THE UNITED STATES ARMY MEDICAL DEPARTMENT

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Perspectives

An Army and an AMEDD in Transition

MG Steve Jones

With the end of combat operations in Iraq and the drawdown of forces in Afghanistan, we are transitioning from an Army at war to one preparing for the next fight—an Army of Preparation. The Army Medical Department (AMEDD) must now shift from a singular focus on caring for the casualties of Operating Enduring Freedom to a broader view that also looks to the future. As we continue to provide the same high level of care to the casualties of this conflict, we will transform to provide even more effective care in the next. As noted by General Robert W. Cone, commander of the Army's Training and Doctrine Command, we must find the right balance so we shortchange neither the Soldiers fighting in today's war nor those who will fight in future conflicts. We must balance investments in training, equipment and maintenance that keep us ready for today's conflicts, with investments in science and technology that will make us more capable in the future. This task is far more difficult in an environment of fiscal uncertainty.

To provide effective support to an Army of Preparation, the AMEDD must understand the Army Chief of Staff's vision, strategic priorities, and the objectives of Army transformation. The Army is transforming through a strategy that addresses near, mid, and long-term requirements. It will change from an Army focused on winning the current fight to an expeditionary Army that does many things well. In the near term, the Army will create more capable brigade combat teams by adding a third maneuver battalion, fires, and engineer assets. It will develop units that are more expeditionary, scalable, and can be tailored according to the mission. Forces will be regionally aligned so they are able to study the cultures, geography, languages, and militaries of the countries where they are most likely to be employed. They will be trained to conduct operational missions, bilateral and multilateral military exercises, and theater security cooperation activities. Army 2020 will be a more globally responsive force, able to deploy more rapidly, and prepared for the full spectrum of threats the nation is likely to confront. It will be more responsive to the combatant commander and a critical element of Joint Force 2020.

Several initiatives serve as the foundation of Army 2020: The Army Profession, Mission Command, Leader Development, The Squad, and The Army in the Joint Fight. The Army Profession will instill 5 characteristics into Soldiers and Army Civilians: trust, military expertise, esprit de corps, honorable service, and stewardship. Mission Command is a leadership style defined as "the exercise of authority and direction by the commander using mission orders to enable disciplined initiative within the commander's intent." Mission Command was developed because ground combat is complex and unpredictable. It recognizes the requirement for greater decentralization in operational decision making, and the central role of the commander in building adaptive teams. Leader Development is key to preparing officers and noncommissioned officers to succeed in the more dangerous and complex security environment, and lead Army, joint, and multinational teams. The Squad Initiative extends technology, leader development, and training to the squad, the fundamental building block of Army 2020. It will provide the squad the lethality and mobility to achieve and retain overmatch. The Army in the Joint Fight recognizes that we will continue to fight as part of a joint team, with interagency, coalition, and host nation partners.

In the midterm the Army will transition to Force 2025, a leaner, more capable, and more expeditionary force than today. Smaller but equally capable units will deploy to remote and austere environments. They must be prepared to defeat adversaries who attempt to exclude or limit United States access to forward areas and staging bases. These adversaries will avoid our strengths, cause us to fight in ways we do not want to fight, and prolong conflict to undermine our national will. Forces in 2025 will operate differently. Deployment and employment of units will be unpredictable, nonlinear, and much faster, taking hours or days rather than weeks or months. Deploying units will integrate their operations with unified action partners and regionally aligned forces already in theater conducting exercises or engagement activities. They will be delegated the authority required to respond more quickly to changing circumstances. They will be distributed across the area of operations to reduce mass, hide their intent, cover more terrain, and be better prepared to react to opposing forces' capabilities.

It will take a very different AMEDD to support future operations. The first step in our transformation is to capture and build on the lessons of the past 12 years of war. What we learned on the battlefield, in our medical

treatment facilities, and in Warrior Transition Units must be incorporated into doctrine and standard operating procedures. The second step is to redesign medical units to make them more expeditionary and capable. As the brigade combat team becomes smaller, the brigade support battalion medical company will get smaller as well. We will be flexible and responsive when supporting combatant commanders. They tell us the capabilities they need and we provide them quickly. If the commander only needs 10 beds, that is all we will send, not an entire combat support hospital. We will work with Special Operations Forces, and we will support the Army's regionally aligned forces. We will train designated medical units and individuals on the health aspects of their region. They will learn the unique diseases, environmental, cultural, and political considerations affecting health care that will make them more effective. We will review emerging technologies and push forward with the development of those that can increase our capabilities by 2025.

As the Army develops smaller but more capable units, it will seek to improve human performance and develop new technologies. The Human Dimension concept addresses the moral, physical and cognitive components of individual and team performance. The Performance Triad and Comprehensive Soldier and Family Fitness programs are key components. Improvements in accessions, leader development, assignments, training, education, and resilience will lead to more capable Soldiers and units. Army Medicine is moving forward in support of this concept with the AMEDD 2020 Campaign Plan and transition to a System for Health. The AMEDD is reinvigorating leader development and will soon publish a leader development strategy. It is implementing the philosophy of mission command using the operating company model as a tool. Combat Medics and Soldiers will learn more advanced techniques to maintain their health and fitness, and treat casualties on the battlefield.

Throughout its transformation, the Army will maintain a continuity of vision and requirements. It will field Army 2020 while focusing on Force 2025 and rebalancing investments in science and technology. By 2025 the Army will have leaner, more expeditionary formations with equal or greater capabilities, and strategic leaders working to create a fundamentally different Army for 2030 and beyond.

EDITOR'S PERSPECTIVES

From the earliest days of formal, structured military organizations, the requirement for the Warfighters to possess a high level of physical fitness, both strength and endurance, was recognized and addressed in one form or another. Historically, the various approaches in training to achieve fitness were based mostly on guesswork, personal opinions, and tradition. Indeed, prior to the 19th century, usually physical fitness was achieved through rigorous combat skills training and the sheer hard work demanded within military service. As Dr Joseph Knapik and Dr "Chip" East explain in their excellent article, the first effort to establish a physical training doctrine in the US military was an 1851 initiative at the US Military Academy. Their article then tracks the evolution of US military physical fitness and readiness standards from that point to the present, as reflected by the work to establish objective tests measuring an individual's physical capability to perform the necessary tasks of military service. Their extensive research resulted in a historical record of the increasing level of sophistication in the methodology employed in evaluating the physical demands of military service, and the types of tests which are most indicative of an individual's capabilities. This is a detailed, revealing chronology which demonstrates the commitment to establishing the safest and most effective physical readiness training possible, and the willingness to quickly make changes based on research and results.

The study described in the next article is an excellent example of research directed at determining tests that demonstrate an accurate, direct relationship to specific military physical tasks. Ms Tunde Szivak, a doctoral fellow in the Department of Kinesiology at the University of Connecticut, and her team of coauthors report the results of their research examining such relationships for women in the military. As the roles of women in the military have greatly expanded, so have their challenges in situations and job categories which historically require body strength and physical endurance. The study concentrated on perhaps the most basic of those requirements, lifting and carrying heavy loads over long distances in combat situations. The proven statistical relationship between the test results and task performance allow physiologists and training specialists to design training regimen which provide physical requirements similar to those involved in the actual tasks, and objectively evaluate the results. This research presented in this article is representative of the increasingly refined science now used to optimize efficiency, safety, and results in military physical fitness and readiness training.

MAJ John Lane's article is another look at the Army's emphasis on maintaining a healthy force rather than treating injuries and sickness. He reports on a study performed by the Injury Protection Program at Fort Lee, Virginia, to investigate any relationship between a newly

accessed Soldier's posture and his or her experience with back and/or hip pain during Basic Combat Training. In addition, the study provided data on the individual's awareness of his or her personal posture, whether proper or faulty, to examine whether those without pain were aware of postural faults. The investigators were interested in determining whether bad posture could be a reliable indicator (or predictor) of hip and/or back pain. If so, perhaps such pain could be prevented with posture correction, application of exercises, or physical therapy. This is an interesting look at another effort to identify potential problems and apply corrective measures to prevent problems later, before they can adversely affect readiness or combat effectiveness.

Despite the best efforts to build and maintain a healthy force, injuries occur and debilitating conditions do develop, and Army Medicine is prepared to address them and return the Soldier to full duty status as quickly as possible. Of course, that is possible only if the correct diagnosis is developed for prompt, appropriate treatment and/or therapy. LTC Mark Thelen and his coauthors have contributed an article about a condition that is difficult to diagnose because it can manifest as neurologic and musculoskeletal symptoms anywhere in the body. For this reason, they have added cervical myelopathy (spinal cord disease) to the list of conditions known as "great imposters." Further, the potential for misdiagnosis is especially present within the military population, because the condition is most prevalent in those aged 55 years or more, well above the age range of most active duty military personnel. However, cervical myelopathy is also found among those who participate in contact sports and military activities involving repetitive trauma and the general wear and tear of those occupations. The article discusses a number of diagnostic tests and techniques that can be performed efficiently and inexpensively to assess the possibility of myelopathy producing the observed symptoms. LTC Thelen et al have presented important, detailed information which should be understood by all those charged with providing healthcare to our nation's Warriors of all ages.

Dr Ketan Desai of the Veterans Administration has contributed a case report about a diagnostic presentation that is not normally associated with the underlying condition. In his article, he describes how a patient successfully being treated for rheumatoid arthritis presented with angioedema which did not respond to the normal treatments for the swelling in the subcutaneous tissues of the tongue, lips, etc. However, eventually a relationship between the occurrence of the angioedema and flares of rheumatoid arthritis in this patient was determined, an observation that was not reflected in a literature search. This is an interesting and unique case report which should be of interest for both rheumatologists and immunologists who may be involved in treatment of the same patient for conditions usually considered unrelated.

Dr Gaurav Gupta and his coauthors work with Canadian Forces Health Services and pain management clinics in Canada. They have provided an excellent article describing a successful, nonpharmaceutical treatment which relieved osteoarthritic hip joint pain in a patient awaiting hip replacement surgery. After extensive research of the literature, they employed a different approach to a procedure using thermal radiofrequency probes to denervate the nerves in the joint, thus reducing the pain level by 90% in the initial treatment. Previously, the patient had little success and some adverse reactions to conventional treatments employing medications, physical therapy, and injections. He was facing a number of months of severe pain and limited mobility until the hip replacement could be performed. The procedure developed and performed by Dr Gupta and his team provided crucial pain relief during that period. The significant pain reduction afforded by the initial procedure was temporary (6 months), but a subsequent second treatment and medication provided additional relief until the surgery. This is a meticulously written, very professional presentation of the case study and supporting scientific literature which should be must-reading for caregivers treating chronic joint pain.

Pain is also the focus of CPT Stewart Stancil's article, but from the perspective of the emergency department where patient load and is often high and staff resources can be severely taxed. He proposes a protocol for use of a regional anesthetic technique, the Bier block, first introduced in 1908 for procedures on the body's extremities, such as treatment of broken bones, wounds, removal of foreign bodies, burns, etc. Normally, treatment of such injuries involves sedation or general anesthesia, relatively complex procedures which require more material, caregivers, and time than application of the Bier block. CPT Stancil presents a carefully researched, clearly explained protocol which can be administered by a single caregiver both before and after the treatment procedure. In addition to emergency room use, the potential advantages of such a protocol in a battlefield environment are very obvious. This article deserves the attention of those charged with establishing standards and doctrine for military medical care, both in garrison and in deployed conditions.

Of necessity, standards and screening mean that people accepted for military service are healthier than the general population in almost every way. Further, the nature of the military organization establishes that the vast majority of active duty military personnel are young, therefore

not normally developing health problems and conditions associated with aging. Military healthcare professionals must be vigilant and professionally sound to recognize, diagnose, and treat conditions that may have never been seen by even the most experienced among them. This issue contains 2 articles from Army Dental Corps professionals who had just such encounters. MAJ John Batson and former MAJ Frank Strickland provided a case report about an 18 year-old-patient who presented with central odontogenic fibroma, an extremely rare type of tumor, in his left mandible. The article clearly describes the diagnostic and corrective procedures that were followed, as well as the information regarding the rarity of this occurrence. This is another example of the high level of knowledge and skill that is the norm among the Army's military healthcare professionals.

MAJ Zachary Highberger and his colleagues contributed a case study concerning another extremely unusual and rare oral condition that was presented with a 32-year-old Soldier. Focal epithelial hyperplasia, also known as Heck's disease, is a virus-induced disease that causes lesions to grow in the mouth; in this case they manifested on the patient's tongue. Their research revealed that Heck's disease is primarily found in western hemisphere Indian populations, including Eskimos, which is the patient's racial heritage. Their research also revealed that the Heck's disease virus has been found in HIV patients, possibly owing to immunosuppression of their antibodies. Obviously this should be considered whenever Heck's disease is diagnosed. This article is a very interesting, clearly presented description of their research, diagnosis, and treatment of a condition that the majority of dental professionals will probably never encounter. Again, another example of the caliber of knowledge, skill level, and professionalism of the members of the US Army Dental Corps.

COL Scott Shaffer and his colleagues return the Army-Baylor University Doctoral Program in Physical Therapy to the pages of the *AMEDD Journal* with a report on their study investigating the presence of electrodiagnostic abnormalities in the median and ulnar nerves among active duty military dental personnel assigned to Fort Sam Houston, Texas. A high prevalence of upper-extremity musculoskeletal disorders among dental care providers relative to the general population has been recognized for a number of years. Although many studies have explored these disorders, COL Shaffer et al found a lack of published research involving patient history, physical examination, and nerve conduction studies. Their article is the first published dental study to report electrodiagnostic findings of ulnar mononeuropathy at or distal to the wrist. This well-designed and executed research project is another example of level of professional expertise that military medicine directs towards providing only the best "care for the caregivers" across all of our specialties.

Although there are exceptions, for the vast majority of people, physical fitness and body fat have a direct inverse relationship. Unfortunately, it is obvious to even the casual observer that the modern lifestyle of the population of the United States is conducive to increased body fat, with a majority proportion of the general population now considered to be overweight or obese according to the classifications of the Centers for Disease Control and Prevention. The US military is not immune to this phenomenon, but the adverse ramifications of the trend towards increasing body fat among the military population can be significant, not only to the individuals, but also to the security of the United States. Over the last several decades, the military services have been required to increasingly focus on this trend in their forces. Now, as the numbers of women in the armed forces have continued to grow, both in real numbers and in proportion of the total force, attention is being directed to understanding the risk factors associated with excess body fat in women who are assigned to deployable combat units. Morgan Anderson and her coauthors have contributed the results of their study examining those factors—personal characteristics, physical training, physical fitness, injury history—among women Soldiers in a light infantry brigade. The results of their study are concerning, but this is an initial effort to capture data which can be used to identify and address the factors peculiar to women, and design/refine programs to specifically address those requirements.

The challenges faced by our Warriors attempting to return to normal life while suffering from traumatic brain injury and/or posttraumatic stress disorder are daunting. Fortunately, there are many concerned, dedicated professionals throughout military medicine who work tirelessly to assist them, often devising unique and innovative techniques based on their research and personal experience in other areas. Genie Joseph and Dr Wynona Bice-Stephens close this issue of the *AMEDD Journal* with a description of one such program that Ms Joseph conceived while volunteering at the Tripler Army Medical Center in Hawaii. The program is called Act Resilient, a 4 to 8 week educational program which uses coping skills, improvisation, expressive arts, emotional flexibility, and laughter to teach stress management. Family members are encouraged to participate, learning to recognize subtle changes in body language and nonverbal cues. All indications are that the program has been very successful in lowering stress and raising morale, not only for the Soldier, but for those closest to him or her. Act Resilient is providing a new start for those in difficulty.

History of United States Army Physical Fitness and Physical Readiness Testing

Joseph J. Knapik, ScD
Whitfield B. East, PhD

ABSTRACT

This article traces the history of US Army physical fitness assessments from the first test developed for Cadets at the US Military Academy in 1858 through efforts to revise the current Army Physical Fitness Test (APFT). The first "Individual Efficiency Test" (1920) for all Soldiers consisted of a 100-yard run, running broad jump, wall climb, hand grenade throw, and obstacle course. The first scientific efforts involved testing of 400 Soldiers and a factor analysis of 25 individual test items. In 1944, this resulted in a 7-item test (pull-up, burpee, squat jump, push-up, man-carry, sit-up and 300-yard run) with a 100-point scoring system. In 1943, women were encouraged to take a "self-assessment" consisting of push-ups, bent knee sit-ups, wing lifts, squat thrusts, running, and a stork stand. In 1946, age-adjusted standards were introduced and in 1965 semiannual fitness assessments were mandated. The number of tests proliferated in the 1969-1973 period with 7 separate assessments. The current APFT consisting of push-ups, sit-ups, and a 2-mile run was introduced in 1980 and alternative tests for those with physical limitations in 1982. Current efforts to revise the assessment involve systematic literature reviews and validating the relationship between test items and common Soldiering tasks.

The physical fitness of individual Soldiers is a critical element in military operations. Military historians have repeatedly emphasized the importance of a high level of physical capability for the occupational tasks that Soldiers are required to perform.[1-3] Early in US history, physical training was disorganized and decentralized involving primarily drill and ceremony combined with demanding physical labor. The Prussian "Turnverein" movement initiated by Ludwig Jahn in 1806 which emphasized mass calisthenic-type exercises and gymnastics, was brought to the United States by immigrants in the mid-1800s. During this period of Army history, the US Military Academy (USMA) was the center of training doctrine. The first attempt to establish a physical training doctrine was initiated by First Lieutenant John Kelton in 1851. At the behest of USMA Superintendent Richard Delafield, Kelton traveled to Europe just prior to the Civil War to learn the European system of Turnverein "gymnastics." Kelton conducted a thorough, professional review and recommended comprehensive changes in the USMA physical education program. He proposed a curriculum that included instruction in gymnastics, calisthenics, swimming, and fencing.

After a long hiatus caused by the US Civil War, the USMA hired Herman John Koehler as its first professional physical educator in 1885. Koehler was a graduate of the Normal School of the Turnerbund (North American Gymnastic Union) of Milwaukee and served as Master of the Sword at the USMA from 1885 to 1923. Under his wide-ranging influence, systematic physical training was initiated throughout the US Army.[4] Koehler's physical training manual, *A Manual of Calisthenic Exercises*,[5] was published in 1892 and became the first Army-wide publication providing leaders with guidance to methodically improve the physical fitness of individual Soldiers.

While the value of physical training for improving Soldier operational performance has long been understood and appreciated,[4] the testing of Soldier physical capability in the Army has a shorter history. This article reviews the history of Army fitness evaluations and examines the development and rationale for these evaluations. Recently, there has been an effort by the Initial Military Training Center of Excellence of the US Army Training and Doctrine Command to revise the current Army Physical Fitness Test that has been in place since 1980. Knowledge of the past Army fitness assessments may assist in placing the current efforts into a broader historical context.

EARLY TESTS AND INFLUENCES

First Lieutenant John Kelton proposed the first physical assessment and standards for USMA Cadets in 1858. Kelton's test involved climbing a 15-foot wall, vaulting a horse 15 hands high (5 feet), leaping a 10-foot ditch, running a mile in 8 minutes or 2 miles in 18 minutes, walking 4.5 miles in one hour, and walking 3 miles in one hour with a 20-pound knapsack, arms, and equipment. Kelton also recommended that each USMA Cadet

should be able to swim a mile, dive and remain 45 seconds swimming underwater, dive head first from a height of 8 feet, and leap into the water from a height of 20 feet. Kelton's recommendations were adopted along with other physical training proposals. However, the program and testing was discontinued in 1861 with the onset of the Civil War.[6,7]

In the late 1800s and early 1900s, the concept of objective measurements of physical capacity was rapidly developing in American colleges, universities, and elsewhere. Initially, pioneers like Dudley Sargent, John Kellogg, and EG Martin promulgated objective methods of measuring strength using dynamometers.[8-11] Sargent later thought that strength tests were somewhat limited because they did not "…try the heart and lungs sufficiently to afford a good test of endurance…." He developed a test involving 6 items that was required to be performed continuously and completed in 30 minutes.[12,13] Others agreed that strength tests were limited[14] and various tests to evaluate "athletic achievement" and "physical efficiency" emerged. One of the earliest of these was that of Luther Gulick, developed for the Athletic League of the YMCA. It consisted of a 100-yard dash, high jump, triple jump, shot put, and rope climb.[15] Later, college athletic tests were proposed at Columbia University (New York),[14,16] the University of California,[17] and The Ohio State University.[18] Physical efficiency tests were also proposed for elementary school students.[19,20] In 1913 and 1916, the American Playground Association developed the Athletic Badge Test for boys and girls, respectively. The exact test items and standards to achieve the badge depended on age.[21,22] The application of statistical methods for the development of normative scoring tables for athletic achievement tests was discussed by Charles McCloy in 1921.[23]

The first systematic program of unit physical training for the entire US Army was published in 1906 in General Order Number 44.[24] This order required infantry troops to conduct weekly marches of 12 miles and horse-mounted artillery and cavalry troops 18 miles. A 3-day, 90-mile riding test (on horseback) for artillery/cavalry and 45-mile marching test for infantry was initiated to assess the benefits of the new physical training program. General Franklin Bell was the driving force behind implementation of the order. He was widely noted for addressing fitness issues and had studied under Dudley Sargent in 1887. There was much opposition to Bell's strong desire to physically transform the Army, likely due to the poor physical condition of many senior Army leaders.[4] However, Bell's efforts were reinforced by Theodore Roosevelt, US President from 1901-1909. Partly as a result of his combat service with the Rough Riders (2nd Brigade, 1st US Volunteer Cavalry) in the 1898 Spanish-American War. Roosevelt was a strong proponent of rigorous physical training. He was also the honorary president of the Playground Association of American that had developed the Athletic Badge Tests.[25] Like Bell, Roosevelt was concerned with the ability of Army officers to ride long distances on horses and believed that such "physical fitness" could only be demonstrated by "actual physical tests." As President, he directed that all officers considered for promotion be tested for skill and endurance in riding.[26] Roosevelt later prescribed that all field officers would perform daily horseback marches of not less than 30 miles/day over a period of 3 days (90 miles total) in the fall of the year. He also required that "appropriate action should be taken in the case of all officers found not qualified physically for active service."[27]

INFLUENCES OF WORLD WAR I

It was not surprising that the advances in the testing and measurement of physical capacities in universities were soon applied to the military where a high level of physical ability was an occupational necessity. From 1917 to 1919, Dr Joseph Raycroft served as chairman of the Athletic Division of the Commission on Training Camp Activities. The Commission directed sport and recreational activities at military camps during World War I.[4,25,28] Prior to Raycroft's selection for the chairmanship, he had been the Chairman/Professor of Hygiene and Physical Education at Princeton University since 1911. In 1920, through a consortial effort of active duty officers and civilian fitness experts, Raycroft published *Mass Physical Training for Use in the Army and Reserve Officers' Training Corps* with approval of the War Department, War Plans Division of the General Staff.[29] In this book, Raycroft proposed an Individual Efficiency Test consisting of the 6 items and passing standards shown in Table 1. Included in the test battery was the first obstacle course test, a 100-yard linear route consisting of 6 obstacles: (1) vaulting a 3-foot hurdle; (2) negotiating a 10-foot wire entanglement (arms folded); (3) climbing a 5-foot ramp; (4) jumping from the top of the 5-foot ramp over a 10-foot trench; (5) negotiating a 1-foot wide, 20-foot long plank; and (6) climbing an 8-foot, smooth-faced wall. Soldiers sprinted 10 to 15 yards between each obstacle and at the start

Table 1. Test Items and Passing Standards for the Individual Efficiency Test (1920).

Event	Passing Standard
Run, 100 yd	14 seconds
Running broad jump	12 ft
Wall climb (8 ft high, unassisted)	Climb over
Hand grenade throw (distance 30 yd; 10 ft square)	Hit inside Square
Obstacle course (6 obstacles)	30 seconds

and finish of the course. Based on testing at Camp Gordon, Georgia, suggestions and considerations for other test items were made by Dr Thomas Browne from the University of North Carolina.[30]

Although the Army published a basic field manual in 1927 and again in 1936 that incorporated various aspects of physical training, it was not until March 1941 that the Army published the first field manual dedicated exclusively to physical training, *Field Manual (FM) 21-20*.[31] The Standards and Testing section of this manual stated that "…the physical training program should be based upon the condition and aptitude of the men to be trained. The best method of determining this condition and aptitude of the group is by comparison with known standards." Table 2 shows the test items with the qualitative, 4-level, graded, performance scale which was included in the manual. In addition to the 4-item test, there were 14 other potential test items described in Table 3. Instructors were encouraged to conduct tests at regular intervals to measure fitness improvements among Soldiers and to determine the effectiveness of the training program. It was also stated that Soldiers would be able to compare their ability with that of other men.

Table 2. Tests and Standards (1941).

Event	Minimum Standard	Average	Above Average	Superior
Dash, 100 yd	14 sec	13 sec	12.6 sec	12.2 sec
Running high jump	3 ft, 9 in	4 ft	4 ft, 3 in	4 ft, 6 in
Running broad jump	12 ft	13 ft, 6 in	15 ft	16 ft, 6 in
Push-up from ground	20 reps	25 reps	30 reps	35 reps

Note: reps indicates repetitions; sec indicates seconds.

Field Manual 21-20[31] also described a 100-yard obstacle course modeled after Raycroft's course. The rationale provided for the obstacle course was that running, jumping, vaulting, climbing, and crawling were basic activities that all Soldiers would be required to perform and the obstacle course could enhance these skills, in addition to developing endurance, agility, and self-confidence. A figure from *FM 21-20*[31] describing the course is shown as Figure 1. The Soldier was required to sprint between the obstacles, spaced at the distances shown. *Field Manual 21-20*[31] described a progressive training program for the course. No criterion standard was described, but it did state that "…when the Soldier has shown that he can overcome each obstacle in the course, he should be required to run the course against time. However, the time allowed should be determined by the condition and ability of the Soldier. As his condition and ability improve, the time should be reduced."

Table 3. Additional Test Items and Standards for "Average Men" (1941).

Event	Minimum Standards for Average Men
Baseball throw	125 ft
Basketball throw	60 ft
Bar or fence vault	4 ft
Run, ¼ mile	87 sec
Run, ½ mile	3 min, 15 sec
Walk, 2 miles	23 min, 30 sec
Vertical jump	13 in
Pull-up	6 reps
Rope climb, 20 ft	20 sec
Standing hop, step, and jump	18 ft
Running hop, step, and jump	22 ft
Standing broad jump	6 ft
Standing backward jump	2 ft, 8 in
Running long dive	5 ft, 6 in

Note: reps indicates repetitions; sec indicates seconds.

THE WORLD WAR II PERIOD

In the 1930s, the selection of test events to measure physical ability was aided by the development of a statistical technique called factor analysis. As it applied to the development of a physical fitness test battery, factor analysis involved evaluating the performance of individuals on a broad array of physical tasks for which quantitative measures could be obtained. The tests were mathematically assembled into groupings (called factors) that were assumed to have a hypothetical common physical performance attribute/requirement. A "factor loading" described the degree of relationship between a single test item and a hypothetical factor; some tests would have high factor loadings and others less so.[32,33] Generally, the test event with the highest factor loading would provide an optimal simulation of the factor, and therefore be selected for the test battery. In some cases, test selection depended upon other requirements such as cost, simplicity of the test, availability of equipment, and rater training.

