________	___________
Flexion	___________	___________

Posture assessment	**measure 1**	**measure 2**
T1-T3 angle	___________	___________
T10-T12 angle	___________	___________

Special Tests:	**Right shoulder**		**Left Shoulder**	
Painful Arc	+	-	+	-
Drop Arm	+	-	+	-
ER LAG sign:	+	-	+	-
Sulcus Sign	+	-	+	-
Hawkins:	+	-	+	-
Neer:	+	-	+	-
Lift off test	+	-	+	-
SAT (flex)	+	-	+	-

Pain levels with the SAT: Flexion
Right Flexion = pain ___/10 Flexion w/ SAT = pain ___/10
Left Flexion = pain ___/10 Flexion w/ SAT = pain ___/10

Apprehension test	+	-	+	-
Relocation	+	-	+	-

Scapular Dyskinesia Test, External load, 0 lbs. 3 lbs. (BW < 68.2kg, 150lbs), 5 lbs. (BW >68.2kg, 150)

Right

Flexion	Normal	Subtle	Obvious
Classification	Winging	Shrugging	Dumping

Left

Flexion	Normal	Subtle	Obvious
Classification	Winging	Shrugging	Dumping

Subject ID number: ____________________ **Date:** ___/___/___

Participant's Physical Measures

Arm Length (cm)	Trial 1	Trial 2
Right arm		
Posterior Acromion → Olecranon		
Olecranon → Ulnar styloid		
Left arm		
Posterior Acromion → Olecranon		
Olecranon → Ulnar styloid		

Pre-Exercise FORCE AND PAIN

Right Shoulder

Trial	Condition	Pain (0-10)	Force (lbs.)
1	ER IR ABD		
2	ER IR ABD		
3	ER IR ABD		
4	ER IR ABD		
5	ER IR ABD		
6	ER IR ABD		

Left Shoulder

Trial	Condition	Pain (0-10)	Force (lbs.)
1	ER IR ABD		
2	ER IR ABD		
3	ER IR ABD		
4	ER IR ABD		
5	ER IR ABD		
6	ER IR ABD		

Pre exercise Manual Muscle Tests

	Right 1		Right 2		Left 1		Left 2	
	Force	Pain	Force	Pain	Force	Pain	Force	Pain
Serratus anterior								
Lower Trapezius								
Middle trapezius								
Grip Strength position 2								
Grip Strength position 3								

Subject ID number: ______________________ **Date:** ____/____/____

Post exercise Scapular Dyskinesia Test, External load, 0 lbs. 3 lbs. (BW < 68.2kg, 150lbs), 5 lbs. (BW >68.2kg, 150)

Right				
	Flexion	Normal	Subtle	Obvious
	Classification	Winging	Shrugging	Dumping
Left				
	Flexion	Normal	Subtle	Obvious
	Classification	Winging	Shrugging	Dumping

Post Exercise FORCE AND PAIN

Right Shoulder

Trial	Condition	Pain (0-10)	Force (lbs.)
1	ER IR ABD		
2	ER IR ABD		
3	ER IR ABD		
4	ER IR ABD		
5	ER IR ABD		
6	ER IR ABD		

Left Shoulder

Trial	Condition	Pain (0-10)	Force (lbs.)
1	ER IR ABD		
2	ER IR ABD		
3	ER IR ABD		
4	ER IR ABD		
5	ER IR ABD		
6	ER IR ABD		

Post exercise Manual Muscle Tests

	Right 1		Right 2		Left 1		Left 2	
	Force	Pain	Force	Pain	Force	Pain	Force	Pain
Serratus anterior								
Lower Trapezius								
Middle trapezius								

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APPENDIX G: ACFT SCORE CARD AND RUBRIC