The first scientific efforts directed at military physical readiness assessment was spearheaded by Colonel Theodore Bank working with Dr Charles McCloy and Dr Arthur Esslinger who were physical educators at the University of Iowa and Stanford University, respectively.[4] They conducted studies in which 25 tests were administered to 400 men. The 10 tests that "best discriminated between fit and unfit individuals" were pull-ups, the 20-second burpee, 3 broad jumps, the shotput, push-ups, 75-yard pick-a-back (man carry), dodging run, 6-second run, sit-ups, and 300-yard run.[34] Charles McCloy published a portion of these results and, through a factor analysis of 12 items, demonstrated the existence of 4 physical fitness factors, which he titled (1) circulo-respiratory endurance, (2) velocity or muscular contraction speed, (3) muscular endurance, and (4) mesomorphic build.[35]

Before Bank, McCloy, and Esslinger could complete their investigations, the Army conducted a

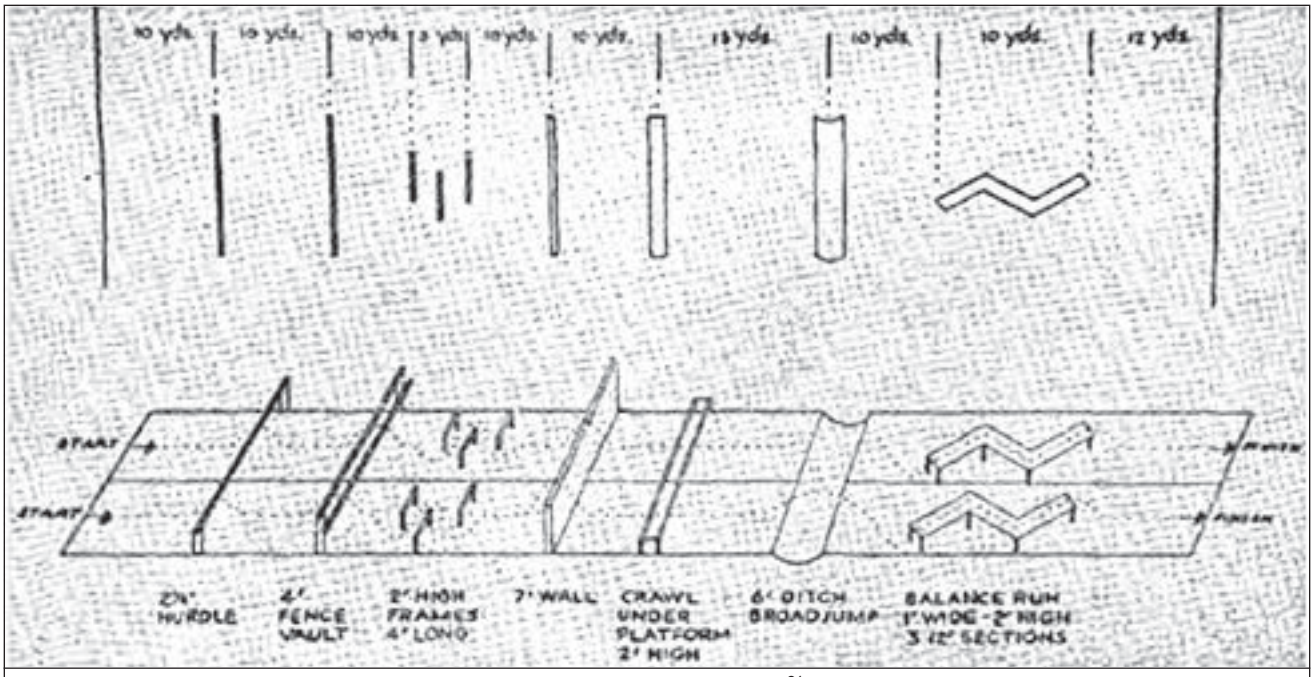

Figure 1. The obstacle course as depicted in the 1941 *Field Manual 21-20*.[31]

major reorganization in preparation for war in which the Army Ground Forces was created. The Army Ground Forces was tasked with proponency for physical readiness training and assessment, and in 1942 published the Army Ground Forces Test.[36,37] That test consisted of the 6 events shown in Table 4, and was administered in the order shown. The 70-yard zigzag run was a complex set of movements involving creeping, crawling, jumping, and running in 7 legs of 10-yards each. On the 4-mile march, "straggling" was defined as 1 minute late at any mile marker. The score the Soldier achieved on each event was multiplied by a weighting factor (Table 4), added together, and divided by the sum of the weighting factors (10). The resulting score was given a qualitative rating such that less than 70 was unsatisfactory, 70-77 was satisfactory, 78-87 was very satisfactory, 88-94 was excellent, and greater than 94 was superior.[36,37]

The Women's Auxiliary Corps, later renamed the Women's Army Corps (WAC), was established in 1942,[38] and in 1943, *FM 35-20* was published.[39] It provided guidance for physical training for the WAC and included a chapter entitled "Self Testing Activities." The self-test items included push-ups, bent knee sit-ups, wing lifts, squat thrusts, running, and the stork stand. Push-ups were executed with knees on the ground. Wing lifts involved prone trunk extensions with the fingers interlocked behind the head. Running could be in place (stationary) or for an unspecified distance, with the goal of progressively increasing time or distance. The stork stand involved balancing on one leg with the unsupported leg on the supported knee, eyes closed, and arms crossed in front of the body. While there were no published standards, women were encouraged to use the test to gauge their improvement over time and instructors were encouraged to use the tests to evaluate the "physical quality" of the group.

War Department Pamphlet 21-9[40] was published in May 1944. It contained an entire chapter devoted to "Physical Efficiency Testing" and provided the criteria used for selection of the test items. These criteria included minimal use of equipment, quick and easy administration, safety, and the facts that the test items measured individual fitness components, were not dependent on skill

Table 4. Events and Scoring of the Army Ground Forces Test (1942).

Event	Scoring	Maximum Score (100%)	Weighting Factor
Push-up	3% added for each repetition	34	1
Run, 150 yd out, 150 yd back	4% deducted for each sec >45 sec	45 sec	2
Burpee, 20 sec	9% added for each repetition	12	1
Pick-a-back, 75 yd	4% deducted for each sec >20 sec	20 sec	2
Zigzag run, 70 yd	4% deducted for each sec >30 sec	30 sec	1
March, 4 miles	8% deducted for straggling 1st mile, 6% deducted for straggling 2nd mile, 4% deducted for straggling 3rd mile, 2% deducted for straggling 4th mile.	50 min	3

Note: sec indicates seconds.

acquisition, could separate fit and unfit men, and could be scored with a point system. The pamphlet states that "this test battery was developed after a tremendous amount of testing experience in the Army. It represents the 7 best tests out of an original group of 25." Thus, it was likely that the events were selected directly from the work of Bank, McCloy, and Esslinger. No specific test order was prescribed, but it was noted that all men should take the test in the same order and recommended retesting no more than every 8 to 12 weeks. Table 5 shows the 7 events in the "Physical Efficiency Test Battery" and a sample of the point system. The points were established on a normative scale using data from "an average infantry division." Fifty points represented the mean, a score of 100 represented 3 standard deviations above the mean, and zero represented 3 standard deviations below the mean. The points achieved on each event were added together and a qualitative scale provided such that "excellent" was more than 600, "good" was 445-600, "average" was 247-444, "poor" was 114 to 246, and "very poor" was less than 114. The point scale was to provide commanders with a quantitative assessment of the physical readiness of an individual Soldier or unit.

Table 5. Events and Scoring for the Physical Efficiency Test Battery (1944).

Event	Maximum Score (100 points)	Average Score (50 points)	Parachute Trooper Average Score
Pull-up (reps)	18	8	11
Burpee, 20 sec (reps)	13.75	10.5	12
Squat jump (reps)	72	32	40
Push-up (reps)	44	24[a]	33
Pick-a-back, 100 yd (sec)	18	26	23
Sit-up (reps)	82	32	70
Shuttle run, 300 yd (sec)[b]	35	45[c]	43

Note: reps indicates repetitions; sec indicates seconds.
[a]Fifty points for the push-up event is 23 reps in another table in *War Department Pamphlet 21-9*.[40]
[b]Five repeats of 60 yd each.
[c]Fifty points for the 300-yd run is 46 seconds in another table in *War Department Pamphlet 21-9*.[40]

THE POST WORLD WAR II AND KOREAN WAR PERIOD

In January 1946, *FM 21-20* was revised[41] and superseded *War Department Pamphlet 21-9* (1944)[40] and the earlier *FM 21-20* (1941).[31] The test items and a sample of the scoring system of the new Physical Efficiency Test Battery are shown in Table 6. *Field Manual 21-20* (1946)[41] provided both an indoor test and an outdoor test. The burpee and pick-a-back events of the 1941 test were no longer included as part of the outdoor test. The scoring system differed from that of 1944[40] for the remaining outdoor items. A higher performance level was necessary to achieve maximal or average scores on squat jumps and push-ups; the 300-yard run standards were lower. The sit-up was now limited to 2 minutes, whereas in 1941 there was no time limit. For the first time there was an adjustment for age such that scores dropped one point for each year a Soldier was 30 or more years of age. Thus, a score of 50 achieved by a 40-year-old Soldier was equivalent to a score of 60 achieved by a Soldier aged 30 or less years.

The 1950 *FM 21-20*[42] retained the same test items and the scoring system of the 1946 *FM 21-20*.[41] In 1957, *FM 21-20*[43] was significantly revised and a complimentary *Technical Manual 21-200*[44] was introduced. There were several changes in the scoring system Physical Efficiency Test Battery as shown in Table 6. The shuttle run was eliminated from the outdoor test. The 1957 *FM 21-20*[43] stated that "…10,000 men…were tested to establish the scoring tables." Both the outdoor and indoor tests were now called "Physical Fitness Tests" and the test items were to be administered in the order shown in Table 6. In an unprecedented move, the Army also introduced a functional "combat readiness" test in 1957. The "Physical Achievement Test" was for administration to "combat type units" only and included the events and scoring shown in Table 7. For the first time, in keeping with the birth of the aerobics movement in the United States,[4] a longer-distance run (1-mile) was included as a test item and the pick-a-back test returned in the form of a 150-yard man carry. *Technical Manual 21-200*[44] specified that the first 4 items should be administered on one day and the 1-mile run administered within 4 days of the first 4 items.

THE COLD WAR PERIOD AND BEYOND

In July 1961, the Army published Change 2 to *Technical Manual 21-200*,[45] within which the lessons learned in Korea were reflected in training doctrine. Change 2 marked a return to "combat readiness" as the primary focus of Army fitness testing (as was the case in 1920 and again in 1946). As described in Change 2 to the manual,[45] the major purpose of Army physical fitness testing was to assess those components of fitness and functional skills that were deemed necessary in combat. Essential military skills were defined as running, jumping, dodging, climbing and traversing, vaulting, carrying, balancing, falling, and swimming. Both the Physical Fitness Test and the Physical Achievement Test (1957) were discarded in favor of the Physical Combat Proficiency Test. The test events and scoring are shown in Table 8. Each event had a maximal score of 100 points with a maximum total score of 500 points. A minimum of 300 points was considered passing, and a Soldier had to achieve a minimum of 60 points/event to be considered "combat qualified." The grenade throw

Table 6. Events and Scoring for the Physical Efficiency Test Battery (1946, 1950) and Physical Fitness Test (1957).

Test Location	Event	1946/1950 Scores		1957 Scores	
		Maximum Score (100 points)	Average Score (≈50 points[a])	Maximum Score (100 points)	Average Score (≈50 points[a])
Outdoor Test	Pull-up (reps)	20	8	18	6
	Squat jump (reps)	75	34	95	52
	Push-up (reps)	54	28	60	27
	Sit-up, 2 min (reps)	79	46	85	47
	Shuttle run, 300 yd (sec)[b]	44.0	51.5	44.0	58.5
Indoor Test (same events as above but substituted shuttle run or squat thrust for 300-yd run)	Shuttle run, 250 yd (reps)[c]	41	47	NA[d]	NA[d]
	Squat thrust, 1 min (reps)	41	29	41	29

Note: reps indicates repetitions; sec indicates seconds.
[a]Some events do not have exact values at 50 points but rather at 51 or 52 points. The values shown are as close to 50 points as possible.
[b]Shuttle run was 5 laps of 60 yd each.
[c]Shuttle run was 10 laps of 25 yd each.
[d]Shuttle run was not included in the 1957 *Field Manual 21-20*[43] or *Technical Manual 21-200*.[44]

involved throwing 5 grenades at a series of 4 concentric circles (Figure 2), the center of which was 90 feet away from the throw line. Figure 3 depicts the layout, setup, and running directions for the run, dodge, and jump, and Figure 4 shows Soldiers performing the horizontal ladder event. The Physical Combat Proficiency Test was mandatory for Basic Combat Training (BCT) and generally used to assess combat readiness of most Soldiers.

Department of the Army Pamphlet (DA Pam) 21-1[46] was published in 1963. In an attempt to reduce the training requirements for some Soldiers, the pamphlet introduced a "Minimum Physical Fitness Test-Male" for male Soldiers who were "… instructors at service schools, staff officers, technicians, specialists, and other personnel assigned to T/D type organizations who perform duty only in an administrative or sedentary capacity." The test items and "minimal acceptable standards" are shown in Table 9. Before starting a physical training program, individuals 40 years of age or older were directed to obtain a physical exam including a "cardiograph check." Change 2 to *DA Pam 21-1*[47] emphasized that the test was mandatory for Soldiers less than 40 years of age. *Department of the Army Pamphlet 21-2*,[48] published in 1963, contained an "Army Minimum Physical Fitness Test-Female." The test items and "minimal acceptable standards" are shown in Table 9. Change 1 to *DA Pam 21-2*[49] emphasized that the test was also mandatory for female military personnel less than 40 years of age. The second edition of *DA Pam 21-2*[50] noted that the test could be taken in shorts and provided only standards for women aged 17 to 29 years and 30 to 39 years.

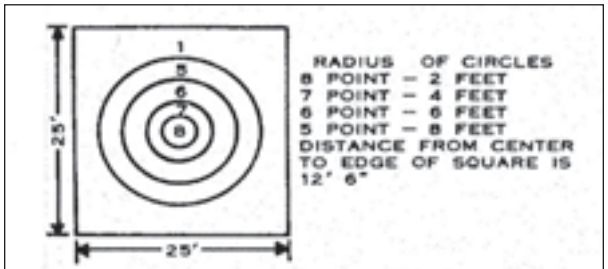

Figure 2. Grenade throw event target layout and scoring table.

In January 1965, *Army Regulation 600-9*[51] specified for the first time that all male and female personnel less than 40 years of age would be tested periodically for physical fitness. Twice yearly testing was mandated for all active Army units and minimum passing standards were specified. Testing was also required for BCT, Advanced Individual Training (AIT), leadership-type schools that were 8 weeks or more in length, and specialist courses which required 20 or more weeks. Personnel who failed to pass the applicable tests were allowed retesting and personnel action was to be considered for Soldiers who could not meet the test standards.

In January 1969, the fifth revision of *FM 21-20* was published,[52] and it contained 4 assessments that commanders could use. These were the Physical Combat Proficiency Test, the Minimum Fitness Test-Male, Airborne Physical Fitness Test, and the Inclement Weather Test. The Physical Combat Proficiency Test was considered the standard test and the test items. The slightly revised scoring (compared to 1961) is shown in Table 8. Retained was the 1961 minimum "combat ready" criteria of 300 total points with at least 60 points

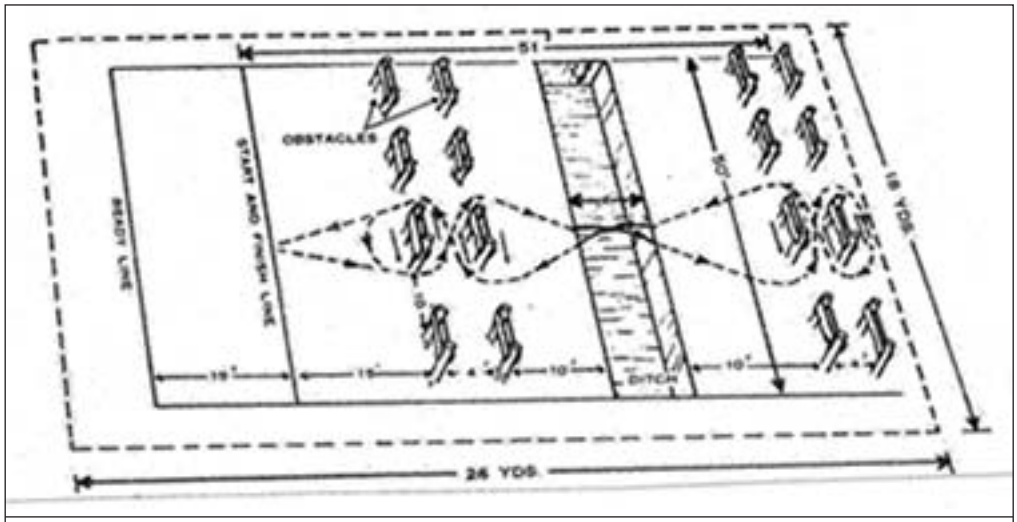

Figure 3. Setup and running route of the run, dodge, and jump event.

and Allowances units; and staff, faculty, and students assigned to Army schools). There was also an Inclement Weather/Limited Facility Fitness Test administered in inclement weather or when units did not have the facilities for the other 2 tests. Table 11 shows the events and scoring for the 3 tests. To pass the Advanced Physical Fitness Test, 300 points were required with at least 60 points in each event; the Staff and Specialist Fitness Test required only 300 total points (no minimum on each event). The point scale was age-adjusted and Soldiers aged 40 years or more were not required to take either test.

on each test event. "Combat support" personnel had to achieve a minimum of 45 points on each event and a 300-point total score. In BCT, AIT, and Combat Support Training (CST), a 150-yard man carry was substituted for the grenade throw, with 100 points awarded for a 34-second performance and 60 points for 52 seconds. The Minimum Fitness Test-Male was to be used for "… active duty personnel who are assigned to duties that preclude their participation in a physical fitness program that prepare them for the Physical Combat Proficiency Test." The test could also be used when facilities were lacking for conducting the Physical Combat Proficiency Test. The Minimum Fitness Test-Male had 6 events, and each event had an alternative. The Soldier could choose which primary or alternative testing event he desired. The test had the age-adjusted pass or fail standards shown in Table 10. The Airborne Trainee Physical Fitness Test was also a pass or fail evaluation in which passing required at least 6 chin-ups, 80 knee benders (2 minutes), 22 push-ups, 20 sit-ups, and completing a 1-mile run in 8.5 minutes. The airborne test was actually first published in Change 3 to *Technical Manual 21-200* in 1962.[53] The Inclement Weather Test was not described in the 1969 *FM 21-20*.[52]

Four special purpose tests were also identified in the 1973 *FM 21-20*.[54] Events and scoring for 3 of these tests are shown in Table 12. A total score of 300 points with 60 points or more on each event was required to pass, and there was no age adjustment. The Basic Physical Fitness Test (Table 12)was used to measure the physical fitness of new Soldiers (BCT and Modified BCT). To graduate from AIT or CST, new Soldiers were required to pass the Advanced Physical Fitness Test (Table 11) with 300 or more total points and 60 or more points on each event for the 17-25 year age group. The Minimum Physical Fitness Test (Table 12) was administered to personnel aged 40 years or more who volunteered to be tested. Two special tests were administered to individuals attempting to qualify for Ranger or Special Forces training (Table 12) and for Airborne training. The Airborne Trainee Physical Fitness Qualification Test had only passing standards as follows: 6 chin-ups, 20 bent-knee sit-ups, 22 push-ups, 80 half knee bends (2 minute period), and 8.5 minutes or less on a 1-mile run.

The 1973 *FM 21-20*[54] produced further test proliferation and identified 7 separate assessments that were part of the "Army Physical Fitness Evaluation." The 2 tests designed for operational units were the Advanced Physical Fitness Test (for combat and combat support units) and the Staff and Specialist Fitness Test (for combat support units; Table of Distribution

Table 7. Events and Scoring for the Physical Achievement Test (1957)

Event	Maximum Score (100 points)	Average Score (50 points)
Dash, 75-Yd (sec)	8.0	10.0
Triple jump (ft)	26.5	20.0
Rope climb, 5-Sec (ft)	20.0	12.5
Man carry, 150 Yd (sec)	30.0	47.0
Run, 1 mile (min)	5.1	7.5

Note: sec indicates seconds.

Change 1 to the 1973 *FM 21-20*[54] was published in January 1974.[55] The test items on the 7 tests remained the same, but the point system on several tests were revised as shown in Table 13. On the Advanced Physical Fitness Test, higher performance levels were required for both maximal and passing scores on the inverted crawl, sit-up, and 2-mile run.

Figure 4. Soldiers performing the horizontal ladder event, circa 1969.

On the run, dodge, and jump, maximum performance standards also became faster. Only minor changes were made on the Staff and Specialist Physical Fitness Test. Performance required for the maximum score and for passing the Basic Physical Fitness Test was more difficult on 4 of the 5 events. Passing standards for those in AIT or CST were also more difficult on 3 of the 5 events, with graduation still requiring new Soldiers to pass the Advanced Physical Fitness Test with 60 or more points on each event at the 17-25 year age group.

Editions of *FM 35-20* were published in 1956 and 1965, both of which were entitled *Physical Training, Women's Army Corps*. The 1965 edition mentions fitness evaluations but provides no test and does not refer to the test in the 1963 or 1965 *DA Pam 21-2*.[48,50] The fourth edition of *FM 35-20*[56] was published in 1975 with the new title *Physical Fitness Training for Women*, and contained 5 physical fitness tests. The events and standards for 3 of these tests are shown in Table 14. The Advanced Physical Fitness Test for Women was for those in combat and combat support units as well as trainees in AIT and Advanced Reserve Officer Training Corps. The minimum passing score was 300 or more points with 60 or more points on each event. The push-up and sit-up events were not timed and women were instructed to complete as many as possible. The Staff and Specialist Physical Fitness Test for Women was administered to women assigned to combat service support units and military school faculty, staff, and students. The passing score was 300 or more points with no passing standard for individual events. The Basic Physical Fitness Test was administered in BCT. Passing the test required 300 or more total points with 50 or more points on each event. The Airborne Trainee Physical Fitness Qualification Test for women was for those who were training to become parachute riggers. Each test event had a minimum passing standard (no point system) requiring 7 incline chin-ups, 50 knee benders (2 minutes), 22 modified push-ups, 20 bent-knee sit-ups, and completing a 1-mile run in 10.0 minutes or less. The incline chin-up used a foot rest with a bar adjusted to the woman's height. An Inclement Weather Physical Fitness Test for BCT and AIT involved the same test items as the Basic Physical Fitness Test for Women except that a stationary run was substituted for the half-mile run with 100 points for 596 steps and 50 points for 346 steps.

The WAC was disestablished by the US Congress in 1978 and women were integrated into the regular Army.[57] General Donn Starry directed an Army Physical Readiness Study Group to revise and combine the physical training and testing doctrine in *FM 21-20* (for men) and *FM 35-20* (for women). The guidance General Starry provided the study group was to develop an

Table 8. Events and Scoring for the Physical Combat Proficiency Test (1961 and 1969).

Publication	Event	Maximum Score (100 points)	Combat Ready Score (60 points)	Combat Support Passing Score (45 points)
Technical Manual 21-200, Change 2 (1961)[45]	Low crawl, 40 yds (sec)	25	36	Not Considered
	Horizontal ladder (rungs)	76	36	
	Run, dodge, and jump (sec)	22.0	26.5	
	Grenade throw (points)	36	15	
	Run, 1 mile (min)	6.0	8.5	
Field Manual 21-20 (1969)[52]	Low crawl, 40 yds (sec)	23	36	45
	Horizontal ladder (rungs)	76	36	21
	Run, dodge, and jump (sec)	21.0	25.0	27.0
	Grenade throw (points)	36	15	8
	Run, 1 mile (min)	6.0	8.6	9.6

Note: sec indicates seconds.

Table 9. Events and "Minimal Acceptable Standards" for the Army Minimum Physical Fitness Tests (1963).

Men								
Test	Event Number[a]	Event	Age Group for Men (years)					
			17-29	30-39	40-44	45-49	50-59	≥60
Army Minimum Physical Fitness Test–Male	1	Bend and reach (reps)[b]	15	12	10	8	6	5
		Squat stretch (reps)[b]	15	12	10	8	6	5
	2	Rower (reps)[b]	15	12	10	8	6	5
		Sit-ups (rep)[b]	15	12	10	8	6	5
	3	Trunk twister (reps)[b]	12	10	8	6	4	3
		Body twist (rep)[b]	10	9	8	6	4	2
	4	8-count push-up (reps)[c]	5	4	4	3	2	1
		Push-up (reps)[b]	10	8	8	6	4	2
	5	½-mile run (min)[d]	4.0	4.0	–	–	–	–
		1-mile walk (min)[d]	–	–	15.0	15.0	15.0	15.0
		Stationary run, 2 min (reps)[d,e]	175	150	125	115	100	90
Women								
Test	Event Number[a]	Event	Age Group for Women (years)					
			17-29	30-39	40-44	45-50	>50	
Army Minimum Physical Fitness Test–Female	1	Jumping jack (reps)[f]	16	12	10	8	6	
		Bouncing (reps)[b]	16	12	10	8	6	
	2	Double arm circle (reps)[g]	18	12	12	6	6	
		Double arm swing (reps)[b]	18	12	12	6	6	
	3	Twister (reps)[b]	15	12	10	8	6	
		Cross and fly (reps)[b]	15	12	10	8	6	
	4	Sit-up (reps)[f]	15	12	10	8	6	
		Circle-O (reps)[h]	15	12	10	8	6	
	5	Bent-over airplane (reps)[f]	15	12	10	8	6	
		Trunk twist & arm fling (reps)[f]	15	12	10	8	6	

Note: reps indicates repetitions.
[a] The Soldier selected one test from among the 2 listed under each Event Number.
[b] 4-count is one rep.
[c] 8-count is one rep.
[d] The ½-mile run was for Soldiers aged 17-39 years; the 1-mile walk or stationary run was for all age groups.
[e] Count each time left foot hits ground.
[f] 2-count is one rep.
[g] 6-count is one rep.
[h] 3-count is one rep.

assessment that was gender integrated, easy to administer at any location, and required no or minimal equipment.[4] According to Dr James Vogel (oral communication), the scientific advisors in the study group settled on the push-up to measure upper body muscular endurance and the 2-mile run to measure cardiorespiratory endurance. There was discussion that the pull-up might be a more appropriate test of upper body muscular strength/endurance but at the time studies had shown that few women could perform a single pull-up.[58,59] Since trunk muscular endurance appeared to be an independent fitness factor,[33,60-62] a sit-up test was also recommended.

The work of the Army Physical Readiness Study Group was codified into Army doctrine in the 1980 edition of *FM 21-20*.[63] The events and age-adjusted scoring for the new Army Physical Readiness Test is shown in Tables 15 and 16. Push-up and sit-up standards for those aged 40 or more years were not provided until 1982 in Change 1 to *FM 21-20*.[64] Testing was mandated twice a year for all Soldiers aged 60 or less years. Soldiers aged 40 or more years were required to go through medical screening for cardiovascular disease prior to testing. Only passing standards were provided for those aged 40 or more years. Alternative tests were provided for those aged 40 or more years with limiting medical conditions (profiles). These alternative tests included an 800-yard swim, 6-mile cycle test, and a 2.5-mile walking test, all of which had age-adjusted standards. Soldiers in Initial Entry Training (IET) were required to achieve 50 or more points on each event by the sixth week of IET and 60 or more points on each event by graduation.

In publications after 1980, the test scoring standards were revised based on the testing of large groups of Soldiers performed by the US Army Physical Fitness

Table 10. Events and Scoring for the Minimum Physical Fitness Test-Male (1969).

Event Number[a]	Event	Minimum Passing Score, Aged 17 to 29 Years	Minimum Passing Score, Aged 30 to 39 Years
1	Squat bender (reps)	10	9
	Squat stretch (reps)	10	9
2	Push-up (reps)	19	17
	Push-up, 8 count (reps)	7	6
3	Sit-up (reps)	19	17
	Body twist (reps)	10	9
4	Legs-over (reps)	16	14
	Leg spreader (reps)	21	20
5	Squat thrust (reps)	10	9
	Mountain climber (reps)	21	20
6	Run, stationary (reps)[b]	350	275
	Run, ½ mile (min)	4.0	4.0

Note: reps indicates repetitions.
[a]The Soldier selected one test from among the 2 listed under each Event Number.
[b]Count each time left foot hits ground.

School. Although there were changes to the standards, the 3 test items (push-ups, sit-ups, and 2-mile run) have remained until this writing. The 1985 edition of *FM 21-20*[65] contained the identical scoring system as that of the 1980 edition,[63] but the test was called the Army Physical Fitness Test. Male Soldiers were directed to take the test in "…attire that is appropriate for physical training (shorts, T-shirt, socks, running shoes)…" Prior to this, male Soldiers took the tests in their uniforms (without blouse) and boots. Alternative test events with pass/fail standards were provided for Soldiers of all ages who had temporary or permanent profiles. Alternative test events included an 800-yard swim, 6.2-mile cycle (stationary and track), and a 3-mile walk. Change 1 to the 1985 *FM 21-20* was published in June 1986.[66] This change revised the age groups and provided a 100 point system for those 40 or more years of age (Tables 15 and 16), instead of just the earlier (1982) pass or fail standard (Table 15). Examination of Tables 15 and 16 shows that the performance levels required to achieve points in 1986 were considerably higher as compared to 1982.[66]

The ninth and final full-form edition of *FM 21-20*[67] was published in 1992. It retained the 1986 standards[66] except for a revised 2-mile run point system for women aged 27-31 years. For these Soldiers, 100 points were awarded for 17 minutes or less, reducing to 60 points at 21 minutes. Change 1 to the 1992 *FM 21-20* was published in 1998[68] containing the final revision of the point system to date. The new point system expanded the age gradations for those aged 52 years or more. The sit-up point system was identical for men and women. Points were established such that 100 points represented the 90th percentile and the 60 points represented the 8th percentile, based on testing of large groups of Soldiers (Louis Tomasi, oral communication). The 800-yard swim and 6.2-mile alternative tests and their standards

Table 11. Events and Scoring for the Advanced Physical Fitness Test, Staff and Specialist Physical Fitness Test, and Inclement Weather/Limited Facility Fitness Test (1973).

Test	Event	100 points (Maximum Score)				60 Points (Passing Score)			
		Age Group (years)				Age Group (years)			
		17-25	26-30	31-35	36-39	17-25	26-30	31-35	36-39
Advanced Physical Fitness Test	Inverted crawl, 40 yd (sec)[a]	16.0	17.0	18.0	19.0	29.0	30.0	31.0	32.0
	Run, dodge & jump (sec)	20.5	21.0	21.5	22.0	24.5	25.0	25.5	26.0
	Horizontal ladder, 1 min (rungs)	84	80	75	69	39	32	27	21
	Sit-up, bent knee, 1 min (reps)	50	49	48	47	30	29	28	27
	Run, 2 miles (min)	14.7	14.8	14.9	15.0	20.6	20.7	20.9	21.1
Staff and Specialist Physical Fitness Test	Push-up, 1 min (reps)	51	49	47	44	26	24	22	19
	Run, dodge & jump (sec)	20.5	21.0	21.5	22.5	24.5	25.0	25.5	26.5
	Horizontal ladder (rungs)	80	75	74	73	33	28	27	25
	Sit-up, bent knee, 1 min (reps)	48	47	45	43	28	27	25	23
	Run, 1 mile (min)	6.0	6.1	6.2	6.3	8.3	8.5	8.6	8.7
Inclement Weather/ Limited Facility Fitness Test	Push-up, 1 min (reps)	50	48	46	44	25	23	21	19
	Bend and reach, 2 min (reps)	114	109	104	99	83	78	73	68
	Squat thrusts, 2 min (reps)	57	54	51	48	34	31	28	25
	Sit-up, bent knee, 1 min (reps)	50	47	45	43	27	24	22	20
	Shuttle run, 80 m (sec)[b]	21.0	21.5	22.0	22.5	25.0	25.5	26.0	26.5

Note: reps indicates repetitions; sec indicates seconds.
[a]20 yd out and 20 yd back.
[b]Eight laps of 10 m each shuttling 4 by 4 by 2 inch wooden blocks back and forth.

were identical to that of 1986, but the walk test distance was reduced to a 2.5-miles with new passing standards. Two other physical training manuals have been published since 1998[69,70] but these publications have the identical test items and standards as that of 1998 (Tables 15 and 16).

Since 1998, there have been 2 attempts by the US Army Physical Fitness School to revise the Army Physical Fitness Test items. The 2003 proposed test items included a standing long jump (2 trials), a 1-minute power squat, a 1-minute heel hook, a shuttle run (12 repeats of 25 yards each), a 1-minute push-up, and a 1-mile run. The 2003 proposal was not implemented due partly to concerns of the safety and administration of some test items.[71] The 2010 proposal included a test of physical capacity (Army Physical Readiness Test (APRT)) and a test of functional capacity (Army Combat Readiness Test(ACRT)). The APRT consisted of a standing long jump, a 1-minute rower, a shuttle run (60 yards), a 1-minute push-up, and a 1.5-mile run. The ACRT (Figure 5) was designed to assess Soldier mobility and was similar to the obstacle courses of the 1920s and 1940s. It was proposed that both the APRT and ACRT be performed once per year. After Army leaders expressed concerns about the scientific basis about the effectiveness of the fitness test and the feasibility of the ACRT, the US Army Training and

Table 12. Events and Scoring for the Basic Physical Fitness Test, Minimum Physical Fitness Test, and Ranger/Special Force Qualification Test (1973).

Test	Event	100 Points (Maximum Score)	60 Point Criteria
Basic Physical Fitness Test	Inverted crawl, 40 yd (sec)[a]	16.0	29.0
	Run, dodge & jump (sec)	20.5	24.5
	Horizontal ladder (rungs)	84	36
	Sit up, bent knee, 1-min (reps)	50	28
	Run, 1 mile (min)	5.9	8.0
Minimum Physical Fitness Test (Voluntary)	Run, dodge & jump (sec)	23.0	30.0
	Push-up, 1 min (reps)	34	15
	Sit-up, bent knee, 1 min (reps)	34	22
	Squat thrust, 1 min (reps)	27	15
	Run, ½ mile (min)	3.2	5.6
Ranger and Special Forces Qualification Test	Inverted crawl, 40 yd (sec)[a]	15.0	25.0
	Sit-up, bent knee, 1 min (reps)	55	37
	Push-up, 1 min (reps)	54	33
	Run, dodge & jump (sec)	20.0	24.0
	Run, 2 mile (min)	12.8	16.5
	Swim, 15 m or 50 m	Pass/Fail[b]	Pass/Fail[b]

Note: reps indicates repetitions; sec indicates seconds.
[a]20 yd out and 20 yd back.
[b]Ranger qualification: the trainee was required to complete a 15-m swim with clothing, boots, equipment (pistol belt, first aid pouch, 2 full canteens, 2 ammunition pouches, and harness), and rifle. Special Forces qualification: the trainee was required to complete a 50-m swim with clothing and boots..

Table 13. Events and Scoring for the Advanced Physical Fitness Test, Staff and Specialist Physical Fitness Test, and Basic Physical Fitness Test (1974).

Test	Event	100 points (Maximum Score)				60 Points (Passing Score)			
		Age Group (years)				Age Group (years)			
		17-25	26-30	31-35	36-39	17-25	26-30	31-35	36-39
Advanced Physical Fitness Test	Inverted crawl, 40 yd (sec)[a]	14.0	15.0	16.0	17.0	25.0	27.0	28.0	29.0
	Run, dodge & jump (sec)	19.5	20.0	20.5	21.0	24.5	25.0	25.5	26.0
	Horizontal ladder, 1 min (rungs)	83	80	75	69	36	32	27	21
	Sit-up, bent knee, 1 min (reps)	54	53	52	51	32	31	30	29
	Run, 2 miles (min)	14.1	14.4	14.6	14.7	19.1	19.3	19.5	19.6
Staff & Specialist Physical Fitness Test	Push-up, 1 min (reps)	51	49	47	44	26	24	22	19
	Run, dodge & jump (sec)	20.5	21.0	21.5	22.5	25.0	25.5	26.0	27.0
	Horizontal ladder (rungs)	80	75	71	67	34	30	25	19
	Sit-up, bent knee, 1 min (reps)	48	47	45	43	28	27	25	23
	Run, 1 mile (min)	6.1	6.2	6.3	6.4	8.4	8.5	8.7	8.8
Basic Physical Fitness Test[b]	Inverted crawl, 40 yd (sec)[a]	15.0				27.0			
	Run, dodge & jump (sec)	20.0				25.5			
	Horizontal ladder, 1 min (rungs)	82				34			
	Sit-up, bent knee, 1 min (reps)	52				30			
	Run, 1 mile (min)	6.0				8.3			

Note: reps indicates repetitions; sec indicates seconds.
[a]20 yd out and 20 yd back.
[b]There were no age-adjusted standards for this test.

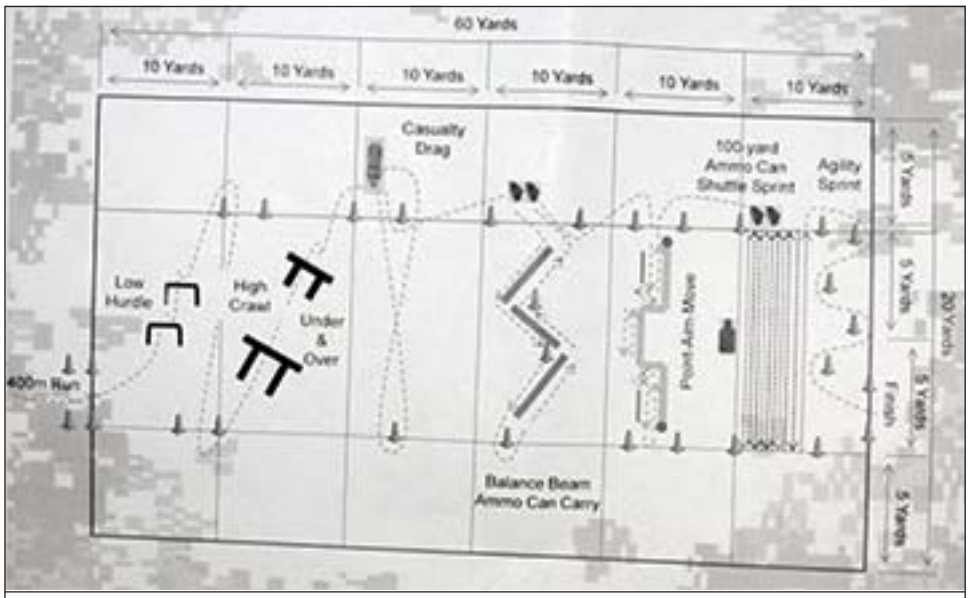

Figure 5. The Combat Readiness Test proposed by the Army Physical Fitness School (2012).

Doctrine Command ordered a feasibility study in 2011. After reviewing input from several sources, Army leaders postponed implementation of the APRT and ACRT and ordered a comprehensive study of Army physical readiness testing. That study, began in May 2012, involves a number of organizations and has a 3-pronged approach. Organizations include the US Military Academy, the Initial Military Training Center of Excellence, the US Army Research Institute of Environmental Medicine, and the US Army Public Health Command. The approach involves (1) systematic literature reviews, (2) linking both capacity and functional fitness assessments to common soldering tasks, and (3) validating the final test items against Soldiering tasks.[4] It is anticipated that the primary study will be completed in late 2014 or early 2015.

SUMMARY AND CONCLUSIONS

Physical readiness and fitness testing within the US Army has evolved in concert with the evolution of concepts of physical fitness and military readiness. Combat experience in both World Wars, the Korean War, and the Cold War added combat-specific events (such as grenade throw, rope climb, wall climb, obstacle course) and developments in physical education and the exercise sciences provided more general performance events to assess physical fitness. The current Army Physical Fitness Test was based primarily on the scientific literature and the expert opinion of scientists and Army leaders. The currently evolving approach to the development of a new test will involve the most comprehensive review and evaluation performed in the history of Army fitness testing, and hopefully will provide a more solid scientific foundation based on our current knowledge of the physical fitness and physical requirements of Army operations. It will likely incorporate lessons learned in the Iraq and Afghanistan conflicts.

While the individual test items in US Army physical fitness and physical readiness assessments have changed over time, the basic reasons for using these assessments have remained the same since they were outlined by Raycroft[29] in his description of the Physical Efficiency Test in 1920: motivate physical training, provide commanders with an evaluation of the physical capacity of his/her Soldiers, and examine the effectiveness of physical training programs. These goals will likely remain even as individual test items change and concepts of physical fitness and the physical requirements of military operations evolve.

Table 14. Events and Scoring for the 3 Physical Fitness Tests for Women (1975).

Test	Event	100 Points (Maximum Score)	60 Points[a]	50 Points[b]
Advanced Physical Fitness Test for Women	Shuttle run, 80 m (sec)	21.0	26.5	28.0
	Modified push-up (reps)[c]	42	18	15
	Run, dodge & jump (sec)	21.0	27.5	28.5
	Sit up, bent knee, (reps)	44	20	17
	Run, 1 mile (min)	7.6	10.8	11.1
Staff & Specialist Physical Fitness Test for Women	Shuttle run, 80 m (sec)	22.5	28.0	29.0
	Modified push-up (reps)[c]	36	16	14
	Run, dodge & jump (sec)	22.0	29.0	30.0
	Sit up, bent-knee (reps)	38	18	16
	Run, stationary (steps)[d]	596	396	346
Basic Physical Fitness Test	Shuttle run, 80 m (sec)	21.5	27.0	28.5
	Modified push-up (reps)[c]	40	18	16
	Run, dodge & jump (sec)	21.5	27.5	28.5
	Sit up, bent-knee (reps)	40	20	17
	Run, ½ mile (min)	3.3	4.4	4.8

Note: reps indicates repetitions; sec indicates seconds.
[a]Criteria was required on each event to pass the Advanced Physical Fitness Test for women.
[b]Criterion was required on each event to pass the Basic Physical Fitness Test for women. Criteria are approximate for all tests other than the Basic Physical Fitness Test since in some cases there are no values at the exact 50 point level, only at 52 or 53 point level.
[c]Knees on ground.
[d]Steps counted each time the left foot hit the ground.

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Table 15. Events and Maximum Score Standards for the Army Physical Readiness/Fitness Tests (1980-2012).

Publication	Age Group (years)	Maximum Score (100 points)					
		Men			Women		
		Push-up, 2 min (reps)	Sit-up, 2 min (reps)[b]	Run, 2 miles (min)	Push-up, 2 min (reps)	Sit-up, 2 min (reps)[b]	Run, 2 miles (min)
[a]*Field Manual 21-20* (1980)[63]; [a]*Field Manual 21-20*, Change 1 (1982)[64]; [a]*Field Manual 21-20* (1985)[65]	17-25	68	69	13.1	40	61	17.2
	26-30	66	67	13.7	38	51	17.4
	31-35	61	65	14.3	34	41	19.0
	36-39	60	63	15.1	30	31	20.5
	40-45	Only passing standards for those aged 40 years or more (Table 16).					
	46-50						
	51-55						
	56-60						
[a]*Field Manual 21-20*, Change 1 (1986)[66]	17-21	82	92	11.9	58	90	14.9
	22-26	80	87	12.6	56	85	15.6
	27-31	78	82	13.3	54	80	15.7
	32-36	73	78	14.0	52	75	18.6
	37-41	72	73	14.7	48	70	19.6
	42-46	66	69	15.1	45	67	20.0
	47-51	62	67	15.6	41	64	20.5
	≥52	56	66	16.0	40	62	21.0
[a]*Field Manual 21-20*, Change 1 (1998)[68]; [a]*Training Circular 3-22.20* (2010)[69]; *Field Manual 7-22* Change 1 (2012)[70]	17-21	71	76	13.0	42	76	15.6
	22-26	75	80	13.0	46	80	15.6
	27-31	77	82	13.3	50	82	15.8
	32-36	75	76	13.3	45	76	15.9
	37-41	73	76	13.6	40	76	17.0
	42-46	66	72	14.1	37	72	17.4
	47-51	59	66	14.4	34	66	17.6
	52-56	56	66	14.7	31	66	19.0
	57-61	53	64	15.3	28	64	19.7
	62+	50	63	15.7	25	63	20.0

Note: reps indicates repetitions.
[a]Obsolete.
[b]Sit-ups are/were performed with bent knees.

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Table 16. Events and Passing Score Standards for the Army Physical Readiness/ Fitness Tests (1980-2012).

Publication	Age Group (years)	Passing Score (60 points)					
		Men			Women		
		Push-up, 2 min (reps)	Sit-up, 2 min (reps)[b]	Run, 2 miles (min)	Push-up, 2 min (reps)	Sit-up, 2 min (reps)[b]	Run, 2 miles (min)
[a]*Field Manual 21-20* (1980)[63]; [a]*Field Manual 21-20*, Change 1 (1982)[64]; [a]*Field Manual 21-20* (1985)[65]	17-25	40	40	17.9	16	27	22.2
	26-30	38	38	18.5	15	25	22.5
	31-35	33	36	19.2	14	23	24.1
	36-39	32	34	19.6	13	21	25.6
	40-45	20	25	20.0	10	15	26.0
	46-50	20	25	21.0	10	15	27.0
	51-55	15	20	22.0	8	10	28.0
	56-60	15	20	23.0	8	10	29.0
[a]*Field Manual 21-20*, Change 1 (1986)[66]	17-21	42	52	15.9	18	50	18.9
	22-26	40	47	16.6	16	45	19.6
	27-31	38	42	17.3	15	40	19.7
	32-36	33	38	18.0	14	35	22.6
	37-41	32	33	18.7	13	30	23.6
	42-46	26	29	19.1	12	27	24.0
	47-51	22	27	19.6	10	24	24.5
	≥52	16	26	20.0	9	22	25.0
[a]*Field Manual 21-20*, Change 1 (1998)[68]; [a]*Training Circular 3-22.20* (2010)[69]; *Field Manual 7-22* Change 1 (2012)[70]	17-21	42	53	15.9	19	53	18.9
	22-26	40	50	16.6	17	50	19.6
	27-31	39	45	17.0	17	45	20.5
	32-36	36	42	17.7	15	42	21.7
	37-41	34	38	18.3	13	38	22.7
	42-46	30	32	18.7	12	32	23.7
	47-51	25	30	19.5	10	30	24.0
	52-56	20	28	19.8	9	28	24.4
	57-61	18	27	19.9	8	27	24.8
	62+	16	26	20.0	7	26	25.0

Note: reps indicates repetitions.
[a]Obsolete.
[b]Sit-ups are/were performed with bent knees.

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Relationships of Physical Performance Tests to Military-relevant Tasks in Women

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ABSTRACT

Purpose: This investigation sought to determine the most predictive measures of performance on a repetitive box lifting task (RBLT) and load bearing task (LBT) among 123 women (aged 23±4 years, height 165±7 cm, body mass 64±10 kg).

Methods: To determine the relationship of various predictors to performance on the RBLT and LBT, multiple regression analysis was conducted on body mass, height, leg cross-sectional area, upper and lower body muscular strength, lower body explosive power, upper and lower body local muscular endurance, and aerobic capacity.

Results: The mean±SD (range) number of repetitions for the RBLT was 86±23 (20-159). The mean±SD (range) time to complete the LBT was 2,054±340 seconds (1,307-3,447). The following equations were generated: RBLT (number of repetitions)=57.4+0.2(peak jump power)+0.4(number of pushups in 2 minutes)+0.15(number of repetitions during the squat endurance test)+1.39(one repetition maximal strength boxlift (kg))−0.04(2-mile run time (2MR) in seconds), R=0.81; standard error of the estimate (SEE)=14; LBT (in seconds)=1,831−4.28(number of repetitions during the squat endurance test)+0.95(2MR in seconds)−13.4(body mass), R=0.73; SEE=232.

Conclusions: We found that the 2MR and squat endurance test were significant predictive factors for performance on both load carriage tasks. These data also imply that women's performance in combat-related tasks can be improved with training that targets muscular strength, power, and local muscular endurance in addition to aerobic capacity.

Due to recent changes in Department of Defense policy, women in the military will have more opportunities to serve in combat arms military occupational specialties (MOS). These new opportunities will bring new challenges, including the ability to carry heavy loads over long distances in combat situations. Historically, the ability to lift and carry has been an important contributor to success in military combat operations.[1,2] As modern warfare incorporates increasingly heavier external loads, load carriage capability has gained recognition as an essential physical attribute in warfare.[3-5] Specifically, "fighting" loads average 29 kg, "approach" loads average 46 kg, and "emergency approach" loads average 60 kg.[1,2,6] These heavy loads often exceed the limits recommended by Army doctrine[1,6] and may partially explain why musculoskeletal injuries now comprise the largest proportion of all injuries.[7-10] Thus, as women enter new combat roles, it is necessary to determine which physical abilities are most closely related to performance on load carriage tasks. With this knowledge, load carriage-specific training interventions can be developed and implemented.[7,11,12]

The components of physical fitness that contribute the most to successful load carriage performance in women have been previously examined and are a growing area of research.[3,13-16] Load carriage is a frequent physical demand, particularly in deployed environments. Thus, a stronger Soldier could be expected to perform better on load carriage tasks and demonstrate greater resilience to the inherent injury risks these tasks present.[7,17,18] To that end, Kraemer et al,[16,19] Harman et al,[20] and Hendrickson et al[21] have shown that strength improvement, particularly in the upper body, has a profound impact on women's physical performance in military-specific tasks (ie, load carriage). Nevertheless, since loads are often carried over great distances and with considerable speed, high aerobic capacity is a common trait in Soldiers who successfully perform long distance load carriages.[2,3,12,21,22]

The prevalence of acute and overuse injuries to the spine and lower body[3,7,18,23-27] during military duties necessitates general physical preparedness and an emphasis on both strength and endurance capacity.[16,21] A Soldier's performance on military-relevant load carriage tasks

may provide insight into his or her current state of physical preparation. Furthermore, due to the physically demanding nature of these tasks, directly addressing them in training programs may help resolve existing deficiencies. This is of paramount importance when load carriage and repetitive lifting tasks are performed in theatre under less than ideal conditions (ie, extreme fatigue, dehydration, extended combat operations), which contribute to increased injury likelihood and incidence.[10,28-30] A well-designed training program that emphasizes both resistance exercise and traditional cardiovascular training may not only improve Soldier performance, but also help prevent common overuse injuries that occur during load carriage tasks.

To better understand the physical demands of load carriage in women, we must evaluate the relationship of military-relevant tasks with various characteristics of physical fitness. Such data would not only help to characterize the physical requirements of these tasks but would also provide valuable information on the physical training required to enable female Soldiers to successfully perform the duties of combat MOSs. The purpose of this investigation was to identify the physical fitness components that most strongly predicted women's performance in 2 military-relevant occupational tasks. These tasks utilized loads and conditions that reflect limits prescribed by Army doctrine for approach marches,[1,2] Soldier testing and training, and previous experimental work.[12,19,20,31,32] These tasks included a repetitive box lifting task and an endurance-based, load bearing task. The knowledge obtained during this investigation could assist in the development of training strategies that, with time and further refinement, would allow for improved Soldier productivity, resilience, and injury rates.

MATERIALS AND METHODS

The study participants were 123 untrained civilian women (mean±SD: aged 23±4 years; height 165±7 cm; body mass 64±10 kg). Each subject was briefed on the risks and benefits of the investigation, and each signed an institutionally approved, informed consent document prior to her participation. Each subject was medically screened by a physician to eliminate any medical concerns or pathologies that may have compromised the subject's participation or confounded the results. This sample population of healthy women with no previous history of resistance training demonstrated a wide range of fitness capabilities, such that might be representative of a typical cohort of women entering into military service.[33,34] The factors used to predict task performance in this study were body mass, height, magnetic resonance imaging (MRI)-assessed thigh muscle cross-sectional area, one repetition maximal strength in the bench press, back squat, high pull and the box lift, pushup muscular endurance, explosive jump power, squat endurance, and 2-mile run time. All predictors and load carriage tasks had been previously shown to possess test-retest reliability correlations $R \geq 0.95$.[19]

Performance Predictors

1. Thigh muscle cross-sectional area (TMCSA). The TMCSA was assessed for the dominant leg using an MRI 0.5 Tesla super conduction magnet (Picker International Inc, Highland Heights, OH) with MR6B software. Tissue cross sectional area was obtained by displaying the images through a Maxitron displayer and Adobe program and using the MacIntosh version NIH 1.55.20A Image Analysis computer program (National Institutes of Health, Washington, DC).

2. One repetition maximal strength (1RM) measures. These strength measures consisted of the squat, bench press, high pull, and box lift and were assessed with the use of the Plyometric Power System (PPS) (Power Systems Inc, Knoxville, TN). The PPS was specially designed to accurately collect strength and power data and to safeguard against injury by using a braking system to prevent falls. A National Strength and Conditioning Association Certified Strength and Conditioning Specialist monitored all tests and ensured compliance with prescribed exercise techniques. For the 1RM squat, the subject was required to descend into a parallel squat position by flexing the knees and hips until the trochanteric head of the femur reached the same plane as the superior border of the patella.[35] For the 1RM bench press, the subject was required to lower the bar until it touched the chest, and lift the bar back to the straight-arm position.[35] For the 1RM high pull, the subject stood upright with arms extended at the sides of the body and the feet positioned so that the instep of each foot was directly under the bar (resting position). The subject then flexed her hips before performing a simultaneous "triple extension" (of the ankle, knee, and hips) with maximal power while pulling the bar, using trapezoid flexion and shoulder abduction, to the height of the medial clavicles (the finish position).[35] The 1RM box lift required the subject to lift a box from the floor to a height of 1.32 m (simulating the bed height of a military 5-ton cargo truck). Upon failing at an attempt on any of the 1RM tests, the subject was given a final attempt with a weight less than that used in the failed attempt, but greater than that of the highest successful attempt (adapted from Maud and Foster[35]).

3. Muscular endurance and aerobic capacity. The maximum number of pushups that a subject could perform correctly in 2 minutes was used to assess upper body muscular endurance. The minimum amount of

time in which a subject completed a 2-mile run was used to assess aerobic capacity. Both of these measures were tested according to guidelines and procedures provided in *Field Manual 21-20* (now obsolete, superseded by *Field Manual 7-22*[36])

4. Squat endurance test. The squat endurance test required the subjects to perform repetitive squatting with an absolute load of 45.36 kg placed on the PPS barbell system which was lifted over a specific distance of 0.36 m per repetition at a rate of 37.5 repetitions per minute (0.625 repetitions per second).[19] These specifications were employed to allow for an external power output of 100 watts during the test. The total number of repetitions that the subject performed was used for analysis.

5. Lower body explosive power. To assess lower body explosive power, subjects performed an explosive squat jump lift using the PPS interfaced with a computer for data acquisition. Each subject's previously determined 1RM squat load was used to calculate her 30% of 1RM intensity for use in the squat jump test. The squat jump required the subject to perform a parallel squat and, upon reaching the bottom position of the lift, to explosively extend the hips and knees, thus accelerating the barbell mass upward with maximum power.[19,37]

Military-relevant Occupational Tasks

1. Repetitive box lift task (RBLT). The RBLT required the repetitive lifting of two 20.45 kg metal boxes placed on 2 platforms 1.32 m high (again, to simulate the height of a 5-ton military cargo truck) and 2.4 m apart. The subject moved at a volitional pace between one platform and the other to lift the box from its position adjacent to the platform to the top of that platform. The purpose of the test was to measure the subject's ability to lift as many boxes as possible in 10 minutes; performance was measured by the total number of boxes lifted (adapted from Harman et al[38] and Knapik[39]).

2. Load bearing task (LBT). The LBT required the subjects to carry a 34.1 kg backpack (termed rucksack) a distance of 2 miles on an all-weather 400 m track. The rucksack was constructed of an external frame with an attached backpack in which the load was properly positioned. Upon command, the subjects moved as fast as they could to cover the 2-mile distance. The performance was measured in seconds.[19]

Statistical Analyses

Values are reported as means±SD. Prior to all statistical runs, the data were confirmed to have met the statistical assumptions for linear statistics. Simple and stepwise multiple regression analyses were used to determine relationships between and among variables and to determine the proportion of variance explained by specific variables of interest that entered into the respective regression equations for the RBLT and the LBT. In this study, significance was defined as $P \leq .05$.

RESULTS

Table 1 lists the descriptive data for the various tests and with the 25th, 50th, and 75th percentiles presented for all variables. These variables were selected because they represent a broad spectrum of physical fitness components that influence military task performance. We attempted to select tests that assessed upper and lower body muscular strength, power, and endurance as well as aerobic capacity. Depending on the variable (as shown in Table 1), data was collected for 113 to 123 study participants. For some variables (eg, pushups and squat endurance) some subjects failed to complete a successful repetition, thus demonstrating a high discriminating ability for these tests.

Table 2 displays the correlational matrix among all variables. All of the independent variables were significantly correlated with the 2 dependent variables (RBLT and LBT). The 2-mile run time yielded the highest

Table 1. Descriptive Data for the Various Tests. The variables were selected because they represent a broad spectrum of physical fitness components that influence military task performance.