PLEASE WRITE LEGIBLY

ARMY COMBAT FITNESS TEST SCORECARD

NAME: LAST, FIRST, MI: ______________________________

GENDER: ___ MALE ___ FEMALE UNIT/LOCATION: ____________________

DATE	GRADE	MOS	AGE

HEIGHT (inches)	BODY COMPOSITION	
	WEIGHT: _____ LBS GO ☐ NO GO ☐	BODY FAT: _____ % GO ☐ NO GO ☐

3 REPETITION MAXIMUM DEADLIFT: (weight lifted - circle highest score)

LIFT 1 (RAW SCORE)	LIFT 2 (RAW SCORE)	POINTS	INTIALS

STANDING POWER THROW: (distance thrown - circle highest score)

THROW 1 (RAW SCORE)	THROW 2 (RAW SCORE)	POINTS	INITIALS
F1 F2	F1 F2		

HAND RELEASE PUSH-UP: Number correctly performed repetitions

RAW SCORE	POINTS	INTIALS

SPRINT-DRAG-CARRY: Overall event time (min:sec)

RAW SCORE	POINTS	INTIALS

LEG TUCK: Number of correctly performed repetitions

RAW SCORE	POINTS	INTIALS

TWO-MILE RUN: Overal event time (min:sec)

RAW SCORE	POINTS	INTIALS

	TOTAL POINTS
Soldier's Signature: ______________________ Test Start Time: ________ Test End Time: ________	

OIC/NCOIC Print (Last, First, MI)	Signature	Grade/Rank	Unit

AMERICA'S ARMY:
Globally Responsive, Regionally Engaged

Points	Strength Deadlift (lbs)	Power Throw (m)	Release PU (reps)	Sprint Drag Carry (min:sec)	Leg Tuck (reps)	2-Mile Run (min:sec)
100	340	13.5	70	1:40	20	12:45
99	330	13.2	68			13:00
98	320	13.0	66	1:41	19	13:15
97		12.8	64	1:42		13:30
96	310	12.5	62	1:43	18	13:40
95		12.3	60	1:44		13:50
94	300	12.1	58	1:45	17	14:00
93		11.9	56	1:46		14:10
92	290	11.8	54	1:47	16	14:20
91		11.6	52	1:48		14:30
90	280	11.5	50	1:49	15	14:40
89		11.3	49	1:50		14:50
88	270	11.2	48	1:51	14	15:00
87		11.0	47	1:52		15:10
86	260	10.9	46	1:53	13	15:20
85		10.7	45	1:54		15:30
84	250	10.6	44	1:55	12	15:40
83		10.4	43	1:56		15:50
82	240	10.3	42	1:57	11	16:00
81		10.1	41	1:58		16:10
80	230	10.0	40	1:59	10	16:20
79		9.8	39	2:00		16:30
78	220	9.7	38	2:01	9	16:40
77		9.5	37	2:02		16:50
76	210	9.4	36	2:03	8	17:00
75		9.2	35	2:04		17:10
74	200	9.1	34	2:05	7	17:20
73		8.9	33	2:06		17:30
72	190	8.8	32	2:07	6	17:40
71		8.6	31	2:08		17:50
70	180	8.5	30	2:09	5	18:00
69		8.3	28	2:16		18:10
68	170	8.0	26	2:23		18:20
67		7.5	24	2:30	4	18:35
66		7.0	22	2:37		18:50
65	160	6.5	20	2:45	3	19:00
64		6.2	18	2:55		20:10
63	150	5.9	16	3:05	2	20:20
62		5.6	14	3:15		20:30
61		5.3	12	3:25		20:45
60	140	4.6	10	3:35	1	21:07
Army Minimum						

Proposed Scoring For IOC (Field Test) – Modified as data develops during IOC Phase

- Black: Minimum score for Soldiers in heavy physical demand unit/MOS
- Gray: Minimum score for Soldiers in significant physical demand unit/MOS
- Yellow: Minimum Score for Soldiers in moderate physical demand unit/MOS (Army minimum)

As of 31 JULY 2018