Variable	n	Mean±SD (range)	25th Percentile	50th Percentile	75th Percentile
Height (cm)	122	166±7 (145-184)	162	166	169
Weight (kg)	123	64±10 (43-106)	57	62	70
TMCSA (cm^2)	122	122±17 (89-183)	111	120	132
Bench press (kg)	123	32±7 (17-58)	26	31	35
Squat (kg)	123	52±12 (17-88)	44	52	58
High pull (kg)	121	33±6 (15-54)	29	32	36
Maximal box lift (kg)	121	30±5 (21-48)	27	30	33
Pushups (no. reps)	120	20±13 (0-57)	10	17	28
Squat endurance (no. reps)	116	19±14 (0-95)	8	16	24
Jump power (watts)	116	1,623±323 (875-2,868)	1,390	1,587	1,797
Two mile run (seconds)	120	1,213±231 (830-2,040)	1,358	1,191	1,043
Rucksack run (seconds)	113	2,054±337 (1,307-3,447)	2,267	2,025	1,850
Repetitive box lift (reps)	113	86±23 (20-159)	69	85	104

Notes: n=number of participants from which data was collected; TMCSA indicates thigh muscle cross-sectional area; reps indicates repetitions.

Table 2. Matrix of Correlation Among the Variables.

	BP	BL	TCSA	HP	HT	JP	PU	SE	SQ	2MR	BM	RBLT	LBT
BP	1.00*	0.58*	0.50*	0.71*	0.09	0.50*	0.48*	0.48*	0.57*	-0.28*	0.24*	0.56*	-0.48*
BL	0.58*	1.00*	0.53*	0.62*	0.46*	0.66*	0.10	0.43*	0.58*	-0.03	0.53*	0.54*	-0.37*
TCSA	0.50*	0.53*	1.00*	0.60*	0.24*	0.74*	-0.03	0.50*	0.61*	0.00	0.60*	0.41*	-0.31*
HP	0.71*	0.62*	0.61*	1.00*	0.20*	0.66*	0.20*	0.52*	0.58*	-0.18*	0.32*	0.52*	-0.42*
HT	0.09	0.46*	0.29*	0.20*	1.00*	0.44*	-0.35*	0.22*	0.04	0.01	0.54*	0.22*	-0.27*
JP	0.50*	0.66*	0.74*	0.66*	0.44*	1.00*	-0.10	0.59*	0.64*	0.00	0.67*	0.47*	-0.35*
PU	0.48*	0.10	-0.03	0.20*	-0.35*	-0.01	1.00*	0.24*	0.28*	-0.52*	-0.39*	0.45*	0.26*
SE	0.48*	0.43*	0.50*	0.52*	0.22*	0.59*	0.24*	1.00*	0.59*	-0.32*	0.17	0.55*	-0.46*
SQ	0.57*	0.58*	0.61*	0.58*	0.04	0.69*	0.28*	0.59*	1.00*	-0.16	0.26*	0.48*	-0.27*
2MR	-0.28*	-0.03	0.00	-0.18*	0.01	0.00	-0.52*	-0.32*	-0.16*	1.00*	0.41*	-0.54*	0.60*
BM	0.24*	0.53*	0.60*	0.32*	0.54*	0.67*	-0.39*	0.17	0.26*	0.41*	1.00*	0.19*	-0.19*
RBLT	0.56*	0.54*	0.41*	0.52*	0.20*	0.47*	0.45*	0.55*	0.48*	-0.54*	0.19*	1.00*	-0.61*
LBT	-0.48*	-0.37*	-0.31*	-0.42*	-0.27*	-0.35*	-0.26*	-0.46*	-0.27*	0.60*	-0.19*	-0.61*	1.00*

*$P \leq .05$

Key

BP – 1RM bench press (kg)
BL – 1RM box lift (kg)
TCSA – thigh cross-sectional area (cm^2)
HP – 1RM high pull (kg)
HT – height (cm)
JP – jump power (W)
PU – pushups
SE – squat endurance
SQ – 1RM squat (kg)
2MR – 2 mile run time
BM – body mass (kg)
RBL – repetitive box lift
LBT – load bearing task (2-mile rucksack carry)

Table 3. Regression equations for repetitive box lifting tasks (RBLT) and load bearing task (LBT).

Variable	Regression Equation	R	R^2	SEE
RBLT (reps)	57.4+0.2(JP)+0.4(PU)+0.15(SE)+1.39(BL)−0.04(2MR)	0.81	0.65	14
LBT (seconds)	1831−4.28(SE)+0.95(2MR)−13.4(BM)	0.73	0.53	232

Key

reps – repetitions
JP – jump power
PU – pushups
SE – squat endurance
BL – 1RM box lift
2MR – 2 mile run time
BM – body mass (kg)

correlation overall (r=-0.54 for the RBLT and 0.60 for the LBT). Other factors also contributed to these task performances, as only about 36% of the shared variance was explained. It is interesting to note that the test battery used was diverse and represented different physical requirements of the neuromuscular system as noted by the low to moderate relationships for multicollinearity of the tests performed.

Table 3 provides the regression equations for the RBLT and the LBT. For the RBLT; the explosive jump power, pushups, squat endurance test, 1RM box lift, and 2-mile run time entered into the equation. For the LBT; the squat endurance test, 2-mile run time, and body mass entered into the equation.

The final regression equations explained approximately 65% of the variance for the RBLT and 53% of the variance for the LBT. The standard errors of estimates were 14 repetitions for the RBLT and 232 seconds for the LBT. Interestingly, the squat endurance test and timed 2-mile run contributed significantly to both regression equations. Our results show that, depending on the physical demands of the task, both aerobic capacity and local muscular endurance can contribute significantly to task performance.

COMMENT

Research has consistently shown that increased strength contributes to significant improvements in military-specific task performance.[3,16,19,21] Previous studies have demonstrated that stronger, more muscular individuals perform load carriage and repetitive lifting tasks more efficiently and with indications of lower stress to the musculoskeletal system.[3,12,19,20] The results of the present investigation support the argument that upper and lower body strength, power, and local muscular endurance play important roles in load carriage task performance in women. Currently, military physical fitness training prioritizes traditional cardiovascular training. Our findings also support the importance of aerobic capacity, as higher aerobic capacity was associated with decreased

LBT time, while lower aerobic capacity was associated with decreased RBLT volume. It appears that training strategies for military populations must include both resistance and traditional cardiovascular training.

Our findings also reflect the importance of training specificity. For example, the 1RM box lift factored strongly into performance on the RBLT. This is not surprising if we consider that individuals who are able to lift heavier loads (eg, 1RM box lift) will likely perform better on a related task such as the RBLT. Furthermore, lower body power (jump squat) and local muscular endurance (pushups and squat endurance) could be expected to contribute positively to a repetitive box-lifting task, which would appear to require these qualities. Performance on the LBT also appeared to reflect the task's specific physical attributes most strongly. For instance, lower aerobic capacity, reflected in higher 2-mile run times, corresponded with higher LBT times, while increased body mass and lower body muscular endurance were associated with improved LBT times. Nevertheless, performance on both tasks benefitted from higher aerobic capacity and local muscular endurance, thus illustrating the transferability of more nonspecific exercise adaptations.

The principle of specificity dictates that training mirror the specific physical requirements of the activity.[14,40] Therefore, to the extent possible, training programs for Soldiers should include physical tasks that are similar to those required by the MOS or duty assignment. Current training recommendations for load carriage include performing specific load carriage tasks with progressive loading and duration once per week, in addition to resistance training and aerobic conditioning.[22] The selected occupational tasks (LBT and RBLT) were deemed highly relevant—they are either regularly performed or used in training.[1,2,31,41] Our findings also highlight the importance of upper body strength in women, as the 1RM box lift and pushup results were significant predictors of RBLT performance.[19,39]

It is important to note that the 2 tasks evaluated in this study require many performance strategies, physiological systems, psychological demands, and biomechanical techniques. Therefore, it might be expected that the physical components measured in this study do not completely explain performance on these 2 tasks. Psychological factors such as motivation may also explain some of the results. In addition, the use of nonmilitary volunteers might have produced findings that would differ from those of enlisted women although we specifically chose college-aged women of varying fitness and anthropometrics in order to simulate a plausible enlistment cohort. Thus, other tests and/or factors (eg, psychological, inherent differences between enlisted and civilian volunteers) may need to be explored to better predict performance in untrained women. Finally, any laboratory test, however similar to those tasks carried out in combat, should not be expected to possess complete predictive accuracy as it relates to performance in theatre. A true evaluation of performance requires a multifactorial assessment encompassing both physical and psychological motivating factors in combat situations.

RELEVANCE TO PERFORMANCE TRIAD

Muscular endurance, strength, power, aerobic capacity, and task-specific ability are all factors that influence an individual's performance on military load carriage and repetitive lifting tasks such as those evaluated here. These data are important because it is necessary to know what components of physical fitness contribute to military task performance so adequate training programs can be designed. The primary value of this study is that it reports the relationships of various physical fitness components to military task performance in women. Prior research has demonstrated that load carriage can result in overuse injuries, particularly to the spine and lower extremities. Regardless of the injury risk, load carriage is an integral part of soldiering, and the external loads that Soldiers are required to carry has increased in recent years, despite improvements in load carriage equipment.

As the military continues to place heavy demands on Soldiers and expands combat arms MOS opportunities to women, it is paramount that training programs include heavy periodized resistance training to improve lower and upper body power, strength, and local muscular endurance, in addition to traditional cardiovascular training. Moreover, the present investigation highlights the importance of training specificity. To the extent possible, training should reflect occupation-specific tasks such as load carriage.

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Screening Initial Entry Training Trainees for Postural Faults and Low Back or Hip Pain

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ABSTRACT

Background: The frequency of postural faults and postural awareness in military trainees has not been assessed.

Methods: Five hundred Soldiers entering Advanced Individual Training were screened for standing posture and completed an anonymous questionnaire during inprocessing.

Results: Postural faults were identified in 202 subjects. Chi square analysis demonstrated a relationship between posture observed and posture reported: 87% of subjects with postural faults were unaware of postural faults; 12% with proper posture reported having poor posture. Subjects reported comparable frequencies of back pain and hip pain with postural faults (33.2%, 21.2%) and without faults (28.5%, 14.7%). Anonymous reporting was higher than formal reporting and requests for care during the same period (37% vs 3.4%).

BACKGROUND

Nonspecific lower back pain and lower extremity injuries without known event are reported frequently during Army Basic Combat Training (BCT) and Advanced Individual Training (AIT). Postural faults and related muscular endurance are common deficits observed upon physical therapy examination for lower back pain.

Swayback posture is a simple postural fault to identify using gross landmarks of the lateral malleolus, greater trochanter of the femur, and the greater tubercle of the humerus. Exaggerated shifting of weight over one hip is also observable with short term assessment. Both postural faults may be considered a compensation for reduced postural muscle endurance or use and can shift stress to the hip joint or muscles and ligaments of the spine.

When assessed for posture using a plumb line, swayback posture is categorized by the hips and ankle bones being in front of the plumb line, and the upper back trying to counterbalance things by being further behind the line than usual. Kendall has referenced swayback as a primary postural fault.[1] Sahrmann has noted weakness in posterior hip muscles and anterior abdominal muscles to contribute to this postural fault.[2] Reeve et al has found that transverse abdominus thickness and activity is significantly different in erect upright posture sitting or standing in comparison to slumped sitting or swayback posture.[3] Pezolato et al[4] found that the multifidus muscles demonstrated greater fatty infiltrate in subjects with swayback posture, with or without symptoms, in comparison to a control group. Fatty infiltrate in muscle tissue is associated with muscle atrophy.

No study measuring the frequency of postural faults in military trainees was identified on literature review. Literature review did locate 2 studies on nonmilitary populations of similar age. Norris et al observed 26 university students ranging in age from 18 to 28 years in an exercise course. Fifteen of the 26 subjects (58%) demonstrated swayback posture but only six of those 15 had a complaint of low back pain.[5] Abdolvahabi et al observed 70 female students ranging in age from 17 to 26 years without pain complaints to assess the effect of swayback on other joints, categorizing 35% of the subjects as having swayback posture.[6]

In clinical practice, the author has observed a high frequency of military patients with hip or back pain who present with swayback posture, most of whom were not aware of the postural fault. The frequency of subjects who have swayback posture without back or hip pain has not been established on a larger sample.

This study was a cross-sectional survey of the incidence of swayback or exaggerated uneven weight distribution posture and the presence of hip or lower back pain. Male and female military trainees were recruited during inprocessing prior to initiating AIT. The primary research objective was to measure the frequency of subjects with upright, unilateral weight shift posture, or swayback posture and correlation with hip or lower back pain. The secondary research objective was to provide military training installation personnel feedback on the need for postural education and training as part of integration into military training.

Research hypotheses were that subjects with grossly identified unilateral shift or swayback posture will have an increased frequency of low back pain or hip pain history, and that a significant number of subjects without symptoms will be unaware of postural faults.

METHODS

Over a 5-week period, inprocessing AIT trainees (N=1,904) at the installation inprocessing station were informed of the study's process and intent after the subjects had completed administrative forms. The potential subjects were informed that the study would remain anonymous and that consent would be limited to verbal consent due to the limitation in time available for the subjects during inprocessing and prior to starting training. Inclusion and exclusion criteria were strictly based on the subject's agreement to be observed for posture and to complete the questionnaire. The number of subjects verbally declining to participate in the study was not recorded.

Approximately 100 subjects per class were observed after individually providing verbal consent (5 groups totalling 500 subjects) while standing in line for administrative processing. Fourteen unanswered questionnaires were submitted. The final group required measurement of 138 subjects to achieve the desired 500 participants.

Each subject was determined to have upright posture if observation from their side demonstrated a straight line from the ankle to the pelvis/femur and to the shoulder, and observation from the front or behind demonstrated a grossly vertical line with weight distributed between both feet. Subjects were determined to have a postural fault if the pelvis/head of the femur was observed to be forward of the line from shoulder to ankle or the subject's weight was shifted over to a side. Subjects were given a strip-sized questionnaire with bold face type if a swayback fault (bad) was identified, or an underlined questionnaire (upright) if no gross fault was observed. Subjects were not informed of the different strip significance or given any verbal feedback of the author's conclusion.

No demographic data, including name, age, gender, height, or weight, were requested. Multiple subjects inquired about whether to submit their name and were instructed not to include it. This was intentional to avoid concerns for identification and to provide the most honest feedback. Questionnaires were placed in a locked slot box and were not viewed by the author until all forms for that day were collected. Analysis was performed for correlation between postural fault presence and history of back pain, hip pain, and the percentage of subjects who are aware of the presence of a postural fault.

RESULTS

Five hundred total subjects were observed and also completed the questionnaire. Two hundred ninety-eight subjects demonstrated upright posture (59.6%) and 202 (40.4%) demonstrated a postural fault. Three hundred fifteen subjects had no history of hip or lower back pain (63% overall, 65.4% with upright posture, 59.4% with postural fault), 53 subjects reported having lower back and hip pain (10.6%), 99 subjects reported having only lower back pain (19.8%), and 33 subjects reported having only hip pain (6.6%). Total subjects with lower back pain were 152 (30.4%) and hip pain were 86 (17.2%). Thirty-two subjects had bilateral hip pain, 21 subjects had left hip pain, and 33 subjects had right hip pain.

Two hundred sixty of 298 subjects observed with proper posture believed they had proper posture (87.3%); 38 subjects with observed proper posture believed that they had poor posture (12.7%).

One hundred seventy eight of 202 subjects observed with postural faults believed they had proper posture (88%); 24 subjects with observed postural faults believed that they had poor posture (12%).

Hip pain was reported by 44 subjects observed with upright posture (14.7%) and 42 subjects with postural faults (21.2%).

Lower back pain was reported by 85 subjects observed with upright posture (28.5%) and 67 subjects with postural faults (33.2%).

A comparison of frequencies for lower back pain based on observation and patient reports for posture found that lower back pain was present in 23.1% (60 of 260) subjects who demonstrated and reported proper posture, 28.1% (50 of 178) subjects who demonstrated postural faults but reported proper posture, 62.5% (15 of 24) subjects who demonstrated postural faults and reported poor posture, and 71.1% (27 of 38) subjects who demonstrated proper posture but reported poor posture. The distributions are presented in Figures 1 through 4.

Analysis of frequency for hip pain based on observation and patient report for posture found that lower back pain was present in 10.8% (28 of 260) of subjects who demonstrated and reported proper posture, 18.5% (33 of 178) of subjects who demonstrated postural faults but reported proper posture, 37.5% (9 of 24) of subjects who demonstrated postural faults and reported poor posture, and 42.1% (16 of 38) of subjects who demonstrated proper posture but reported poor posture. The data is presented in the Table.

DATA ANALYSIS

Chi-square measurements were completed for the ratios of the subjects with and without postural faults who present with hip pain history, subjects with postural

faults who present with back pain history, and ratio of subjects matching perception of posture.

Values for Pearson χ^2 did not reach significant levels for hip pain (3.071, minimum 34.74) or lower back pain (3.622, minimum 8.48), but did reach significance for perception of posture (278.695, minimum 87.26). Likelihood ratios for poor posture and hip pain (3.03) and lower back pain (3.56) were not strong. Perception of posture had a likelihood ratio of 309.13.

COMMENT

Findings from this study suggest that there is no statistical correlation between observed posture quality and presence or absence of lower back pain or hip pain in this population. The only correlation supported by χ^2 ratios relates to observed posture and perceived posture.

The percentage of subjects with postural faults was comparable to the finding of 35% by Abdolvahabi et al[6] and below the finding of 58% by Norris et al.[5] The percentage reporting back pain was closer to the Norris et al finding (33.2% vs 40% of subjects with swayback).[5]

At the time of this study, the author was participating in an injury prevention program with the single objective of early injury identification. All Soldiers arriving from BCT were given an intake form which included inquiries about any prior injury at BCT and present requests for medical care. More meaningful to military training and injury prevention is the observed discrepancy between prior injury or pain complaints in an anonymous survey and these intake screening questionnaires. This finding was not an initial objective and was not anticipated to the observed magnitude. Initial Entry Training Soldiers often delay reporting injury either during BCT or upon arrival at AIT due to concerns of having a delay in training while receiving medical treatment. During the 5 week study period, only 10 Soldiers reported hip pain and 7 Soldiers reported back pain when given the opportunity to seek care prior to starting advanced training. If all 17 of the Soldiers who requested care were included in the surveyed population, there would

Distribution of observed and reported postures, with related reported pain symptoms.

Posture Category	Total	Low Back Pain	Hip Pain
Upright observed, upright reported	260	60	28
Upright observed, fault reported	38	27	16
Fault observed, upright reported	178	50	33
Fault observed, fault reported	24	15	9

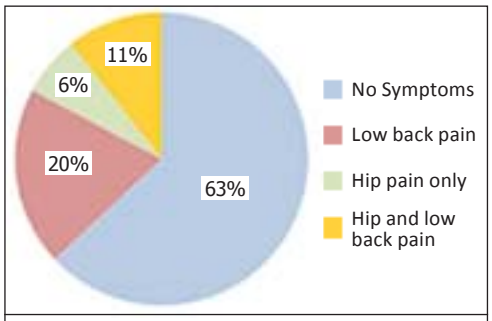

Figure 1. Pain symptom distribution reported by all participants in the study (N=500).

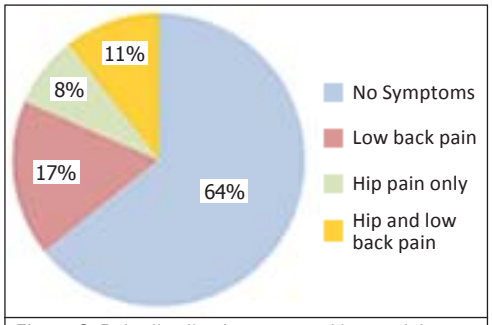

Figure 2. Pain distribution reported by participants who incorrectly believed that they had proper posture (n=178).

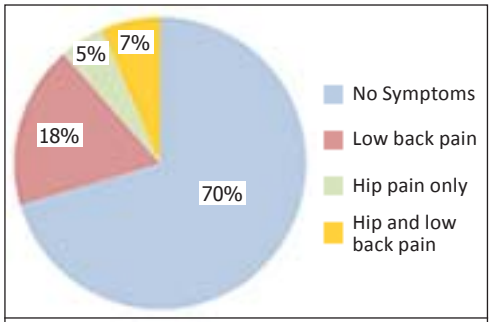

Figure 3. Pain symptom distribution reported by participants who correctly believed that they had proper posture (n=260).

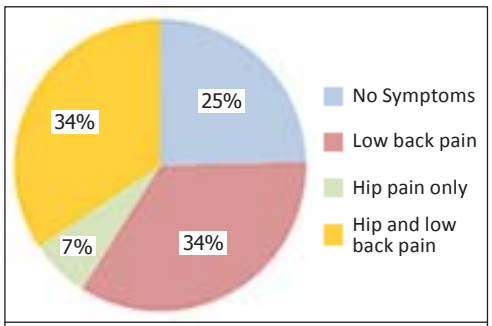

Figure 4. Pain symptom distribution reported by participants who believed that they had poor posture (n=62), although 38 of them were observed to have proper posture.

still be a discrepancy between the rate of direct reporting (3.4%) and the survey results (37%).

Due to the study's anonymity and sample percentage, the investigator is not able to follow-up to determine the number of Soldiers who requested or required medical care during training or at BCT. The other recognized limitation in this finding is the potentially high percentage of reported lower back pain that has been resolved or reported when present for only a few days after more vigorous training.

Although the percentage of subjects who reported having poor posture was only 12.4%, the percentage within that subgroup that reported having a history of hip or back pain was 76% (47 of 62), which was higher than the percentage of subjects with hip or back pain observed with poor posture but reported proper posture (36%), or observed with good posture (24.5%). As a screening process, it suggests limiting future application for larger populations to a written survey. This conclusion will require validation through application on an intake survey that is not anonymous.

Limitations of the study include lack of clarification as to whether the subjects had current back or hip pain and the duration of lower back or hip pain. There was uncertainty if subjects reported short duration soreness after vigorous work (wearing body armor or road march in BCT) as lower back pain, and there was a lack of demographic information including differentiation by gender. Most Soldiers completing initial training are aged 21 years or younger, but comparisons of groups cannot be provided and would require modification of the study and the consent.

The Soldiers participating in the study were typically standing in place for less than 2 to 3 minutes; therefore, postural faults that may develop after 15 to 20 minutes were not observed. Soldiers who have lower back and hip pain may also have concluded that they have poor posture based on symptoms history, but this could not be verified. Due to the limitations in time available and level of consent, the author also consciously removed an axial compression test used in clinical practice to verify postural faults as functional or meaningful.

Follow-up studies should include a study of the rate of injury disclosure through inclusion of postural self-assessment on the intake survey and associated follow-up to assess for hip and lower back pain, and a study to validate the magnitude of swayback that is meaningful.

CONCLUSIONS

Observational screening of posture for Soldiers in Initial Entry Training does not effectively identify Soldiers with a history of lower back or hip pain. Written questionnaires including focus on posture may offer better feedback of a population but would require reevaluation without anonymity.

A significant percentage (40%) of Soldiers in Initial Entry Training demonstrate postural faults, most of which are not recognized by the Soldiers.

ACKNOWLEDGEMENTS

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Cervical Myelopathy: Diagnosing Another Great Impostor

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ABSTRACT

Context: Cervical myelopathy, especially during the early stages of the disorder, is very difficult to diagnose. It has the ability to mimic a number of other neurologic and musculoskeletal conditions, resulting in prolonged diagnostic delay in some cases. Excessive delay can result in permanent paralysis, gait, and genitourinary dysfunction. While most common in aging populations, it can present to military clinicians at any time. Consequently, there needs to be an increased index of clinical suspicion when evaluating Soldiers.

Objective: The purpose of this clinical review is to provide an evidence-based update regarding the diagnostic utility of both common and novel clinical tools.

Data Sources: English language articles published in peer reviewed journals were identified by searching the PubMed, CINAHL, and SPORTDiscus databases.

Results: Historically, clinicians have performed tests such as the Hoffmann or Babinski signs in order to rule out the presence of cervical myelopathy or other upper motor neuron disease. While there is some evidence to suggest their clinical usefulness, several other clinical tools should be considered as well. Specifically, the Trömner and the Wazir hand myelopathy signs are very sensitive for detecting myelopathy at or above the C5-6 level. There is sufficient evidence to suggest that any neurologic screen with the purpose of excluding cervical myelopathy needs to include the lower extremity tests such as the patellar tendon and Rossolimo reflexes. Analysis of the lateral cervical radiograph is an efficient and inexpensive method of evaluating for the presence of congenital cervical spine stenosis, a known risk factor for cervical myelopathy. Magnetic resonance imaging findings on T2, and especially the T1 weighted images, appear correlated with surgical outcomes.

Conclusion: Military clinicians should use the most valid clinical tools when evaluating for the presence of cervical myelopathy.

In every field of clinical medicine there are a number of "cannot miss" diagnoses. These include pathologic conditions where diagnostic delay could contribute to significant morbidity or mortality. For example, in orthopedic surgery this list would certainly include postoperative deep vein thrombosis, joint sepsis, and acute compartment syndrome. In military medicine, the list is substantially longer and occasionally not as obvious clinically. One such diagnosis is cervical myelopathy. Its clinical presentation is often ambiguous, making it difficult to detect, especially in the early stages. Further, it has the ability to produce neurologic and musculoskeletal symptoms anywhere in the body from head to toe. Consequently, it could be considered another "great impostor." A classic medical example of a great impostor is syphilis due to its ability to mimic pathology in virtually any organ system in the body.[1] Other disease processes such as multiple sclerosis, systemic lupus erythematosus, and endocarditis have also been given the label "great masquerader" for similar reasons.[2-5] The purpose of this clinical review is to provide an evidence-based update regarding the diagnostic utility of both common and novel clinical tools.

ETIOLOGY

Myelopathy generally refers to disease within the spinal cord. However, there is no universally agreed-upon definition or pathognomonic findings to assist in the diagnosis. There are several etiologies of cervical myelopathy, including trauma, tumor, abscess, rheumatic disease, metabolic disorders, and syringomyelia, to name a few. The most common etiology is due to progressive degenerative changes within the cervical spine, commonly referred to as cervical spondylotic myelopathy (CSM). The exact prevalence remains unknown. However, it has been reported to be the most frequent cause of cord dysfunction in people older than 55 years.[6] Athletes are more likely to develop cervical spine pathology traumatically during participation in contact sports such as rugby, soccer, football, diving, and horse riding. In addition, some athletes and military occupations are more prone to develop early degenerative changes in the spine secondary to repetitive trauma and enduring the general rigors of their respective professions.[7-9] Consequently, clinicians should not discount the possibility of myelopathy simply due to the age of the patient.

EXAMINATION

Clinical Findings

Patients with cervical myelopathy present with a wide variety of symptoms ranging from mild sensory loss to obvious altered gait and concomitant genitourinary dysfunction. Typically, the onset is insidious in those older than 40 years and usually associated with CSM. The frequency of occurrence of CSM is higher in males by an approximately 3:2 ratio.[10] The specific signs and symptoms of cervical myelopathy will be related to the affected level(s) of the cervical spine. In a severely degenerated spine, compression of the cord to varying degrees can occur at multiple levels, which can further complicate the clinical picture. The signs and symptoms of cervical myelopathy are summarized below. Although common, the presence of neck pain is not a reliable initial clinical indicator, as some will not complain of pain in this region. Stiffness, numbness, and weakness can be present in the upper and/or lower extremities. Further, the symptoms may present in a unilateral or bilateral fashion. Gait disturbance and genitourinary dysfunction is common in progressive stages of the disease. Urinary symptoms, such as increased urgency and frequency, appear to be more common than bowel-related symptoms.[10] However, on some occasions, patients may present with solely lower extremity complaints.[11]

Given the wide diversity of symptoms associated with cervical myelopathy, it is essential to employ clinical tests and measures with the greatest diagnostic utility. Specifically, tests that demonstrate high levels of sensitivity will be of clinical value to sports medicine clinicians, as a negative finding will be helpful in ruling out the disorder. Historically, clinicians have used tests and measures such as ankle clonus, Babinski sign, hyperreflexia, and the Hoffmann sign to screen for cervical myelopathy. However, diagnostic accuracy studies have shown that these clinical tests and measures for cervical myelopathy often display low sensitivity, indicating that a negative finding may falsely suggest the absence of a condition or disease that actually is present. Therefore, to counter the low levels of sensitivity, Cook et al[12] proposed that a pragmatic approach looking at patient history and pertinent contributory tests and measures was the best course of action when evaluating patients for the presence of cervical myelopathy.

Subsequently, Cook et al[6] examined the reliability and sensitivity of 7 clinical tests: Babinski sign, clonus, Hoffmann sign, inverted supinator sign, hand withdrawal reflex, suprapatellar quadriceps reflex, and upper extremity deep tendon reflexes. Two highly experienced clinicians demonstrated substantial inter-rater agreement on 4 of the 7 tests. This potentially limits its applicability to novice clinicians. In contrast to a prior study by Cook et al,[12] they found no single test or combination of tests proved to be an effective screening tool. Of note, the Babinski did alter the post-test probability greater than any combination of tests performed. A possible limitation for this study included the selection of high-intensity signal changes, defined as myelomalacia, found on magnetic resonance imaging (MRI) being selected as the imaging reference standard. There is no definitively accepted diagnostic gold standard for diagnosing cervical myelopathy. Obviously, in order for cord compressive myelopathy to be present, there must be, at a minimum, physical indentation of the spinal cord. Although myelomalacia has commonly been used as a reference standard, this is a highly specific finding only addressing one possible MRI abnormality. Further, the high specificity seen in both clonus and Babinski was possibly due to the fact the all of the subjects were referred to a spine surgeon for surgical evaluation. Therefore, the likelihood of diagnosing other causes of upper motor neuron pathologies was decreased. Lastly, an inconsistent time frame between imaging and examination was observed.

Since most clinical tests used to identify CSM are specific and no clusters of tests have proven more beneficial

Signs and Symptoms of Cervical Myelopathy

Common	
Neck pain	Neck stiffness
Parasthesias in upper extremities	Unilateral or bilateral upper extremity pain
Urinary dysfunction; increased urgency and frequency	Gait disturbance
Hyperreflexia below the level(s) of the lesion	Diminished deep tendon reflexes at the level of the lesion
Primitive reflex(es) present	Normal cranial nerve exam
Upper/lower extremity weakness not confined to single root level	Lhermitte's sign
Less Common	
Bowel dysfunction	Isolated parasthesias in lower extremities
Isolated lower extremity pain	Spasticity (usually in later stages)

than standalone tests in guiding treatment decision making, Cook et al[13] developed a cluster of predictive clinical findings for patients with cervical myelopathy. Data from 249 patients were analyzed using multivariate regression analyses and a definitive cluster was identified. Thirteen clinical findings were investigated for capacity to diagnosis cervical myelopathy. This study found that selected combinations of clinical findings that consisted of (1) gait deviation, (2) positive Hoffmann sign, (3) inverted supinator sign, (4) positive Babinski sign, and (5) patients older than 45 years were effective in ruling out and ruling in cervical spine myelopathy. When clustered into one of 5 positive tests to rule out cervical myelopathy, the negative likelihood ratio was 0.18. When clustered into 3 of 5 positive findings to rule in cervical myelopathy, the positive likelihood ratio was 30.9. This study found clustered combinations of clinical findings that could rule in and rule out cervical myelopathy.

Rhee et al[14] prospectively examined the prevalence of myelopathic findings in patients with and without confirmed CSM. Interestingly, they used postoperative clinical improvement determined by the modified Nurick score as the gold standard for confirming the diagnosis of CSM. At least one physical myelopathic sign was identified in both the CSM group (79%) and the control group (57%). Subjects in the control group presented with neck and/or radicular symptoms, no myelopathic symptoms, no cord compression on imaging, and no history of cervical spine surgery. The primary result was that myelopathic clinical exam findings are more common in those patients with myelopathy, however, it appeared to lack sensitivity for approximately 20% of subjects. No single test proved to be particularly sensitive and test clusters were not evaluated.

More recently, some studies have investigated the frequency of myelopathic clinical exam findings. Chikuda et al[15] performed a retrospective analysis of 120 patients who underwent surgery to address myelopathy due to cervical spondylosis or ossification of the posterior longitudinal ligament. They further stipulated that patients included in the analysis also had high intensity signal changes on preoperative T2 weighted image MRIs. The purpose was to report the sensitivity of pyramidal or long tract signs in patients who underwent surgery for myelopathy. They reported the most sensitive test was an exaggerated patellar tendon reflex (94%), followed by the Hoffmann sign (81%), Babinski sign (53%), and ankle clonus (35%).

Houten and Noce[16] retrospectively reported the prevalence of the Hoffmann sign (68%), Babinski sign (33%) and hyperreflexia (60%) in 225 patients who underwent surgery for CSM. Additionally, the severity of myelopathy as determined by modified Japanese Orthopedic Association (m-JOA) scores showed selective diagnostic benefit for the Hoffmann's sign. Forty-six percent of individuals with mild m-JOA scores had a positive Hoffmann sign, compared to only 10% with Babinski sign present. In those with severe myelopathy, Hoffmann and Babinski signs were positive 81% and 83% respectively. This indicates that the Hoffmann sign is more likely to be present in milder cases and equally likely in severe cases. In addition, they also examined patients presenting exclusively with lumbar spine complaints for the presence of a positive Hoffmann sign. Of the 290 subjects in this group, 12% had a positive Hoffmann sign. Individuals with a bilateral sign had confirmed cord compression on MRI 91% of the time and 50% of the time when the sign was present unilaterally. This finding is consistent with the concept of tandem spinal stenosis which has a reported prevalence of 5% to 25%.[17] Despite the fact that those subjects were currently asymptomatic, the detection of occult cord compression is clinically valuable, especially when considering participation in contact sports or even consenting to surgical procedures that require intubation.

In contrast, Sung and Wang[18] recommended no further evaluation with radiographs or MRI for asymptomatic patients that demonstrate a positive Hoffmann sign. They found 16 such patients, 15 of whom demonstrated signs of cord compression on imaging which ranged from mild to severe. Therefore, the presence of a positive Hoffmann sign in asymptomatic patients strongly suggests underlying cervical pathology. However, since the clinical course was not affected by the imaging results, they concluded that radiographs and MRI were unnecessary in this patient population. While this recommendation may be reasonable for the average patient, the same cannot be said for the Soldier that may be at higher risk for cervical spine injury.

While the Hoffmann sign appears to be very sensitive for detecting cord compression, Chang et al[19] reported the Trömner sign to be a more effective method of detecting CSM. First, however, the difference between the two signs must be clarified. The Hoffmann sign was first reported in 1911 by a student of Johann Hoffmann and is described as flicking or nipping the nail of the middle finger in a downward direction with a resultant flexion of the index finger and/or thumb.[16] The Trömner sign is defined as reflexive flexion of the thumb and finger due to tapping or flicking the volar aspect of the distal phalanx of the middle finger.[19] Both the Trömner and Hoffmann

signs are used as indicators for lesions at or above the C5-6 level. While not frequently reported in the literature, the Trömner sign demonstrated greater diagnostic sensitivity in this study than did the Hoffmann's sign. The reported sensitivity was 93.5% and 89.1% respectively. They further designed a means of quantifying the Trömner sign electrophysiologically and found 100% sensitivity when CSM patients were assessed in that manner. The increased sensitivity of the Trömner sign can be reasoned anatomically, given the lack of nerve endings in the nail itself, and the robust cutaneous innervations on the volar aspect of the distal phalanx.

The same group of researchers[20] also looked to quantify the sensitivity of the Rossolimo reflex in a population with confirmed cervical or thoracic spondylotic myelopathy. The Rossolimo reflex is also underreported in the medical literature with regards to its sensitivity. It is classically described by flicking or tapping the plantar aspect of the toes resulting in flexion of the toes. Chang et al[20] utilized a set-up where the patient is supine (with knees slightly flexed) and a reflex hammer was used to gently strike the skin of the plantar aspect of the 2nd metatarsophalangeal joint. A positive sign was confirmed when there is resultant toe flexion. In their population, the sensitivity of the test was 85.7% when performed manually, and 100% when done using an electrophysiological test.

Recently, Wazir and Kareem[21] also reported a hand-based myelopathy sign that appears to be sensitive for detecting the presence of CSM at or above the C5-6 level. The Wazir hand myelopathy sign is described as the exaggerated flexor response of the thumb, fingers, and wrist when the volar aspect of the relaxed extended wrist is tapped at the level of the palmaris longus tendon (Figure 1). This can be accomplished by lightly tapping with the examiner's middle finger or using a reflex hammer. Ninety-three percent of patients with documented CSM at or above the C5-6 level demonstrated a positive test, while no patients with CSM at or below C6-7 demonstrated a positive sign. The rationale for this is anatomic distinction is clear given the disinhibition of the long finger flexor reflex arc when cord compression is present above the finger flexor root levels.

Kobayashi et al[22] developed a questionnaire that appears to be an effective patient screening tool. Twenty candidate questions were selected from the Japanese Orthopaedic Association Cervical Myelopathy Evaluation Questionnaire. The reliability and validity for this instrument has already been documented.[23] A series of 8 questions were determined to be of the greatest value using multiple linear regression and receiver operating characteristic curve analysis. The range of possible scores for the questionnaire is 0 to 13. When the cut-off point for the total score was set at 6, the sensitivity was 93.5% and the negative likelihood ratio was 0.096. The authors concluded that these values are sufficiently high for screening, and this questionnaire is useful to rule out cervical myelopathy when scores are less than 6. The specificity was 67.3% and the positive likelihood ratio was 2.96, suggesting that scores greater than 6 on the questionnaire are not useful for making a definitive diagnosis of cervical myelopathy.

Imaging

Imaging studies are clearly very important in establishing the diagnosis of cervical myelopathy. While MRI is the imaging study of choice, there is some valuable clinical information that can be obtained via plain radiographs. Particularly, the presence of congenital cervical stenosis can be assessed by applying the Torg-Pavlov ratio on a lateral radiograph. It is defined as the quotient of the development sagittal canal divided by the vertebral body diameter of the same level[24] (Figure 2). Values lower than 0.80 are concerning for the presence of cervical spine stenosis. In one of only 2 published studies directly comparing the Torg-Pavlov ratio on myelopathic with nonmyelopathic individuals, Yue et al[24] found the mean ratios were 0.73 and 0.95 respectively. Age served as a lesser predictive factor revealing that older subjects were more likely to have cervical myelopathy. Gender did not appear to be a predictive factor. Further, 50 years or older was the most common age range of those in the cervical myelopathy group who received surgery; when this subset was analyzed the mean ratios were 0.71 and 0.91 respectively. While this method helps to address concerns over magnification error, it has been shown by Herzog et al[25] to have great sensitivity but low positive predictive value in athletes. False positives in their population of asymptomatic professional football players were largely due to increased diameter of the vertebral

Figure 1. Demonstration of the Wazir hand myelopathy sign.

body. Consequently, Tierney et al[26] proposed a physical measure of the spinal cord using MRI described as space available for the cord (SAC). This measure is obtained from subtracting the sagittal diameter of the spinal cord from the sagittal diameter of the vertebral canal at that level. It is likely a more specific tool to diagnose cervical myelopathy given it directly measures the spinal cord and its surroundings. However, it requires the use of MRI, and critical SAC values consistent with stenosis have yet to be determined. Other canal measurements on the lateral radiograph have been proposed. For example, Herzog et al[25] proposed the shortest distance between the most posteroinferior aspect (likely an osteophytic rim) of the superior vertebral body with the anterosuperior lamina of the inferior vertebral body (Figure 2). This can be assessed in the neutral position or extended. Extension is likely to show more clinically significant diminishment of this diameter. It has been suggested that a distance of at least 11 mm to 13 mm is required to house the spinal cord, and anything less than 11 mm is indicative of stenosis.[10]

Many, if not all, clinicians use MRI images to assist in diagnosing cervical myelopathy. There does not appear to be any true gold standard on MRI findings other than the presence of an indentation of the spinal cord parenchyma.[27] Spinal cord compression, indicated by physical indentation, can be present in asymptomatic individuals,[18,28] but it will always be present with individuals diagnosed with cervical myelopathy. Cook et al[6] specifically used T2 weighted image high intensity signal (T2 WI HI) as the diagnostic standard for their study (Figure 3). The presence of T2 WI HI increases the likelihood of cervical myelopathy, but does not make the diagnosis. Harrop et al[27] demonstrated that when cord compression was evident on MRI, the presence of T2 WI HI (odds ratio of 11.4) and sensory loss (odds ratio of 16.9) increased the likelihood of myelopathy. Kadanka et al[29] prospectively examined a cohort of patients (N=243) to determine if a threshold of cord compression exists at which patients will develop clinical myelopathic signs. They reported that patients with a cross sectional area of between 50 mm^2 and 60 mm^2 in conjunction with T2 WI HI at the same level are most likely to show clinically significant symptoms of cervical myelopathy. Avadhani et al[30] have proposed that both T1 weighted image low intensity signal (T1 WI LI) and T2 WI HI can be prognostically useful in determining those likely to obtain a poor surgical outcome. Their retrospective analysis demonstrated that T1 WI LI along the spinal cord was more predictive of a poor surgical outcome. Further, some patients with a poorer outcome developed T1 WI LI signal changes postoperatively, thereby supporting the value in obtaining postoperative MRI images.

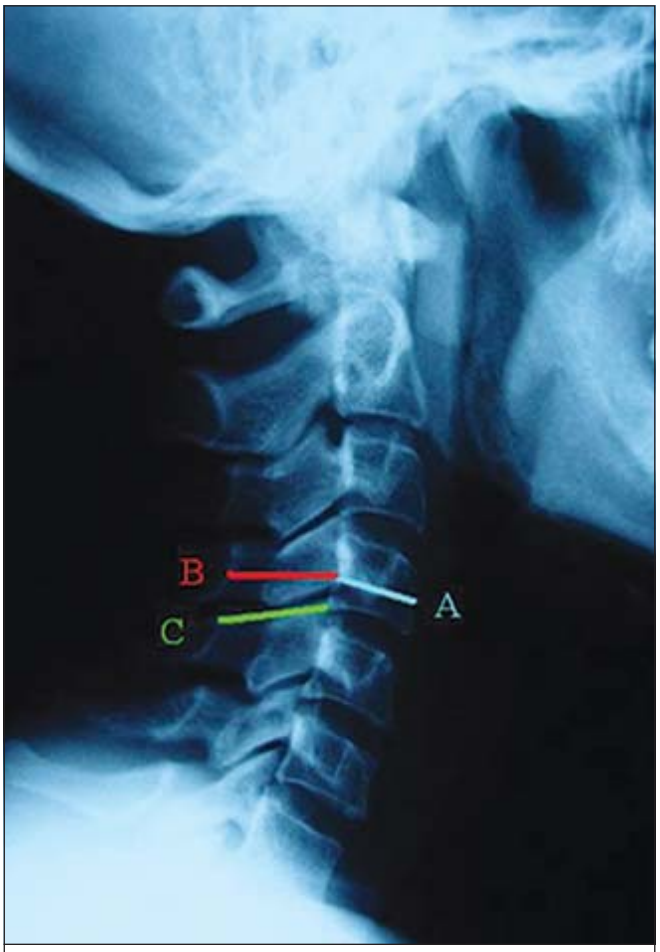

Figure 2. Lateral Radiograph Canal Measurements. The Torg–Pavlov ratio is defined as the ratio of A/B and another method of evaluating canal diameter is through measuring the distance from the posteroinferior rim of the superior vertebral body to the anterosuperior lamina of the inferior vertebral body (C).

Differential Diagnosis

Given the numerous etiologies of myelopathy, and the fact that cervical myelopathy presents either vaguely similar to or near indistinguishably from a multitude of pathologies, the differential diagnosis is very broad. Clearly, several other disease processes can produce long tract or pyramidal signs such as multiple sclerosis, myelitis, and stroke. Obvious muscular causes of upper extremity pain including rotator cuff disease are more likely and should be assessed. Additionally, there is a need to rule out the possibility of isolated or concomitant peripheral neuropathy. However, the list is not simply limited to musculoskeletal or neurologic complaints, but should include other organ systems. Clinicians must consider everything from inflammatory causes of spinal cord dysfunction such as sarcoidosis to vascular abnormalities like arteriovenous malformation. The combination of clinical signs and imaging information discussed above will greatly assist in reducing the possibilities.

TREATMENT

The primary question with treatment concerns conservative or surgical management: which is more effective? Currently, the best course of treatment remains in question. Many clinicians believe that CSM is a result of fixed degenerative deformity, and surgery is the only manner to address it. If a patient were to present with obvious and progressive neurologic decline that correlated with imaging results, it is clear that surgical intervention is necessary. However, a majority of patients presenting to sports medicine clinicians do not have severe cervical myelopathy requiring prompt surgical referral. They will likely fall into the category of asymptomatic, mild or moderately affected. Therefore, MRI findings consistent with cord compression in an asymptomatic patient were found serendipitously. Bednarik et al[28] prospectively evaluated a group of 199 patients with asymptomatic spondylotic cervical spinal cord encroachment with follow-ups ranging from 2 to 12 years in order to determine the clinical factors common in those who ultimately became symptomatic. Those likely to develop symptoms in less than a year had complaints of radiculopathy and abnormal somatosensory evoked potentials or motor evoked potentials during electrophysiological testing. T2 WI was a common predictor for those becoming symptomatic after a year. Ultimately, only 8% of the total group required surgery to address spondylotic cervical spinal cord encroachment during the study period. There are 2 key findings that should be highlighted from this study: (*a*) implementation of preventive surgical decompression into routine clinical practice should be avoided until better-designed studies provide enough evidence for it to take precedence over a conservative approach; and (*b*) the presence of cervical radiculopathy, abnormal electrophysiological findings, and T2 WI require close follow-up. Consequently, patients should closely followed and be restricted from high risk activities in order to decrease the likelihood of spinal cord injury.[31]

Cases of mild cervical myelopathy should also be closely followed and given a trial of conservative care. There is limited evidence to suggest the combination of intermittent cervical traction and thoracic spine manipulation is beneficial for individuals with grade 1 cervical compressive myelopathy attributed to herniated disc.[32] Otherwise, the evidence for conservative treatment approaches is scarce. Patients may also benefit from education, activity modification, and anti-inflammatory or analgesic medications. Kadanka et al[33] completed a prospective investigation comparing surgical to conservative management for mild to moderate nonprogressive CSM. The study, while underpowered, boasted a 10-year follow-up window. There was no difference between the 2 groups regarding m-JOA scores, 10 m timed walk, and quality of daily activities. Therefore, it seems reasonable that a patient with mild to moderate CSM should be routinely followed at 6-month intervals to ensure there is no progression of the disease.

CONCLUSION

Cervical myelopathy represents one of the most challenging clinical conundrums military clinicians will face. The body of evidence regarding the diagnostic accuracy of both clinical tests and imaging modalities is improving, but lacks consistency. More high quality diagnostic cohort trials are needed. In the interim, tests that have demonstrated the greatest sensitivity should be employed. Hoffmann's sign, Trömner sign, and the Wazir hand myelopathy sign offer the best sensitivity for lesions at or above the C5/6 level. Additionally, the Hoffmann sign appears to be especially sensitive in earlier stages of cervical myelopathy. Of the lower extremity tests, the Rossolimo reflex and an exaggerated patellar tendon reflex appear to be most useful. Clinicians that only use Babinski sign and ankle clonus in the lower extremities to evaluate for the possibility of

Figure 3. Sagittal T2 weighted image of the cervical spine demonstrating a protruded disc at C5-6 causing cord compression. Altered signal intensity of the cord is also seen (circle) (indicating localized myelomalacia).

upper motor neuron disease should consider expanding the scope of their neurologic evaluation. The Torg-Pavlov ratio is inexpensive and can indicate the presence of congenital cervical stenosis. Other lateral radiograph measurements can also indicate the presence of congenital or acquired stenosis. Findings on both T1 and T2 weight MRI images should be correlated with clinical exam findings. Ultimately, the clinical exam findings must be correlated with the imaging results to arrive at the diagnosis. In the absence of other known neurologic conditions, the presence of at least one reproducible pyramidal sign and the presence of cord compression and T2 WI HI will significantly increase the likelihood of myelopathy. Asymptomatic individuals and patients with mild signs and symptoms associated with nonprogressive cervical myeloplathy do not require preemptive surgical intervention, but recurrent neurologic follow-up and counseling to avoid high-risk activities are strongly recommended.

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Angioedema as a Prodrome of Rheumatoid Arthritis Exacerbation

Ketan Desai, MD, PhD

SUMMARY

Angioedema has not been associated with rheumatoid arthritis. However, this case report demonstrates that it can be the leading presentation of an exacerbation of rheumatoid arthritis. This case report is important for both rheumatologists and immunologists who see patients with rheumatoid arthritis and angioedema, respectively, so they recognize this presentation.

BACKGROUND

Angioedema is a disorder characterized by swelling in the subcutaneous tissues resulting in a clinical presentation of swollen tongue, lips, throat, orbital tissues, and gastrointestinal tract distress. It can be hereditary or secondary to drugs or allergens. Rarely it can be associated with hypereosinophilic and Gleich's syndrome. It has not been known to herald an acute exacerbation of rheumatoid arthritis. This case report identifies one such possible example.

CASE PRESENTATION

A Caucasian male 62 years of age was diagnosed with rheumatoid arthritis in December 2010 after presenting to his physician with symmetrical pain and swelling in both shoulders and metatarsal phalangeal joints. He was started on methotrexate and titrated to 22.5 mg once a week. In addition, he was treated with prednisone 5 mg orally every day to control his disease. The patient remained on this treatment till December 2011 when the author became his care provider. At this time, he had no morning stiffness or joint swelling. He had mild pain in hands and left foot, rated 4/10. On exam, he had mild tenderness of metacarpal phalangeal and proximal interphalangeal joint pain bilaterally but no swelling or synovial thickening was appreciated. The shoulders were not tender, with normal range of motion. There was mild tenderness of his left metatarsal phalangeal joints but no synovial thickening or swelling was appreciated. Sedimentation rate was 0, rheumatoid factor 12, and anti-CCP antibody greater than 250. At this time, hydroxychloroquine 200 mg bid was started and prednisone was tapered off to avoid steroid side effects.

The patient did well on this regimen and was seen at 3 monthly intervals with monitoring of hematology and chemistries.

Patient noted that he had a sore throat on October 28, 2012, with swelling around eyes and mouth which was associated with pain but no itching. He went to the emergency room where he was noted to have no shortness of breath, but did have swelling of lips and tongue. He was treated with amoxicillin and discharged. He returned to the emergency room on November 2, 2012, with worsening swelling of tongue and lips. He had no skin rash, trouble breathing, diarrhea, abdominal pain, or swelling around the eyes. He was taken off amoxicillin and put on a Medrol dose pack. The lesions attenuated somewhat on Medrol, but recurred after the Medrol dose pack was finished. He once again returned to the emergency room on November 10 where the physician stopped methotrexate and hydroxychloroquine and placed an immunology consult. While waiting for the immunology consult, the patient had recurring episodes of swelling of his lips and periorbital tissues. There was no tongue swelling or trouble swallowing. There were days when he was completely asymptomatic with no symptoms. Despite being off antirheumatic drugs, the pain in joints stayed bearable, with no swelling or morning stiffness.

The immunologist saw the patient on December 18. At that time, the patient had no signs or symptoms of angioedema or urticarial lesions. He had no trouble breathing and had no gastrointestinal symptoms. A workup was ordered, which showed normal levels of C1 inhibitor, C4, hemolytic complement 50, erythrocyte sedimentation rate, comprehensive metabolic panel, urine analysis, and thyroid stimulating hormone. The immunologist advised the patient to restart the antirheumatic drugs and also started him on hydroxyzine and ranitidine. After initiation of hydroxyzine and ranitidine, the episodes of angioedema decreased in severity, with less swelling of lips and periorbital tissues. He continued to have no shortness of breath, abdominal pain, or tongue swelling.

Two months later (February 2013), the patient's rheumatoid arthritis flared, with significant bilateral hand tenderness, swelling, and synovitis in metacarpal phalangeal joints and proximal interphalangeal joints. Morning stiffness increased to 2 hours and sedimentation rate was above 50. His angioedema also became more severe, with greater involvement of lips and periorbital tissues and increased pain in lips. Since he was already on high

dosages of methotrexate and hydroxychloroquine, biologics were considered. After getting PPD and chest X-ray, he was started on an anti-TNF biologic.

Two weeks after starting the anti-TNF, the patient became asymptomatic, with no tenderness, swelling in any joint, and no morning stiffness. His ESR also normalized. The angioedema was completely absent. The hydroxyzine and ranitidine were discontinued after a month of anti-TNF therapy. There has been no recurrence of angioedema over the past 6 months.

COMMENT

Angioedema is the swelling of deep dermis, subcutaneous, or submucosal tissue due to vascular leakage. Histamine and bradykinin are the most recognized vasoactive mediators known to be critical in the pathogenesis of angioedema.[1] Histamine can be released by IgE or non-IgE mechnisms. Most commonly, the release of these mediators is a result of allergens or drugs. Rare causes include hypereosinophilic syndrome and Gleich's Syndrome.[2] Angioedema has not been recognized as a complicating feature of rheumatoid arthritis. Certain medications have been implicated in the induction of angioedema. Among those are antirheumatic agents such as anti-TNF biologics[3] and methotrexate.[4] There have also been rare case reports of rheumatoid arthritis developing in patients with hereditary angioneurotic edema.[5] However, there have been no reported cases of angioedema heralding a flare of rheumatoid arthritis. This is possibly the first such reported case. This is important since recognition of this manifestation can result in quick and appropriate management. It is possible that this could be a manifestation of methotrexate induced angioedema, but is unlikely since the patient had been on methotrexate for 2 years and the angioedema disappeared after the anti-TNF biologic was added, despite continuation of methotrexate.

CONCLUSIONS

- Rheumatologists should be aware that angioedema may herald a flare in rheumatoid arthritis.
- Immunologists should also be aware that the angioedema may be a result of rheumatoid arthritis and can herald a flare.
- The angioedema subsides if the rheumatoid arthritis is treated appropriately.

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Radiofrequency Denervation of the Hip Joint for Pain Management: Case Report and Literature Review

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ABSTRACT

Background: A 55-year-old male presented with severe pain and functional limitations as a result of left hip osteoarthritis. He had failed multiple treatments while waiting for a hip arthroplasty, including physical therapy, medications, and various intra-articular injections. Thermal radiofrequency lesioning of the obturator and femoral articular branches to the hip joint was offered in the interim.

Objectives: To our knowledge, this is the first report to describe an inferior-lateral approach for lesioning the obturator branch, the clinical application of successive lesions to increase denervation area, and outcomes in a patient receiving a second treatment with previously good results.

Methods: To discuss relevant and technical factors for this specific case, we reviewed previous literature on hip joint radiofrequency and critically evaluated previous anatomic studies in the context of radiofrequency.

Results: The first treatment provided significant benefit for a period of 6 months. A second treatment was employed providing only mild to moderate benefit until his joint replacement surgery 4 months later. Literature review revealed studies of low quality secondary to small sample sizes, patient selection methodology, inclusion of patients with heterogenous etiologies for pain, variable needle placement techniques, and lack of measurement of functional outcomes.

Limitations: Case report and low quality studies in existing literature.

Conclusions: Hip joint radiofrequency denervation is a promising avenue for adjunctive treatment of hip pain. Further cadaveric studies are required to clarify a multitude of technical parameters. Once these are well defined, future clinical studies should consider pain, functional, and economic outcomes in their design.

BACKGROUND

Osteoarthritis results in activity and functional limitations, high health care and economic costs, and increased mortality.[1,2] Osteoarthritis (OA) of the hip and knee is the primary etiology of walking-related disability in the United States.[3] Depending on age, hip joint OA alone has an estimated prevalence of 28% to 43% radiologically, and 10% to 17% based on symptoms.[4] The prevalence of this is rising, attributed in some studies to the advancing age of the population and increased incidence of obesity.[5,6]

While no reversible treatment for hip joint OA is available, total hip arthroplasty has been shown to provide excellent pain relief, return of function, and medication reduction.[7] With relatively low associated complication rates,[7] it is the standard of care for patients failing conservative treatment. However, barriers to arthroplasty treatment include patient factors such as comorbidities and active health issues, system factors (surgical wait times, lifespan of surgical implants, etc), and societal factors such as gender and race.[1,7-9]

Proposed conservative treatments for OA have varying levels of evidence and efficacy and include lifestyle modifications (weight loss, exercise, nutriceuticals),[10-14] physical therapy (modalities, bracing, gait aids, shoe modifications, acupuncture, aquatic therapy, strengthening),[15-18] pharmaceuticals (topical medications, acetaminophen, nonsteroidal anti-inflammatories, opioids, nitric oxide),[19] and joint injections (steroids, hyaluronic acid, prolotherapy, autologous blood injections).[20,21]

Thermal radiofrequency (TRF) denervation of the sensory articular nerves to the hip joint is emerging as a possible adjunctive treatment for coxalgia. This has been validated for the management of zygapophyseal joint pain, having been shown to improve pain and function, and has good long term reproducibility.[22,23] Exact mechanisms of action are not known, but coagulation likely

denatures peripheral nerves, preventing conduction in small myelinated and unmyelinated nerve fibers until the nerve regenerates.[24] This treatment is predicated on the need for limited anatomical variation, validated bony landmarks under fluoroscopy, and careful patient selection.[25]

CASE REPORT BACKGROUND

Written permission for publication of this case report was obtained in concordance with current ethical guidelines.

A 55-year-old male presented with severe pain and functional limitations as a result of left groin pain attributed to osteoarthritis. Past medical history included hypertension, dyslipidemia, sleep apnea, type 2 diabetes mellitus, depression, and opioid addiction. Medications included atenolol, hydrochlorothiazide, amlodipine, trazodone, duloxetine, amitriptyline, quetiapine, and pregabalin. Physical examination revealed an antalgic gait, painful range of motion for the left hip, mild pain to palpation in the left groin, and a glove and stocking decrease for pinprick in the lower limbs. X-ray imaging revealed mild superior-lateral hip osteoarthritic changes. Magnetic resonance arthrogram revealed a small, undisplaced, anterior labral tear.

He failed multiple treatments including physical therapy, medications, and various injections. Arthroscopic debridement of the labral tear did not result in clinical improvement, but significant osteoarthritic changes were noted superior-laterally. Because the waitlist for a hip arthroplasty was in excess of one year, thermal radiofrequency lesioning of the articular branches was offered in the interim. Given the patient had a concordant but time-limited response to intrarticular hip injection on 2 separate occasions, diagnostic blocks of the femoral and obturator branches were not performed.

For the obturator articular component, a 10 cm radiofrequency cannula with a 10 mm active tip (Diros Technology Inc., Markham, Ontario, Canada) was advanced into position from an inferior-lateral position, directed towards the inferior-lateral margin of the "teardrop" using a combination of ultrasound (L14-5w linear array probe, Zonare Z.one Ultra sp, Zonare Medical Systems, Mountain View, CA) and fluoroscopy (C-arm, Siemens, Burlington, Ontario, Canada) in an anterior-posterior (AP) projection. Two treatments were made with the cannula translated 1 cm from inferior to superior.

For the femoral branches, the cannula was positioned using the same imaging modalities from the lateral projection. The initial target was immediately inferior to the anterior inferior iliac spine in the upper third of the acetabulum. For the first treatment, 2 lesions were made moving superiorly to inferiorly separated by 1 cm, while the second treatment used 2 lesions along the same trajectory separated by 1 cm medially to laterally (Figure 1). Each radiofrequency lesion occurred at 80°C for 2 minutes.

The first treatment provided almost 90% relief, a return to almost all baseline function except playing hockey, and discontinuation of pain medication for a period of 6 months. The second treatment provided between 20% to 50% relief, with moderate ongoing functional limitations and the necessity for adjunctive pain medication until joint replacement 4 months later.

To our knowledge, this is the first report to describe an inferior-lateral approach for lesioning the obturator branch, clinical application of successive lesions to increase denervation area, and outcomes in a patient receiving a second treatment with previously excellent results. Discussion includes relevant anatomic research, previous clinical studies, possible reasons for differences in outcomes for the second treatment, and future directions.

METHODS

Technical details of the procedure performed on our patient are described in the preceding section.

Literature searches were performed in PubMed, Embase, and Google Scholar. Search terms included hip joint, osteoarthritis, radiofrequency, femoral nerve, sciatic nerve, obturator nerve, hip joint anatomy, neurectomy, articular branch, joint denervation, coxalgia, pain, and hip joint anatomy. Citations were reviewed by authors Gupta and Finlayson, yielding 7 articles relevant to hip joint radiofrequency in a clinical setting, and 18 articles relevant to hip joint innervation or surgical neurectomy. Review of the bibliographies of these studies yielded 2 more radiofrequency articles (for a total of 9), and 12 more anatomy/surgery articles (for a total of 29). Only English language articles were reviewed by authors Gupta and Finlayson, except where a foreign language study was considered to provide unique information.

COMMENT

Clinical Studies-Treatment of Hip Pain Without RF Denervation

There is considerable clinical precedent for denervation treatment for the hip joint for pain. Obturator neurectomy for osteoarthritis of the hip was introduced by Camitz[26] in 1933 and Mol[27] in 1935. Tavernier and Godinot reported successful outcomes in 38% of 57 patients undergoing surgical obturator neurectomy for hip OA.[28]

By combining neurectomy of the obturator and quadratus femoris component, 22 of 24 cases initially had satisfactory results,[29] however, the long term outcomes between 3 and 18 month follow-ups showed excellent results in only 2 patients, and no improvement in 22.[30]

Results from another study showed 28 of 42 patients with hip pain of varying etiologies responded to surgical neurectomy of the obturator and quadratus femoris components, where failures were attributed to an extrapelvic surgical approach and variability in joint innervation. Hip flexion weakness and sensory loss were commonly reported, but not as having any important functional significance.[31] Padovani performed surgical neurectomy including the femoral contribution to achieve complete sensory denervation.[32] Subsequent studies have been reported over the years, but this technique eventually fell from favor owing to mixed results and residual symptoms attributed to iatrogenic nerve injury.[33-35] Akatov and Dreval employed obturator main branch TRF in 15 patients with coxarthrosis, but the reported technical details and clinical outcomes were not clear. All but one patient had sensory disturbances postprocedure, and 3 other patients required additional treatment for myofascial pain.[36]

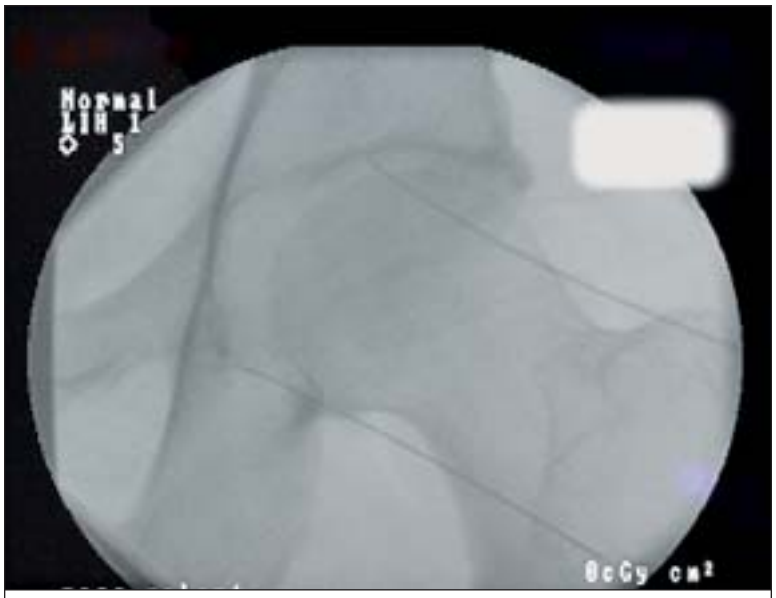

Figure 1. Thermal monopolar radiofrequency denervation of the femoral and obturator branches of the left hip joint.

Heywang-Köbrunner and colleagues used CT guidance for diagnostic and therapeutic large volume, obturator nerve, local anesthetic blocks in 15 patients. Four patients reported excellent relief for between 3 to 11 months, and another 3 patients had good to excellent pain relief varying between one to 8 weeks. For the remaining 8 patients there was either mild effect (4 patients), pain resolved for only one day (2 patients) or no effect.[37]

In contrast, Edmonds-Seal and colleagues compared outcomes for 18 patients with unilateral hip OA in a double blind trial comparing landmark guided, large volume, local anesthetic blocks to saline for the obturator and quadratus femoris branches. Five patients improved in pain and function and 8 patients in mobility, but there was no difference between local anesthetic and saline in treatment outcome, and effect was lost in all but one patient after 4 weeks. There were also a similar number of patients whose pain, function, and mobility worsened postinjection, and one patient seized postblock.[38] Other studies have reported repeat block can be helpful in some patients.[35]

Clinical Studies-Treatment of Hip Pain Using RF Denervation

Rivera and colleagues[39] prospectively studied 17 patients with chronic hip pain who were nonoperative candidates (OA, prolonged postoperative pain). Eight patients reported a decrease in pain of at least 50% at the 6-month follow-up, associated with a statistically significant improvement in WOMAC* and Harris Hip Scores. After noting transient hematoma in 3 cases from vessel puncture, they changed to the lateral needle approach described by Locher and colleagues[40] partway through their study. However, they did not employ multiple lesions per nerve as suggested by Locher et al (ie, lesion stacking).[40]

Kawaguchi and colleagues showed 79% (11 patients) had effective treatment, while 3 patients had an ineffective response. They showed 12 patients had 50% reduction in hip region pain lasting one to 11 months. One patient whose treatment was considered ineffective had close to a 50% reduction in groin pain, but not lateral hip pain. Patients were selected on this basis of response to either obturator blocks and/or response to intra-articular injections. Nine patients had radiofrequency denervation of the obturator component only, and in addition, 5 had denervation of the femoral component.[41]

Malik and colleagues showed denervation of the femoral and obturator components in 4 patients resulted in reduction in pain between 30% and 70%, improvement in function in 3 of 4, and reduced medication usage in 2 patients.[42]

Wu and Groner looked at pulsed radiofrequency (PRF) as a potential treatment for hip pain in 2 patients, citing a small risk of neuroma and neuritis with TRF. When

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compared to thermal radiofrequency, PRF applies heat at a lower temperature and therefore does not cause tissue coagulation, and ideal probe placement is perpendicular to the neural structure. Both patients had improved pain and relative function at short-term follow-up.[43] The evidence for comparing PRF to TRF is limited, but there is suggestion they could be equivalent for cervical radicular pain, while TRF shows better efficacy in idiopathic trigeminal neuralgia.[44] We would not recommend PRF for this use, given that the required perpendicular needle placement is in close proximity to the neurovascular structures.[40]

Chaiban and colleagues used ultrasound guidance for treatment of bilateral hip pain in a single patient with hip osteoarthritis, resulting in 80% reduction in pain at 3-month follow-up.[45] Fukui and Nosaka showed significant decrease in pain, improved walking ability, and reduction in pain medication use for 6 months after femoral and obturator articular branch TRF in one patient. The needle was inserted from anterior-posterior for the obturator branch and directed from the superior pubic ramus to the obturator canal. They argued that motor weakness did not occur because only the obturator branch was only partially destroyed when using lesion of 90°C for 180 seconds.[46] In a Korean language case report, Shin and colleagues reported on a single case of thermal radiofrequency denervation of the femoral and obturator branches resulting in a 50% reduction in pain.[47]

Overall, studies for hip joint radiofrequency were of low quality secondary to small sample sizes, patient selection methodology, inclusion of patients with heterogeneous etiologies for pain (eg, OA, congenital, and metastasis), variable needle placement techniques, and lacking functional outcomes. However, no significant adverse events were reported, with only one study reporting numbness developing in the thigh region in one patient, and another with transient hematoma formation in 3 cases.[39,42]

The relevant articles for hip joint radiofrequency are summarized in the Table.

Anatomical and Safety Considerations for Hip Joint Thermal Radiofrequency

For hip joint thermal radiofrequency denervation, the main anatomic and safety issues are:

- multiple contributions from various nerves,
- variable anatomy and course for each specific nerve,
- vascular injury,
- incomplete denervation secondary to closely associated vessels, and
- further joint injury through nerve or vascular destruction.

The following discussion of anatomy is meant to reflect the perspective of the interventionalist, although most articles do not discuss nerve trajectory with respect to bony structures, which is imperative to designing a reliable and reproducible procedure. Also, for this discussion it is assumed branches that innervate a region of the capsule will supply the neighboring portion of the joint,[48] however, this is not explicitly stated in all articles.

Some guiding principles can be applied to regional innervation of the hip joint, but significant variation has been described.[49] Generally, the anteriormedial portion of the capsule is innervated by the branches of the obturator nerve, anterolateral capsule branches of the femoral nerve, posteromedial joint from branches of the sciatic nerve, and/or nerve to quadratus femoris, superolateral (posterior and anterior) from branches of the superior gluteal nerve. Inferior capsule innervation is possibly from the obturator nerve or inferior gluteal nerve (Figure 2).[40,48,50-65]

The obturator nerve has a variable number of articular branches likely radiating from a common stem located lateral to the obturator foramen inferior to the acetabulum (Figure 3). The radiologic landmark is immediately below the teardrop silhouette seen on AP x-ray, corresponding to the junction of the pubis and ischium, where the lateral line is from the acetabular wall, the medial line formed by the lesser pelvis and the inferior wall from the acetabular notch.[40,41] The branches usually course superior and laterally towards the anteromedial portion of the capsule, but can exit the obturator foramen as inferiorly as the junction between the proximal and middle third.[40]

The excellent anatomic description by Locher and colleagues for a superolateral approach for denervation of obturator components provides a good basis for discussion. The superior approach allows for parallel placement, and therefore the longest lesion along the branches.[40] Our inferior approach may increase the likelihood of denervating multiple branches, but the lesion size will not be in parallel, resulting in a smaller lesion, equivalent to one or 2 electrode widths,[25] and may require longer cannula length depending on the patient.

In our opinion, the initial placement of a 21 gauge spinal needle using the AP approach for guidance and local anesthetic purposes still poses a measurable risk to the neurovascular bundle.[38] In our case, and where the cannula size was previously reported, no radiofrequency cannula

Studies Detailing Clinical Outcomes for Patients Undergoing Articular Radiofrequency for Treatment of Hip Joint Pain.

Study	No. of Patients: Treatment Details	Pathology Types	Results	Adverse Events	Notes
Chaibin et al[45]	1: TRF femoral and obturator bilateral, 80°C for 6 seconds. 22 gauge 5 mm active tip.	OA	P: 80% reduction at 3 months F, M: N/A	None	Ultrasound and fluoro guidance. Used sensory and motor stimulation. Selected based on time limited response to bursa and joint injections. Patient continued anticoagulation.
Rivera et al[39]	17: TRF femoral and obturator branches, 90°C for 90 seconds. 22 gauge 5 mm active tip.	OA, post THA, post girdlestone	P: 30% avg reduction at 6 months, 8 patients >50% relief F: improved Harris Hip and WOMAC scores M: N/A	3 Transient hematomas	Diagnostic blocks (3 cc). Inserted needle medial or lateral to femoral artery for obturator. 5 mm active tip. Sensory and motor stimulation used. Switched to Locher[40] method during course of study.
Wu and Groner[43]	2: PRF femoral and obturator branches, 45°C for 120 seconds. 22 gauge 10 mm active tip.	FHN, post THA	P: 50% to 60% reduction at 3-4 months F: improved ambulation M: N/A	None	Diagnostic blocks (0.5 cc to 1 cc). Sensory stimulation.
Shin et al[47]	1: Femoral and obturator branch TRF	Metastasis	P: 50% reduction	None	Korean Language.
Malik et al[42]	4: Femoral and obturator, TRF 75°C to 80°C for 90 seconds. Cannula size not reported.	OA, FHN, metastasis	P: 30% to 70% NRS at 3 months F: improved ¾ pt M: reduced ½ pt	Thigh numbness, 1 patient	AP approach. Diagnostic blocks (1 cc LA).
Kawaguchi et al[41]	14: Obturator and/or femoral branch, TRF 75°C to 80°C for 90 seconds. Cannula size not reported.	OA, metastasis, DL	P: 50% relief, 86% patients avg 4.2 months (1-11 months) F,M: N/A	None	Suggested pain location predicted articular nerve involved, no block for femoral component. Volume for IA or obturator diagnostic block.
Fukui et al[46]	1: Femoral and obturator branch, TRF 90°C for 180 seconds. 22 gauge 4 mm active tip.	OA, infection	P: 70% relief until 4 months; pain increased at 6 months F: improved walking with cane M: stopped use until 6 months	None	Diagnostic blocks with contrast (3 cc LA). Sensory stimulation. Obturator cannula walked to obturator cannal from superior pubic ramus. Introduced idea of cryoanalgesia for denervation of articular branches. Procedure not repeated because overall pain reduced.
Akatov and Dreval[36]	13 (15 hips): Obturator nerve proper, TRF 80°C for 120 seconds.	OA	Increased range of motion in 9 patients, remainder of results not clear. Followed for up to 3 years.	Sensory loss in all but one patient.	Needle technique not well described. Unclear if live fluoro used. Additional treatment for myofascial pain in 3 patients. Unclear if diagnostic blocks used, but 2 cc to 3 cc of LA injected prior to lesion to ensure pain resolved.

Glossary:
AS – Ankylosing spondylitis
DL – Dislocation (congenital or trauma)
F – Functional improvement
FHN – Head necrosis (AVN, trauma, Legg- Calve-Perthes)
IA - Intra-articular
LA – Local anesthetic
M – Medication reduction
NRS – Numerical rating score
OA – Osteoarthritis
P – Pain reduction
post THA – Post total hip arthroplasty
PRF – Pulsed radiofrequency
RA – Rheumatoid arthritis
TRF – Thermal radiofrequency

larger than 22 gauge was employed.[40,42,44] Rivera and colleagues started with an AP approach presumably using the 22 gauge cannula, but switched to the Locher approach after hematomas were noted.[39,40] For this reason, we do not support use of this component of the approach.

Without the benefit of the 21 gauge guiding needle,[40] and given our limited experience, we found inserting the cannula from the superolateral projection too complex. This concern was not cited by Rivera and colleagues, who also did not report use of the guide needle.[39] In our case, the simultaneous use of ultrasound allowed us to navigate around the neurovascular bundle and advance the needle from the lateral position (allowing us to account for depth), while using intermittent AP fluoroscopy to confirm trajectory. However, the need for both ultrasound and fluoroscopy skills may be a barrier to adoption of this technique.

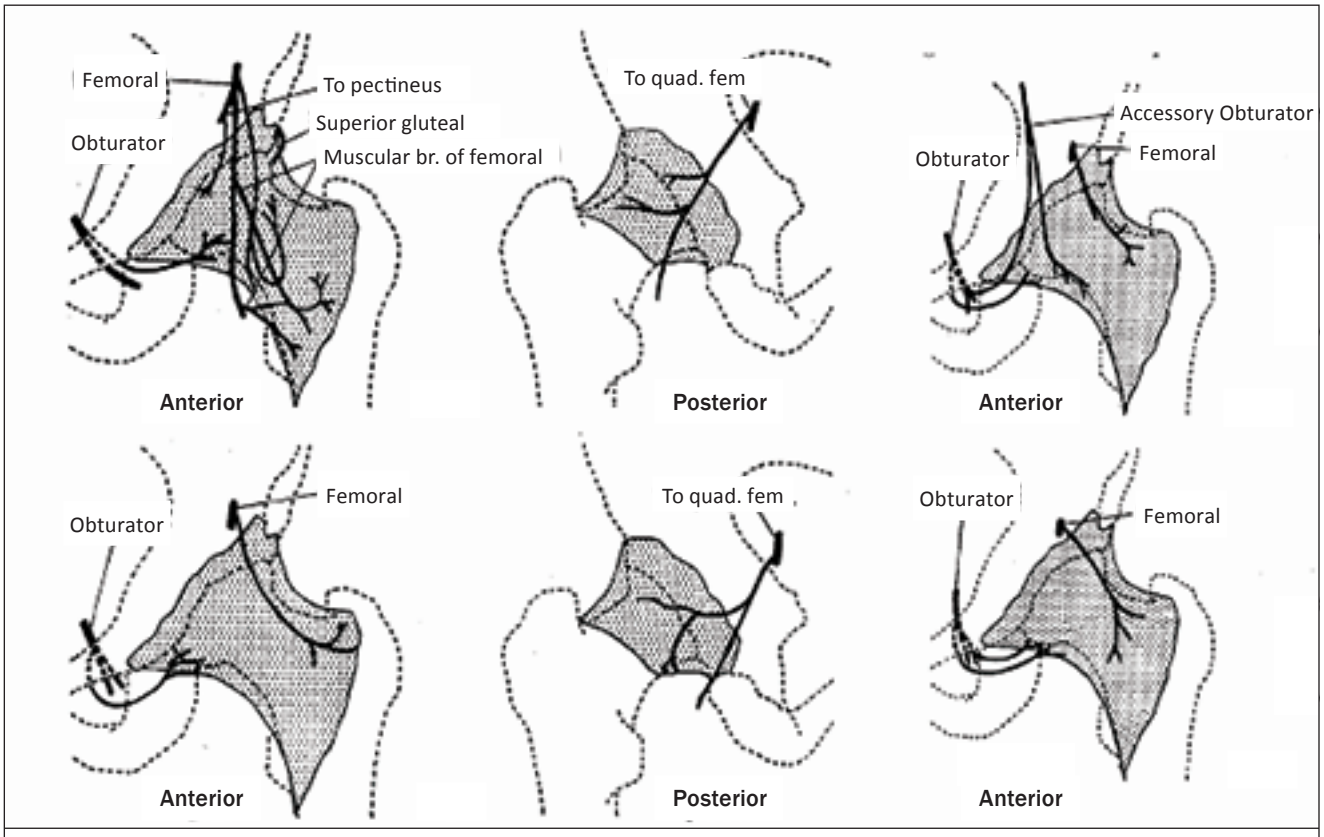

Figure 2. Anterior and posterior views of different types of distribution of nerves to the hip joint. The articular capsule is represented by stippling. Adapted from Gardner[49] with permission.

Another main advancement of the approach used by Locher and colleagues was the introduction of lesion stacking for this specific application to optimize denervation.[40] This concept has previously been described in detail for thermal radiofrequency of other joints.[25] Locher and colleagues advocated withdrawing and directing the cannula more caudally for those individuals where branches exit the obturator foramen more inferiorly.[40] This trajectory was not specifically analyzed by MRI to confirm safety, but the authors suggest staying lateral to the teardrop to avoid the obturator nerve.[40] Presumably, the cannula would remain against the anterior portion of ischium and pubis, so perhaps the risk to the main obturator nerve, which passes anteriorly, may be overstated, but cadaveric validation would be essential to look at this further.

Our technique would not provide adequate coverage for these more inferior articular branches when compared with the Locher method. While not employed in this case, multipolar thermal radiofrequency could be considered in the future to improve coverage and potentially decrease procedure time. Cosman and Gonzalez showed in ex vivo studies that bipolar thermal radiofrequency could provide a longer and wider lesion than previously reported for monopolar or cooled radiofrequency technology. The depth of the lesion produced is similar in all 3 cases, while in the case of bipolar RF, varying the length of the probe's tip could increase the length of the lesion and increasing spacing between probes could increase width. They concluded that an interprobe spacing of 10 mm, a 10 mm or 15 mm cannula active tip, and an 18 gauge or 20 gauge cannula with radiofrequency for 3 minutes at 90°C would provide a rectangular lesion relatively insensitive to small variations/inaccuracies in angles, offsets, and tip spacing.[66] Burnham reported excellent clinical response in one patient with unilateral lumbosacral pseudoarticulation who partially responded to conventional z-joint radiofrequency denervation. Using bipolar radiofrequency, a strip lesion was created along the pseudoarticulation, which allowed the patient 16 months of significant functional improvements.[67]

There are numerous reported variations in the number of branches and branch points for the obturator nerve (for example, anterior vs posterior vs main trunk).[40,47,48,56,57] In these situations, the currently described technical approaches would likely be adequate to denervate these varied articular branches, if these branches exit through the obturator foramen and course over the teardrop

silhouette described above (the junction of the pubis and ischium on an anteroposterior x-ray). However, there are certain described anatomical variations where the current technical approaches would be inadequate for obturator articular branch denervation. These include cases where there are no obturator branches[61]; the articular branches arise before the obturator foramen; there is a dominant anterior obturator nerve (occurs in 10% to 30% of patients); or if the branches do not supply the portion of the joint that is affected clinically.[48-50,52,54,55,58,59,64]

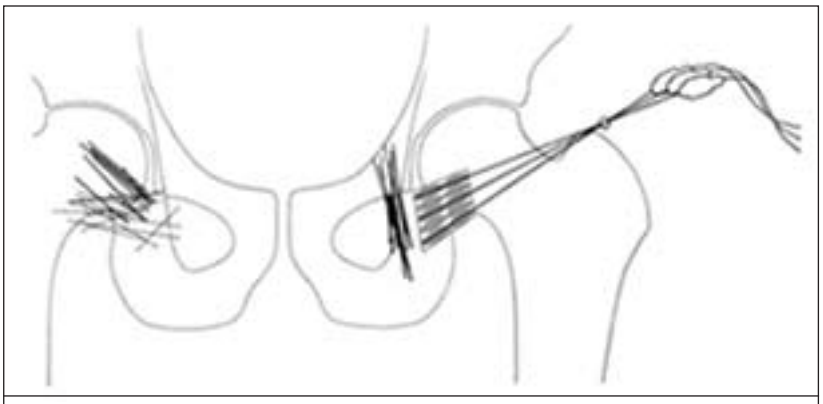

Figure 3. Articular branches of the obturator nerve and target region for radiofrequency denervation. Covering the right hip are tracings of the anteroposterior projections of the metal wires used to mark the location of the articular branches in cadavers. In each cadaver, articular branches were spread across band-like areas. The bold lines represent the upper boundary of each area, and the dotted lines represent the lower boundary. The stem of each band was located below the teardrop shape of the inferior end of the acetabulum. The matrix of lesions required to coagulate the articular branches is illustrated over the left hip. Its medial margin lies opposite and below the teardrop silhouette of the acetabulum. For reference, tracings of wires covering the obturator nerve have been depicted. Adapted from Locher et al[40] with permission.

There is considerably less ability to translate previous anatomic studies to develop a denervation protocol for other articular branches to the joints. According to Locher and colleagues,[40] the variability of the femoral nerve course and branches would necessitate coagulation of several square centimeters (ie, greater than or equal to 50 lesions), but no data was provided as to how this calculation was achieved.

Anatomic concerns also include branches from the femoral innervated muscles for whom trajectories are not clear, relative variability in innervation patterns to the anterior capsule in the presence of an accessory obturator nerve, accessory femoral nerve or superior gluteal nerve branches, the possibility of articular branches that start more inferiorly along the course of the femoral nerve and run with vessels, and a scenario where one common trunk supplies the joint, vessels, and muscles.[47,48,53,55,57,61,62] Therefore, while significant cadaveric work remains, with the preliminary results shown thus far in the literature, we remain hopeful that an acceptable percentage of patients will respond to treatment. Multipolar radiofrequency or a series of successive lesions approaching from the lateral margins (to avoid the femoral nerve) and moving caudally from the anterior inferior iliac spine would require further validation.

Translating current knowledge into a posterior innervation approach will also be challenging without the aid of further cadaveric study. It would appear the inferior to middle-medial to lateral portion of the hip joint are supplied by branches of the sciatic nerve directly, or through the trunk that is given off to the quadratus femoris muscle. Variations include multiple branches from the nerve to the quadratus femoris, different trajectories through the greater and/or lesser sciatic notch, branches from nerves to the obturator internus or superior gemellus, and direct innervation from the sacral branches or obturator nerve. Similarly, the posterior superior portion of the joint may be variably innervated by branches of sciatic nerve, or superior gluteal nerve.[47,48,52-55,57,61-64]

The vascular supply of the femoral neck and hip joint has been closely detailed and must be considered in a posterior approach. An extracapsular arterial ring is formed by branches of the medial and lateral circumflex arteries, contributing to the metaphyseal blood supply. The epiphyseal blood supply is mediated through the ligamentum teres and posterosuperior branches of the lateral epiphyseal vessels. Vascular supply to the joint is therefore predominantly from the posterior circulation of the epiphysis, away from the region of treatment.[67]

Given that the posterior blood supply runs lateral to medial for the hip joint, we propose a radiofrequency approach starting lateral and posterior to the greater trochanter and advancing towards the inferior portion of the acetabulum. Multipolar radiofrequency or successive lesions moving superiorly towards the middle third of the acetabulum may generate sufficient coagulation for the sciatic and/or quadratus femoris nerve branches in this region without affecting any significant neurovascular structures.

Other general reasons for failure of treatment of radiofrequency could arise from joints that have an important innervation from the sympathetic trunk,[48] or posterior femoral cutaneous nerve.[51] In addition, there could be a

long-term risk of developing a Charcot arthropathy, given that denervated nerves and coagulated vessels supply the anteromedial capsule of the hip joint and underlying bone.[47] In some surgical neurectomy studies, femoral head deformity was a noted complication, but this may be attributable to complete denervation of all the sensory branches.[32,47] Animal studies have shown erosion of articular cartilage and bone sclerosis resulting from lumbar sympathetic, 4th lumbar, and 3rd sacral root resection.[34,68,69] The risk of Charcot joint has not been a factor in other similar joint denervation studies.[70]

We therefore propose close clinical follow-up to monitor signs, symptoms, and fall risk where proprioception is a concern. Where indicated, serial imaging could identify changes in patients consistent with a neuroarthropathy. The treatment in these cases would be nonweight-bearing on the affected side until the sensory innervation (ie, pain) returns.[71] In the case of presurgical patients, further joint destruction may be less important if an arthroplasty will eventually be performed.

The final consideration is the value of diagnostic blocks in this setting. Ideally, a low volume comparative diagnostic block could be performed that would have a high positive predictive value for response to radiofrequency treatment. The wider innervation area of the articular branches could lead to false negatives if the injection volume was too small, or false positives if a larger volume was used, or multiple branches were injected simultaneously. The other possibility is the use of intrarticular injections for diagnoses, but this would not direct treatment to a specific articular branch. Again, cadaveric and clinical studies are required to develop this further.

CASE REVIEW

The relative failure of the second treatment in this case was likely because stacked lesions in an inferior to superior manner were not performed for the femoral component. As in the first treatment, this would have likely increased the lesion to up to 4 times the cannula's width and increase the chance for denervation.[25] Instead, we opted to attempt to increase lesion length for this component, which we had hoped would translate into longer clinical efficacy.

Other potential reasons for failure include a placebo response to the first treatment, which has been shown to be high in other controlled trials for some interventional procedures.[72] Progression of the patient's underlying osteoarthritis to other parts of the joints not innervated by the femoral or obturator components[73] is another possibly complicating factor for this case. In cases of neurotmesis, the endoneural tubes are disrupted which can result in misdirected axonal regrowth (ie, synkinesis), which could potentially impact subsequent treatment where needle position is based on bony anatomic landmarks.[74]

Our results also dispute the notion that the articular regions subserved by the obturator component primarly cause groin region pain.[41] In this case, it is more likely the failure of treatment is from the femoral component, not the obturator, where the same protocol was followed. Pain referral may be a helpful indicator of which nerve could be mediating pain, but, as shown in this case, is certainly not diagnostic.[31,41] More study is required to delineate the positive predictive value of pain referral patterns in outcomes of patients undergoing articular branch radiofrequency denervation.

CONCLUSIONS

The current clinical literature concerning radiofrequency for treatment of hip joint pain is of low quality. Based on these studies, we propose the following general guidelines for the procedures:

1. Small volumes for diagnostic blocks, (especially if only a single lesion is to be used).
2. Use of omnipaque to rule out vascular spread, at least for the diagnostic blocks.
3. A lateral approach for the obturator branch to avoid the neurovascular structures, and/or supplementation with ultrasound.
4. At the least, motor stimulation to rule out somatic involvement.
5. At a minimum, 10 mm active tips to increase the length of lesion created and therefore the length of clinical response.
6. Consideration of stacked lesions or multipolar TRF to increase lesion size and thereby account for any anatomic variability.
7. Measurement of both pain and functional outcomes using standardized scales.
8. Close clinical monitoring after TRF in order to identify patients' neurological deficits or those at risk for progression to neuroathropathy.

The future research of this application should validate safe and effective parameters for diagnostic blocks and treatment in cadavers for all articular branches as well as any clinical information relevant to injection selection and/or outcomes, estimate the role of multipolar thermal radiofrequency in denervation of the hip joint,[65,66,75-77] and delineate any associated economic benefits of hip joint thermal radiofrequency.

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A Bier Block Implementation Protocol

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ABSTRACT

The Bier block procedure has been in use for over 100 years, but only recently has received renewed attention. As emergency departments look for ways to maximize efficiency, the use of the Bier block has been recognized as effective and fast with minimal adverse effects. This article summarizes a proposed protocol for the implementation of both pre- and posthospitalization Bier blocks by healthcare providers.

There is a demand for emergency procedures for extremity injuries that minimize time and expense, while still adequately providing treatment. One of these procedures is the Bier block. The advantages of the Bier block lie in the lack of sedating anesthesia, enabling a patient to be quickly treated and discharged with minimal allocation of resources, rather than that required for procedural sedation and certainly general anesthesia. Procedural sedation in the emergency department setting for most protocols requires 2 physicians and at least one nurse. This large provider requirement has the practical effect of almost shutting down one side of a busy emergency department. Completion of the presedation packet can take as long as 15 minutes before any part of patient care is even initiated. The recovery phase from procedural sedation can require an otherwise available bed for as long as an hour, thus presenting a risk of resource shortage for incoming serious emergencies. Lastly, in deployed environments, there is a need to use anesthetic methods that do not incapacitate a Soldier, and do not divert the attention of another Soldier-provider from the care of other patients for solely monitoring sedated patients.

CURRENT INDICATIONS

According to Roberts and Hedges,[1] the Bier block is indicated for procedures including reduction of fractures and dislocations, repair of major lacerations, removal of foreign bodies, debridement of burns, and drainage of infection. Other factors in the decision to use a Bier block are the desire for a bloodless operating field as well as avoiding possible adverse effects of axillary blocks. Furthermore, the Bier block has the advantage of not requiring respiratory monitoring as does procedural sedation. The patient need not be NPO (nothing by mouth) for a Bier block, but, if possible, the procedure should be delayed if the patient has recently eaten a large meal.

CONTRAINDICATIONS

Contraindications include allergy to the anesthetic, uncontrolled hypertension, a preexisting ischemic limb from a crush injury, or disease states such as homozygous sickle cell disease, Reynaud's disease, or Buerger's disease. In addition, the Bier block should not be used in procedures which require monitoring of pulses in the distal extremity, such as a supracondylar fracture reduction. A pneumatic tourniquet is a required equipment item that must be used to administer a Bier block. The block is used for procedures lasting between 30 and 90 minutes in duration. The block can be used in both upper and lower extremity blocks, with modification as discussed further, although Wheeless recommends the Bier block only for the upper extremity.[2] Morbid obesity is also a relative contraindication, since it is difficult to apply effective tamponade pressure to the obese arm with the tourniquet to prevent systemic lidocaine toxicity.

SAFETY OF BIER BLOCKS

The question of safety is relevant in the case of the Bier block, especially with regard to use of the pneumatic pressure tourniquet, and the use of high dose lidocaine (1.5 mg/kg to 3 mg/kg). Several studies have been conducted to assess safety, the larger of which are listed below. There have been no reported cases of mortality resulting from the Bier block procedure.[3]

Whistler Health Care Center (2005-2006, Mohr[4]): a retrospective study involving 1,804 patients who received Bier block anesthesia for wrist, hand, and forearm injuries. Twelve of the patients received bilateral Bier blocks. There was no significant mortality or morbidity, although there were 9 cases of adverse events (0.5%). These included one medication error (0.06%) and 3 cases of improper cuff inflation (0.17%), resulting in tinnitus and dizziness from partial lidocaine entry into the circulation. These conditions resolved after a 30-minute monitoring period. There were 5 cases of inadequate analgesia. The procedure was successfully completed in all cases, as confirmed by c-arm imaging.

Royal United Hospital/Bristol Medical School (2008-2010, Jakeman et al[3]): another retrospective study of 416 patients receiving Bier blocks. There were 39 complications

noted in this study. The complications included transient hypotension, vasovagal episodes, and transient mild bradycardia. No medical intervention was required for any of the episodes. There was no case of significant morbidity or mortality.

Emergency Department Treatment of Childern's Extremity Fractures: Blasier and White[5] detail a 1996 study of 470 children who underwent fracture reduction using the Bier block method from 1989 through 1994. All but 12 patients were successfully reduced. Nine of the 12 required surgical fixation in the operating room. In the other 3 cases, IV access could not be obtained for the Bier block. Two patients complained of significant tourniquet pain. One had a transient metallic taste in his mouth. One patient complained of transient facial tingling without any changes in electrocardiogram readings. There were no cases of hypotension, tachycardia, seizures, or arrhythmia. There were no cases of decreased extremity sensation or neurological function.

EFFECTIVENESS

Handoll et al[6] compared anesthesia techniques and found 5 trials which provided evidence that, when compared with hematoma block, intravenous regional anesthesia provided better analgesia during fracture manipulation and enabled better and easier reduction of the fracture, with additional findings of reduced risk of later redislocation or need for re-reduction. In contrast, hematoma blocks can be performed more easily and quickly, and are less resource intensive.

BIER BLOCK PROTOCOL

The following are 8 steps to simplify Bier block administration:

1. Initiate painless sedation protocol.
2. Obtain IV access.
3. Elevate or apply Eschmarch bandage to the affected extremity.
4. Tourniquet is applied.
5. Lidocaine is injected.
6. Attempt the procedure.
7. Inspect for signs/symptoms of lidocaine toxicity.
8. Deflate the tourniquet.

Details of Each Step in the Bier Block Protocol

1. Initiate painless sedation protocol 45 to 18 minutes before the procedure (T-45 to T-18 minutes).

   Roberts and Hedges[1] recommend consideration of premedication with midazolam, diazepam, or fentanyl, but not necessary on a routine basis. Resusitation equipment and anticonvulsant drugs should be readily available. Ensure that suction is available. Consider delay if the patient has just eaten a large meal. The following is an effective prevascular access method for presedation:

   (*a*) T-45 minutes – First apply EMLA® cream or LMX4® cream about 45 minutes prior at IV sites if time allows. Place the patient on the cardiac monitor.

   (*b*) T-18 minutes – Give intranasal fentanyl at 2 μg/kg and intranasal Versed® at 0.2 mg/kg.

2. Obtain IV access (T-15 minutes).

   The first IV line is place in the noninjured forearm for administration of sedation and fluids. In the injured limb, a butterfly needle is placed in a dorsal vein in the hand, distal to the fracture site.

3. Exsanguinate the extremity (T-14 to T-10 minutes).

   This is done either by elevation of the extremity for 4 minutes or use of an Eschmark bandage. Use elevation only in the case of extremity infections. Elevation for 4 minutes can easily be done by using finger traps.

4. Deploy the tourniquet (T-6 minutes).

   Prior to performing the Bier block, be sure that the tourniquet is working properly. If the tourniquet malfunctions and deflates during the case, the patient may have a seizure due to lidocaine toxicity. The tourniquet must specifically be a double pneumatic tourniquet to prevent failure and deliver the exact amount of pressure needed. This is because the lidocaine maximum dosage (3 mg/kg) used in a Bier block is twice the cardiac dose of lidocaine (1.5 mg/kg). Pressure is 100 mm Hg above the systolic BP in the arm in adults, 150 mm Hg above systolic BP in the legs in adults and 50 mm Hg above systolic BP in children.[7] Marcaine® or any similar long acting anesthetic should never be used, since the medication will still be active when the tourniquet is deflated at the end of the case (causing a seizure). Contraindications include excessive obesity (ie, a large fatty arm), causing excessive tissue damage from necessarily increased tourniquet pressures. For moderately obese patients, the double tourniquet may not provide adequate tamponade pressure to prevent leakage of the lidocaine into the systemic circulation. In this case, if it is determined to continue the Bier block procedure, it may be necessary to use a wide single tourniquet to apply the necessary tamponade force to the obese extremity.

5. Lidocaine administration (T-5 minutes).

   Dose using the "mini-Bier block dose," 1.5 mg/kg of a 0.5% solution. For a 70 kg male, this is 105 mg, or 22 mL. The maximum "full dose Bier block" is 3 mg/kg.[8] Start with the mini-Bier block dose. If more anesthetic is needed in 10 minutes, continue to the full dose Bier block.

6. Attempt procedure (T-zero).

   There will reliably be between 35 to 45 minutes of anesthesia, before the lidocaine is eventually bound to the tissues. After 20 to 30 minutes, the patient will likely begin to experience pain from the tourniquet. To treat tourniquet pain, first inflate the *distal* cuff and then slowly deflate the *proximal* cuff. The distal cuff is therefore now inflated over anesthetized tissue. The inflation must be done in the correct sequence to avoid systemic introduction of lidocaine.

7. Inspect for signs of lidocaine toxicity.

   The first sign of lidocaine toxicity is perioral tingling and tinnitus. The patient may also complain of a metallic taste sensation. The patient must be on a cardiac monitor. Look for increasing PR interval and QRS lengthening.

   At 5 μg/mL, EKG findings of cardiac toxicity begin.

   At 10 μg/mL, seizures begin to occur.

   At 30 μg/mL, cardiovascular depression begins to manifest.

   If these things happen, give IV fluids to treat hypotension. Use push-dose epinephrine to maintain blood pressure with the following method:

   Take 1 mL of 1:10,000 cardiac Epi (100 μg/mL concentration).

   Add 9 mL to make 1:100,000 Epi (10 μg/mL concentration).

   Give 0.5 mL (range of 0.5 mL to 2 mL) every 2 to 5 minutes. This is about the same as an epinephrine drip at 1 to 10 μg/min.

   Obtain TPN for lipid rescue.* First give an initial intravenous bolus of 20% lipid emulsion (approximately 1.5 ml/kg of lean body mass), followed immediately by a continuous infusion (approximately 0.25 to 0.5 ml/kg/min) for roughly 10 minutes following recovery of vital signs. Repeat the bolus as needed every 5 minutes for cardiac instability.[10]

8. Deflate the tourniquet.

   The tourniquet cannot be deflated until at least 25 minutes have transpired since inflation. For additional safety, a 30 minute minimum time to deflation will be used for the protocol. It must then be deflated in a cyclic manner. Deflate over 5 seconds, and then reinflate for 1 to 2 minutes. Repeat this process 3 to 4 times.[7]

Watch the patient for 30 minutes, monitoring for lidocaine toxicity. Peak plasma lidocaine concentrations occur 2 to 4 minutes after cuff deflation, and are minimized by using the cyclic deflation technique. Cardiac toxicity with EKG abnormalities to lidocaine occur between 5 μg/mL and 10 μg/mL plasma concentration. The maximum lidocaine plasma concentration from a Bier block after a properly cycled tourniquet release is 2 μg/mL to 4 μg/mL plasma concentration. Some patients will sense a temporary ringing in their ears, perioral tingling, or a metallic taste. Other reactions include dizziness, headache, and blurred vision. All of these reactions are temporary, occur in about 3% of cases, and no treatment is required. More serious complications include transient seizures, bradycardia, and hypotension which are treated as appropriate. These are most commonly caused by large lidocaine boluses resulting from a tourniquet mistake or failure. There are no reports of deaths from these complications.

Send the patient home with pain control. The tourniquet area will be sore for 1 to 2 days. Although no lingering effects are expected, Roberts and Hedges[1] recommend that the patient not drive for 6 to 8 hours after the procedure.

SAFETY MEASURES INCLUDED IN THE PROTOCOL

- Only use double pneumatic tourniquets. An acquisition process should be implemented detailing the specifications required, so that the various models of tourniquets can be compared objectively.
- There should be a Bier block tool box. Inside will be lipid rescue, diazepam, push-dose epinephrine, and sodium bicarbonate. It should also contain a laminated instruction guide and the brief evaluation forms for research documentation and tracking.
- The tourniquets will only be deflated after 30 minutes, and then at cyclic deflation. The tourniquets will not be inflated for longer than 90 minutes.
- The toxic dose of IV lidocaine (3 mg/kg) should not be exceeded.

FUTURE RESEARCH QUESTIONS TO BE ADDRESSED BY THE PROTOCOL

- Do Bier blocks provide an enhanced means of antibiotic delivery to contaminated/infected wounds?

*Use of TPN was identified by Weinberg, who noted in 1998 that animals were resistant to bupivacaine toxicity when they were cotreated with TPN.[9] Since then, TPN has become an accepted treatment modality for lidocaine overdose. It has also been proven effective for overdoses of beta blockers, bupropion, lamotrigine, calcium channel blockers, and tricyclic antidepressants.[10]

- Bier blocks have been used for complex regional pain syndrome in some locations. There is little data on the effectiveness. Is this a possible application?
- There is little study into the effectiveness of sodium bicarbonate pretreatment before cuff release. Is this a plausible option for minimizing adverse effects?
- Toradol has been used as an anesthetic enhancement. Is this effective adjunct?
- One of the issues of previous studies was the lack of long term follow-up for patients. This is important in determining the ultimate effectiveness of the procedure. An established method of contacting the patients should be established.
- An emergency department cost accounting method should be identified. This will help in the determination of cost effectiveness as the protocol is implemented.

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Central Odontogenic Fibroma: Case Report and Review

MAJ John P. Batson, DC, USA
Frank Strickland, DDS, MPH

Central odontogenic fibroma (COF) is an extremely rare (approximately 50 examples in literature, representing approximately 0.1% of all odontogenic tumors) benign neoplasm composed by varying amounts of inactive-looking odontogenic epithelium embedded in a neoplastic mature and fibrous stroma. The lesion may evolve from a dental germ (dental papilla or follicle) or from the periodontal membrane, and therefore may invariably be related to the coronal or radicular portion of teeth. Due to its nonexclusive histological features, this lesion is often confused with other entities, such as hyperplastic dental follicles, odontogenic myxomas, and desmoplastic fibromas, which highliaght the importance of clinical pathological correlation in the diagnosis of odontogenic fibromas.[1]

Currently, 2 subtypes of COF are recognized. The simple odontogenic fibroma composed of stellate fibroblasts, in a whorled pattern mixed into a back ground of ground substance with or without odontogenic rests. The second subtype is the World Health Organization (WHO) type, having a more complex pattern of cellular fibrous connective tissue with collagen fibers in interlacing bundles. The WHO lesion has odontogenic epithelium in the form of long strands or isolated nests throughout the lesion. Enucleation with vigorous curettage in most cases is appropriate treatment with low recurrence.[2,3]

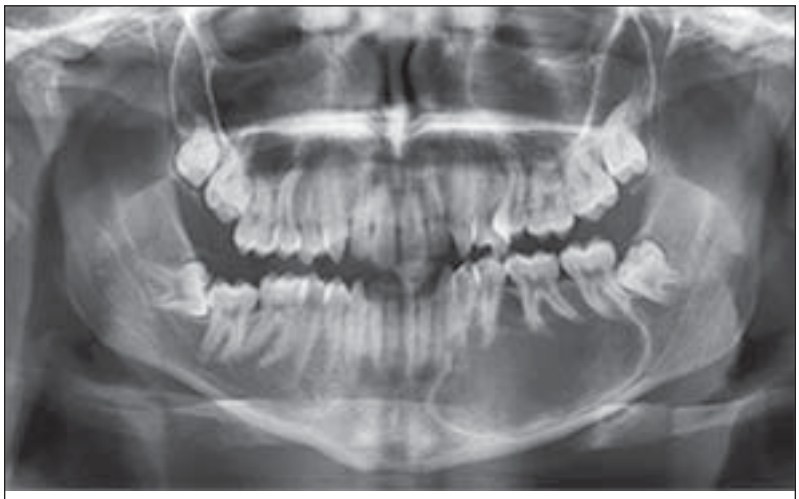

Figure 1. Preoperative panoramic radiograph.

Central odontogenic fibromas occur most frequently anterior to the molars in the maxilla and have a predilection for females. They have also occasionally been associated with an unerupted mandibular third molar. This report concerns a of a case of central odontogenic fibroma found in a young, male, posterior left mandible.

CASE REPORT

An 18-year-old male with a large lesion in the left body of the mandible involving multiple teeth that was found with panoramic radiograph on routine dental exam (Figure 1) presented to the Department of Oral and Maxillofacial Surgery at Womack Army Medical Center, Fort Bragg, NC, in the fall of 2010. The patient had no familial history of cancer or recent symptoms of systemic neoplasm. The lesion was nonpainful, all teeth tested vital, and there was clinical bicortical expansion. The patient did have a history of contact sports.

MATERIALS AND METHODS

Panoramic radiography as well as CT scan with contrast evaluation showed a radiolucent, well corticated, 6 cm oval, unilocular in appearance and extending from the mesial of #22 to the distal of #18. There was significant lingual and buccal cortical expansion. The preoperative diagnosis consisted of traumatic bone cyst, central giant cell granuloma, or ameloblastoma. An incisional biopsy was performed under local anesthesia with a perioperative finding of nonvascular, thin-lined cystic lesion that peeled away easily. The cortical bone was very thick on the buccal without sign of decortications of tooth mobility. The decompressed specimen measuring 1.3 by 1.1 by 0.4 cm in size was sent to the pathologist. The lesion was determined to be a simple type central odontogenic fibroma. A CT of the lesion was obtained and a sterolithic model was created outlining the lesion (Figure 2). Under general anesthesia, enucleation and curettage of the lesion and meticulous periodontal scaling of teeth #18, 19, 20, and 21 were performed. A buccal osteotomy created a window to visualize the lesion (Figure 3). Enucleation followed by vigorous

curettage of the cavity and the teeth roots (Figure 4) provided a specimen 4.3 by 2.1 by 1.4 cm in size, tan brown in color. The inferior alveolar canal roof was identified, however, the inferior alveolar nerve was never visualized. Tooth number 17 (Figure 5) was extracted with associated soft tissue due to extension of the lesion to the cemento-enamel junction. The buccal cortical plate was placed back in the window and fixated with 2 X-plates and 4 monocortical screws (Figure 6). The patient spent one night in the hospital for observation and was released the next morning following postoperative radiographs (Figures 7 and 8). The results from the examination by pathology (Figures 9 and 10) was consistent with original biopsy results. The soft tissue associated with tooth #17 (Figure 5) was a hyperplastic dental follicle. The hardware was removed 10 weeks later once radiographic evidence of bone healing was apparent. Significant bone fill was observed after 6 month and 18 month follow-ups on panoramic radiographs. After 18 months, the teeth in the area tested vital and no complications or signs of recurrence were noted (Figure 11).

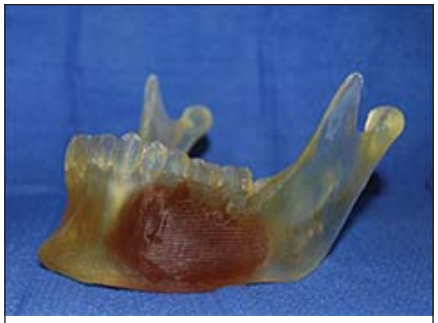

Figure 2. Stereolithic model of the affected area with outline of the lesion.

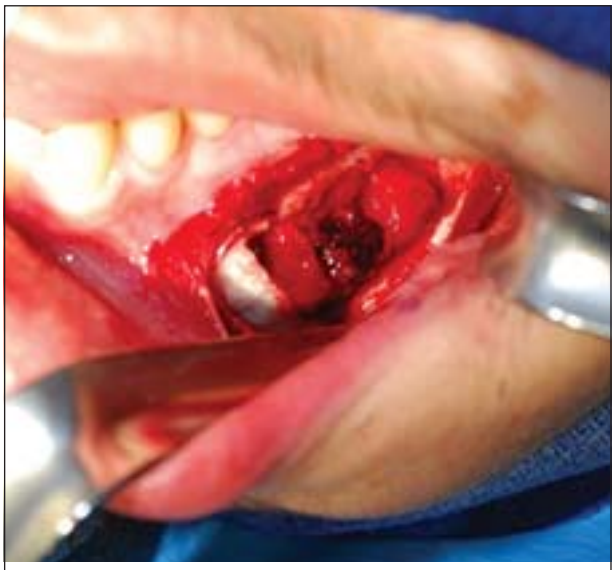

Figure 3. The exposed lesion after a buccal osteotomy.

Figure 4. The cavity following enucleation of the lesion and curettage of the cavity and teeth roots.

COMMENT

The COF is a benign neoplasm reported in the literature usually diagnosed in the second and third decade of life. The most usual sign is swelling of the mandible and the maxilla with infrequent findings of pain and parathesia. Though the COF is reported more in females than males, more frequently in the anterior/premolar area of the maxilla, our patient was an 18-year-old male with occurrence in the posterior mandible. The slow-growing, expansile lesion was unnoticed for several years due to lack of dental care sought by the patient. It was painless with minor swelling and thus the patient had not pursued treatment earlier. Despite the rarity of this lesion, it is important for providers to be aware of the clinical, radiographic, and histopathology of this intraosseous lesion in order to include it in the differential.

Figure 5. Extracted tooth #17 with associated soft tissue due to extension of the lesion to the cemento-enamel junction.

Figure 6. The buccal cortical plate replaced and held in place with 2 X-plates attached with 4 monocortical screws.

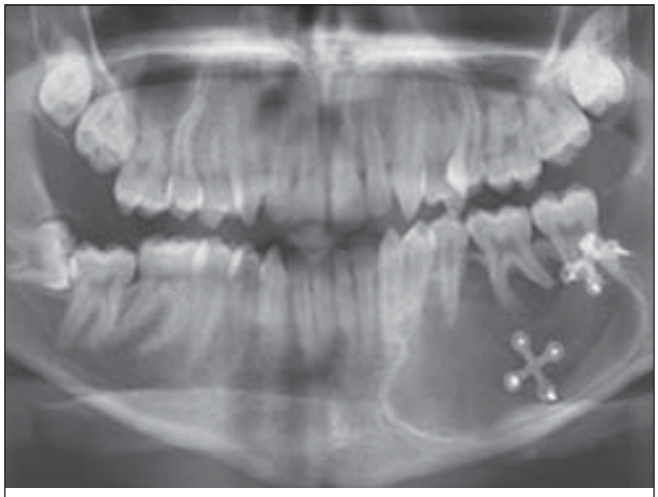

Figure 7. Following day postoperative panoramic radiograph.

Figure 8. Following day postoperative radiograph.

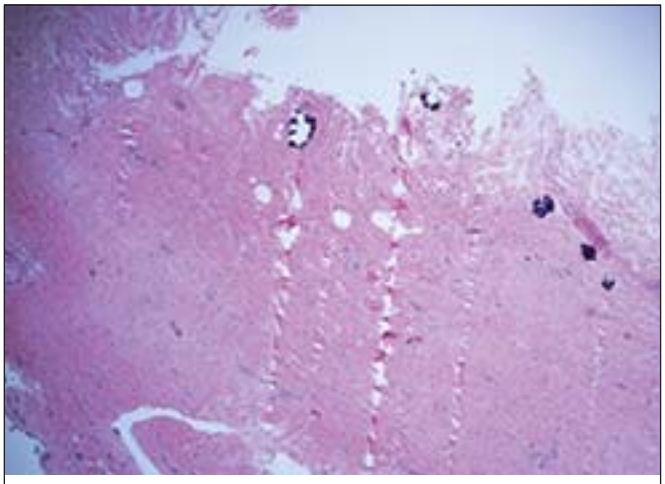

Figure 9. The specimen exhibits a dense fibroblastic stroma with thin walled vascular channels and focal areas with basophilic mineralization (hematoxylin and eosin stain; original magnification ×40).

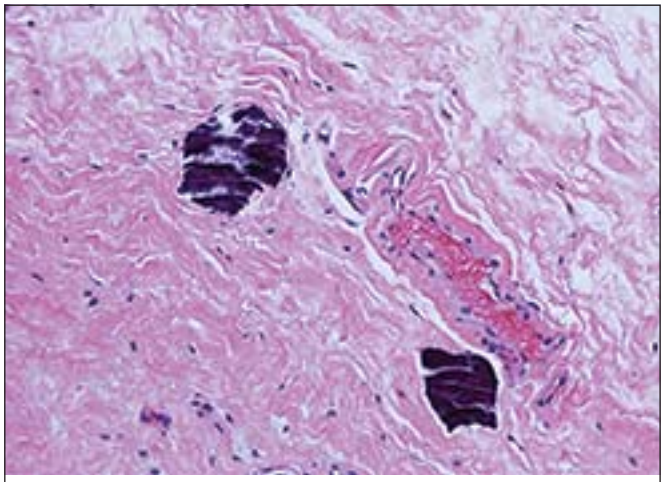

Figure 10. The specimen exhibits dense fibrocollagenous tissue, a congested vascular channel, and basophilic mineralization. (hematoxylin and eosin stain; original magnification ×200).

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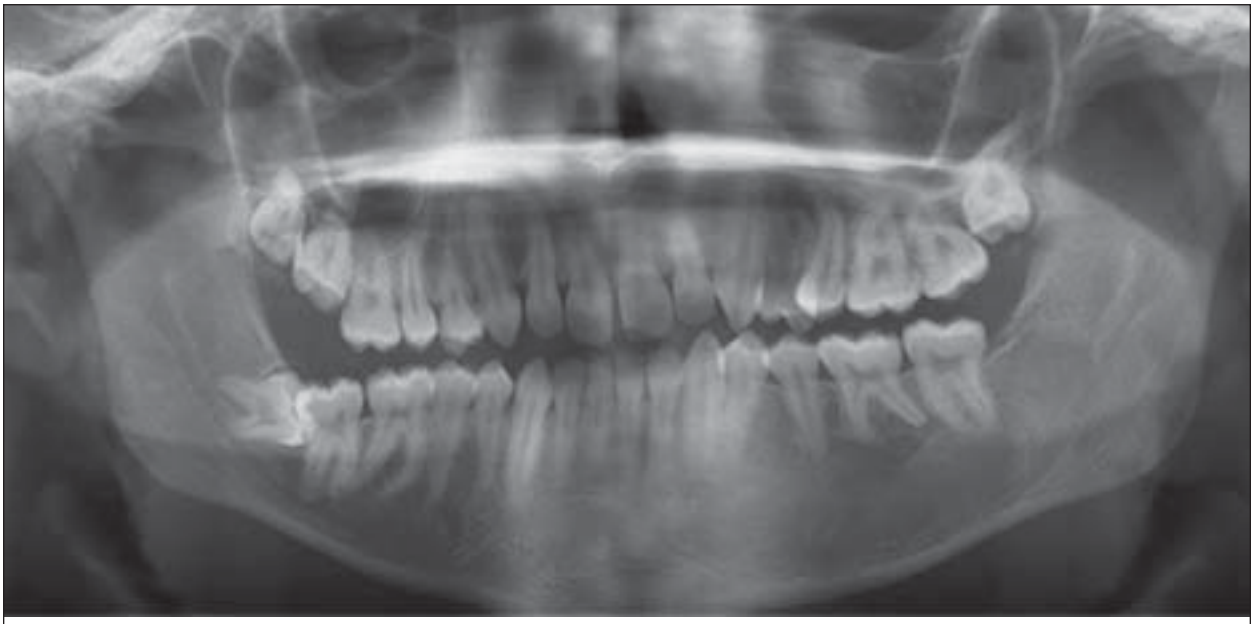

Figure 11. Panoramic radiograph taken 18 months postoperative.

Focal Epithelial Hyperplasia (Heck's Disease): A Case Report and Review

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Focal epithelial hyperplasia (FEH), or Heck's disease, is a virus-induced, local proliferation of oral squamous epithelium.[1] It is a rare contagious disease caused by the human papillomavirus (HPV), a nonenveloped DNA virus.[2] It was first described in Navajo, Chavante Indian, and Alaskan Eskimo children in 1965 by Archard et al.[3] Since 1965, the majority of published cases report FEH in Eskimos and North, South, and Central American Indians.[4] In more rare instances, FEH has been reported in western European, African, Caucasian, and Asian populations.[5] The frequency of this disease is variable with a wide range from 0.002% to 35%, depending on the population studied and the geographical region.[6] Worldwide, FEH is predominantly seen in children with no gender predilection. However, cases are reported in young, middle-aged, and older adults, with an almost 5:1 female to male ratio in some populations.[4,7,8] Intraoral lesions associated with FEH have been seen to spontaneously regress, however, lesions can persist the lifetime of the affected individual. Many studies link FEH to malnutrition, poor oral hygiene, low socioeconomic status, and communal lifestyles.[7] Interestingly, recent reports have indicated the presence of FEH in HIV patients, indicating that immunosuppression leaves patients vulnerable to opportunistic infections, including HPV.[4] The etiology of FEH may have a genetic component, as it is found in the presence of HLA-DRB1*0404.[8] This HLA-DR allele is commonly present in some indigenous Americans, such as the Mazatecans, Nahuas, and Mexican mestizo populations.[8] Remarkably, since 1965, FEH has been detected in animals, including chimpanzees (*Pan troglodytes*), pygmy chimpanzees (*Pan paniscus*), howler monkeys (*Alouatta fusca*), and Asian lions (*Panthera leo persica*).[9]

As established by Pfister et al[10] and Ozden et al,[4] HPV subtypes 13 and 32 have been identified as the cause for FEH lesions through polymerase chain reaction (PCR) analysis and Southern blot hybridization, respectively. Other studies show that HPV DNA has been detected in 80.3% of FEH lesions.[8] A site-specific attraction for keratinized and nonkeratinized epithelial surfaces of the oral cavity has been observed in HPV subtypes 13 and 32, respectively.[4] The lesions associated with FEH are usually multiple, generally involving the labial and lingual mucosa.[1,4,11] Other sites include the lower lip, tongue, and less often on the upper lip, gingiva, palate, and tonsils.[1,4,11] The lesions are 3 mm to 10 mm papules or nodules, varying in color from pink to white.[8,12] Lesions are well demarcated, but they can often cluster closely together to form a cobblestone or fissured appearance.[1] Focal epithelial hyperplasia has 2 clinical forms: papulonodular and papillomatous.[8] The papulonodular variant is more common. This clinical variant usually occurs on the buccal and labial mucosa, as well as on the commisures of the mouth.[8] The papillomatous variant is less common and is usually located on the masticatory mucosa such as the tongue and attached gingiva.[8] Although the diagnosis of FEH can sometimes be made by clinical examinations, biopsy is the gold standard for accurate diagnosis.[8]

Histologically, the trademark of FEH is dramatic acanthosis of the oral epithelium. The thickened oral mucosa extends upward, away from the underlying connective tissue with the lesional rete ridges at the same level as adjacent normal rete ridges. The lesional rete ridges are widened, elongated, thickened and fused.[8] Epithelial surface cells show vacuolated cytoplasm around irregular, pyknotic nuclei.[12] Superficial keratinocytes can show viral koilocytic changes seen in other HPV infections. Viral particles and viral antigens have been identified in lesional keratinocytes with electron microscopy and immunohistochemistry, respectively.[6,13] Oral epithelial cells can exhibit an altered nucleus resembling a mitotic figure (mitosoid cell) with rare inflammatory changes.[1,14] Although FEH is associated with HPV, there seems to be no risk for dysplasia or malignant transformation.[1] Individual lesions generally show no ulceration or erosion.[8] In this article, we report a histopathologically diagnosed case of FEH in a young adult male of Eskimo (Inuit) descent.

CASE REPORT

A 32-year-old male active duty Soldier of Eskimo descent reported to the Oral and Maxillofacial Surgery clinic at Womack Army Medical Center, Fort Bragg, NC. This

Figure 1. Three separate FEH lesions of right lateral tongue border.

Figure 2. Two separate FEH lesions of left lateral tongue border.

Figure 3. Anterior FEH lesion (8 mm) of left lateral tongue border (excisional biopsy).

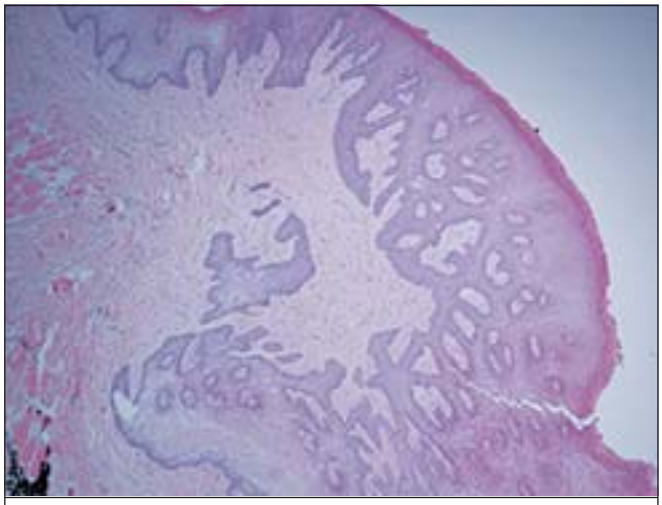

Figure 4. Photomicrograph of FEH lesion showing dramatic acanthosis (hematoxylin and eosin stain, ×4).

patient had a chief complaint of long-standing mucosal colored lesions on the right and left lateral borders of his tongue, creating a cosmetic concern. His medical history was unremarkable. He took no medications and had no history of serious illness or operations. His risk factors were minimal, being a non-smoker with only occasional social alcohol intake.

Upon clinical examination, 5 pink mucosal colored sessile papules were identified on the patient's lateral tongue borders. On the right lateral border, there were 3 distinct 3 mm lesions. On the left lateral border, there were single 8 mm and 2 mm lesions observed anteriorly and posteriorly, respectively (Figures 1 and 2). As reported in past studies, removal of FEH lesions may not be necessary except in cases of chronic trauma and aesthetic concerns.[4] Possible treatment modalities have been reported, including surgical excision, laser ablation, cryotherapy, electrocauterization, interferon, and retinoic acid. Low recurrence is seen with all treatment methods. In our case, the patient had cosmetic concerns. We decided to perform an excisional biopsy of all tongue lesions to address his chief complaint and evaluate for more significant pathology.

Excisional biopsies of all lesions were performed and sent to our facility's Oral and Maxillofacial pathologist for histopathological examination (Figure 3). Setting the diagnosis of FEH is important to ensure differential diagnosis from other more serious conditions including inflammatory fibrous hyperplasia, inflammatory papillary hyperplasia, verruciform xanthoma, verrucous carcinoma, condyloma acuminatum, Cowden's Syndrome, Crohn's disease, and Amyloidosis.[4,8] In our case, FEH was diagnosed based on the presentation of considerable acanthosis (Figures 4 and 5) of the oral epithelium and mitosoid cells present in superficial keratinocytes (Figures 6 and 7). Our patient progressed postoperatively

without incident. The biopsy sites healed optimally without recurrence after a 12-month follow-up period.

COMMENT

Focal epithelial hyperplasia, or Heck's disease, is a rare, viral-induced proliferation of oral squamous epithelium. As described in the literature, FEH is a benign condition that can regress spontaneously without surgical intervention. It has been linked to HPV subtypes 13 and 32 using PCR analysis and Southern blot hybridization. Focal epithelial hyperplasia is benign with no risk of malignant transformation, however, evaluating lesions is prudent to rule out more serious conditions. Detection of oral disease can, in many cases, result in early diagnosis of HIV and other states of immune system compromise.

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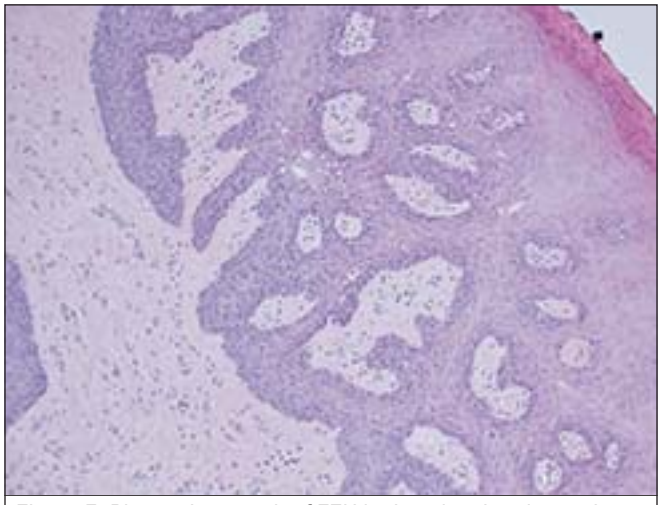

Figure 5. Photomicrograph of FEH lesion showing dramatic acanthosis (hematoxylin and eosin stain, ×10).

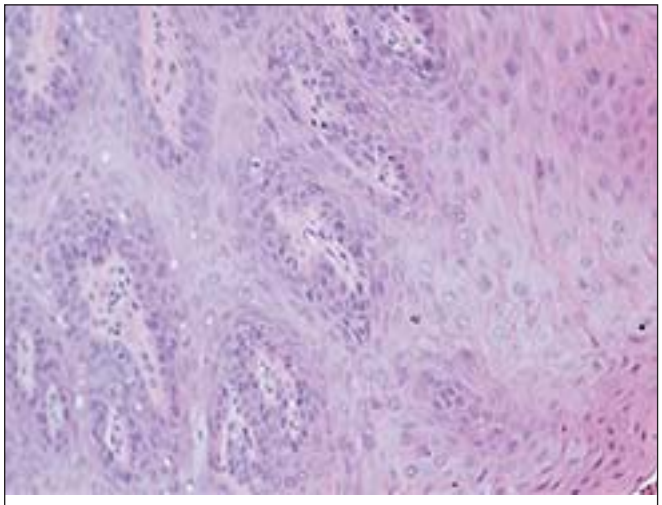

Figure 6. Photomicrograph of FEH lesion showing mitosoid cell (hematoxylin and eosin stain, ×20).

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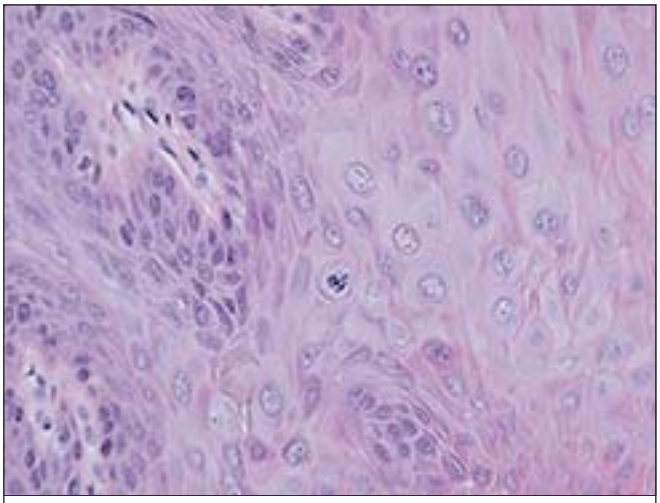
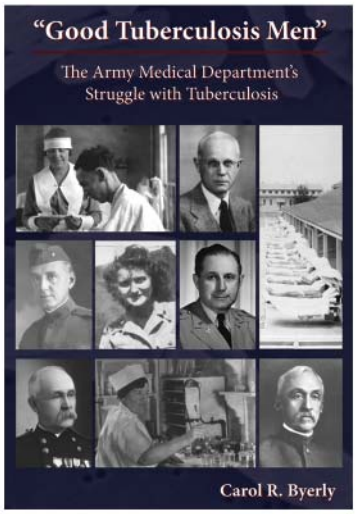


Figure 7. Photomicrograph of FEH lesion showing mitosoid cell (hematoxylin and eosin stain, ×40).

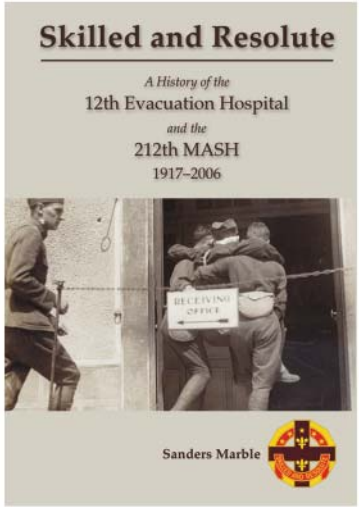
"GOOD TUBERCULOSIS MEN"
THE ARMY MEDICAL DEPARTMENT'S STRUGGLE WITH TUBERCULOSIS

SKILLED AND RESOLUTE
THE HISTORY OF THE 12TH EVACUATION HOSPITAL AND 212TH MASH, 1917–2006



This book chronicles the life of Brigadier General George Miller Sternberg, who served as the 18th Surgeon General of the US Army from 30 May 1893 to 8 June 1902. He was combat tested in the American Civil War and the campaigns against the Native Americans on the frontier. His lifelong interest in infectious disease defined him as one of the premier medical scientists of his day and as "America's first bacteriologist." As Surgeon General, he established the Army Medical School, led the Army Medical Department through the Spanish American War, and appointed the Yellow Fever Commission.

Tracing the 90-year history of the US Army`s oldest deployable hospital, this book looks at how medicine and the military have changed in these decades. Recognizing the challenges and accomplishments of the men and wome of the 12th Evac and and 212th MASH, the text pays tribute to each generation of these "skilled and resolute" soldiers as they worked to save the lives of fellow US service members, allies, prisoners, and local civilians, from World War I Europe to recent conflicts in the Near East.



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Median and Ulnar Neuropathies in US Army Dental Personnel at Fort Sam, Houston, Texas

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ABSTRACT

Background: Dental personnel have an increased prevalence of upper-extremity (UE) musculoskeletal (MSK) disorders, including carpal tunnel syndrome (CTS). Military dental personnel report more UE MSK complaints than their civilian counterparts. Literature using nerve conduction studies (NCS) to diagnose UE neuropathy in dental personnel is lacking.

Purpose: The purpose of this descriptive study was to determine the presence of electrodiagnostic abnormalities of the median and ulnar nerves in active duty military dental personnel assigned to Fort Sam Houston, TX.

Subjects: Twenty (14 male, 6 female) active duty, US Army dentists (n=9), preventive dental specialists (n=4), dental assistants (n=3), dental lab technicians (n=3), and dental logistics technician (n=1) assigned to the Dental Command at Fort Sam Houston, TX, volunteered to participate in the study. The mean age of the dental personnel was 38±9.8 years (range: 26 to 56 years). The mean time in dental practice was 13.3±7.96 years (range: 2 to 29 years). The mean length of time in the US Army dental services was 11.8±7.7 years (range: one to 26 years).

Methods and Materials: Subjects completed a history form, were interviewed, and underwent a physical examination of the cervical spine and bilateral upper extremities. Nerve conduction studies of the bilateral median and ulnar nerves were performed. Electrophysiological variables served as the reference standard for median and ulnar neuropathy and included distal sensory latencies, distal motor latencies, amplitudes, conduction velocities, and comparison study latencies. Descriptive statistics for subject demographics and nerve conduction study variables were also calculated.

Results: Seven of the 20 subjects (35%) presented with abnormal electrophysiologic values suggestive of an upper extremity mononeuropathy. Five of the subjects had abnormal electrophysiologic values of the median nerve at or distal to the wrist (3 bilateral, 2 unilateral). Two subjects had abnormal ulnar nerve findings at or distal to the wrist (1 bilateral, 1 unilateral). Three of the 7 subjects with electrodiagnostic evidence of median and ulnar neuropathies had positive findings on physical examination. However, there was no significant correlation between the NCS and history/physical examination findings.

Conclusions and Clinical Significance: The prevalence of mononeuropathies in this sample of US Army dental personnel is similar to previous research involving dental assistants and preventive dental specialists and far exceeds that reported in the general population. This is the first dental study to report electrodiagnostic findings of ulnar mononeuropathy at or distal to the wrist. The NCS findings did not correlate with subjective or physical exam findings. Prospective research investigating screening, examination items, and injury prevention measures in dental personnel appears to be warranted.

Median mononeuropathy at or distal to the wrist, or carpal tunnel syndrome, and other musculoskeletal dysfunction of the upper extremities is a well-documented problem in dental personnel, including dentists and dental hygienists. Median neuropathy at or distal to the wrist or carpal tunnel syndrome (CTS) is one of a number of muscle-, tendon-, and nerve-related disorders that affect people performing intensive work with their hands.[1-3] Both dentists and dental hygienists have been reported to have a high prevalence of upper-extremity musculoskeletal disorders, including CTS.[4-8] A 1997 American Dental Association survey reported that 9.2% of dentists had been diagnosed by a physician as having some type of repetitive motion disorder.[9]

A 2001 study by Hamann et al determined the prevalence in dentists of abnormal sensory nerve conduction and/or symptoms of carpal tunnel syndrome.[10] In this

cross-sectional study, 1,079 dentists participating in the 1997 and 1998 American Dental Association's Annual Health Screening Program were screened by means of standard electrodiagnostic measures in the dominant hand and a self-reported questionnaire. Thirteen percent of screened dentists were diagnosed with a median mononeuropathy (using a 0.5 millisecond prolongation as the criterion), but only 32% of these had symptoms consistent with CTS (4.8% overall).

The prevalence of CTS among dental hygienists has also been documented.[4,5,11-15] In a study that surveyed US Army dental personnel, Lalumandier and McPhee stated that 75% of dental hygienists reported having hand problems, and 56% exhibited probable or classic symptoms of CTS.[11] Rice et al reported symptoms associated with CTS were noted by 75.6% of dental workers, 11% reported diagnosed CTS, and 53% reported back and shoulder pain.[12] The dental hygienists and dental assistant-expanded function (DH/DAEF) group was found at greatest risk for developing upper extremity symptoms, CTS, and back pain. Other investigators have reported the prevalence of CTS among dental hygienists was 6%[14] and 7%,[15] respectively.

Median mononeuropathy at or distal to the wrist or CTS has been demonstrated in US Army dental assistants (68E*) who had prior clinical experience and were enrolled in the Preventive Dental Specialist (68E-X2*) training course.[16] Specifically, 26% of subjects exhibited electrophysiologic evidence consistent with median neuropathy at the wrist at the onset of training.[16] The 12-week Preventive Dental Specialist training course also did not increase the incidence of electrodiagnostic CTS in this population of students.[17] Median mononeuropathy at or distal to the wrist or CTS was also found in 11% of a sample of US Army dental assistants (68E) at the onset of their professional training and who had no experience as dental assistants.[18]

Literature using history, physical examination, and nerve conduction studies (NCS) to diagnose UE neuropathy in dental personnel is lacking. Therefore, the primary purpose of this descriptive study was to determine the presence of median and ulnar mononeuropathies in a population of dental personnel assigned to Fort Sam Houston, Texas. It is hypothesized that at least 5% of dental personnel would have abnormal electrophysiological findings. The secondary objective of this study was to determine the inter-rater reliability of various clinical examination and nerve conduction items. We hypothesized that the majority of items would exhibit excellent reliability (intraclass correlation coefficients >0.75). This population of dental personnel included all active duty dentists, preventive dental specialists, dental assistants, and dental lab technicians assigned to Fort Sam Houston, TX, during the study period.

METHODS AND MATERIALS

All active duty US Army dental personnel at Fort Sam Houston, Texas (N=45) were approached to participate in this study. This included dentists, preventive dental specialists, dental assistants, dental lab technicians, and dental logistics technicians assigned to the Dental Command. Twenty (14 male/6 female) active duty US Army dentists (n=9), preventive dental specialists (n=4), dental assistants (n=3), dental lab technicians (n=3), and a dental logistics technician (n=1) volunteered to participate in the study. Five potential subjects declined to participate and 2 originally volunteered during recruitment but did not keep their appointment for the data collection session.

Experimental procedures, risks, and subject rights were discussed before participation in the study. All subjects signed an institutionally approved written consent form. Individuals were excluded if they were pregnant. The study was approved by the Institutional Review Board of Brooke Army Medical Center, Fort Sam Houston, TX (Approval #372631).

A history, physical examination, and upper quarter neuromuscular screen were performed to determine the musculoskeletal status of the neck and upper extremities and neural integrity of the median, ulnar, radial nerves and corresponding dermatomes/myotomes.

History

A history was taken from each patient in questionnaire format. The history included information pertaining to demographics, medical history, military background, work experience, hand dominance, and the amount of time using a computer.

Physical Examination

A physical (screening) examination was part of the evaluation process of each subject. The physical examination included assessment of active range of motion, manual muscle tests, sensory evaluation, reflex testing, and select special tests.[19,20] Active range of motion was assessed for the cervical spine, shoulders, elbows, and wrists and hands. Manual muscle testing was performed for all major muscle groups in both upper extremities with a focus to test at least 2 muscles from each corresponding myotome from C5-T1. Sensory assessment was determined with light touch, vibration, and pain/pin prick assessment of the bilateral upper extremities.

*Military occupational specialty designation.

Light touch and pin prick sensation included the bilateral C4-T1 dermatomes. Vibration sensory testing was conducted using the Bio-Thesiometer (Bio-Medical Instrument Co, Newbury, OH). Testing was performed at the dorsal 1st metacarpal and distal tip of the thumbs, long fingers, and middle fingers. Muscle stretch reflexes (also known as deep tendon reflexes) were obtained from the biceps brachii, brachioradialis, and triceps in the upper extremities. Upper extremity pathological reflexes were assessed with the Hoffman sign.

Last, the special tests of Tinel's sign of median and ulnar nerves at the wrist, Tinel's sign of the ulnar nerve at the elbow, Phalen's test, and the assessment of the radial pulses during positional changes of the upper extremities and neck (Adson's maneuver) were examined.[19,20] Additional special tests of the median and ulnar nerves were performed on both upper extremities of each subject and included the elbow hyperflexion test to assess for ulnar neuropathy at the elbow,[21] upper limb neural dynamic testing to determine irritation of the cervical nerve roots or upper extremity nerves,[22] and wrist ratio tests that determines the ratio of both the anterior-posterior and medial-lateral widths measured at the distal crease of the wrist.[23-25]

Nerve Conduction Studies

At the time of volunteer solicitation, potential subjects were instructed to abstain from exercising for one hour prior to testing. Skin temperature at the wrist was measured using a digital thermometer model TM99A (Cooper Instrument Corp, Middlefield, CT), and was maintained at or above 32ºC. If skin temperature fell below this value, the wrist, hand, and forearm were re-warmed with warm towels.

The Cadwell Wave electromyograph and stimulator (Cadwell Laboratories, Inc, Kennewick, WA) were used to measure the compound motor action potential (CMAP) and sensory nerve action potential (SNAP) latencies and amplitudes. The stimulating current was a monophasic pulse 0.1 millisecond long. The oscilloscope was set to a sweep duration of 2.0 milliseconds per division and a gain of 20 μV per division for the SNAPs. For the CMAPs, the oscilloscope was set to a sweep duration of 2.0 milliseconds per division and a gain of 5 mV per division. The filter settings were 10 Hz–10 kHz for the motor potentials and 10 Hz–2 kHz for the sensory potentials. The sensory latency was measured at the negative peak of the SNAP, and the amplitude was measured from negative peak to positive peak. The motor latency was measured from the negative takeoff of the evoked CMAP, while the amplitude was measured from the baseline to the negative peak of the evoked response. The obtained results were recorded manually and on computer printout.

Specific details for performing the median and ulnar nerve conduction studies (NCS) were presented in studies by Harkins et al[26] and Greathouse et al[27] and follow procedures previously described.[28-31] The median and ulnar nerve palmar and digital distal sensory latencies (DSLs), distal motor latencies (DMLs), and conduction velocities were obtained from both upper extremities. All NCS procedures included measuring the anatomic course of the nerve: median and ulnar palmar DSLs (8 cm), median and ulnar digital DSLs (14 cm), and median and ulnar DMLs (8 cm). In addition to comparing median nerve palmar and digital DSLs, DMLs, and conduction velocities with a chart of normal values, comparison studies between median and ulnar palmar DSLs, digit DSLs (digit 2 and digit 5, digit 4 median/ulnar), and DMLs in the same and opposite extremities were obtained. Examination of median and ulnar latencies in the same extremity and median and ulnar latencies in opposite extremities has been shown to assist in early electrodiagnosis of CTS.[28-31] The presence of median or ulnar neuropathy was operationally defined as one or more electrophysiological values outside the normal range (Table 1) or slowing on comparison studies (Table 2).

Preventive Guidelines and Exercises for the Wrist and Hand

Upon completion of the examination, each Soldier received educational tips regarding stretching, strengthening, resting, and nerve gliding techniques to assist in the prevention of future musculoskeletal injury. The exercises focused on the forearm, wrist, and hand. The purpose of providing upper extremity exercises (mobility, strengthening, and stretching) was to increase the Soldier's awareness of possible musculoskeletal problems in dental personnel. Additionally, the subjects were advised to incorporate these exercises into their dental practice.

In an effort to ensure consistency across subjects, one investigator (KA) collected history data, another investigator (RM) performed the physical examinations, and a third investigator (CK) performed the nerve conduction tests. The neural conduction assessment of the median and ulnar nerves that were performed by researcher number 3 (CK) was directly monitored by either investigator 1 (SS), 6 (JM), or 7 (DG). Investigators 1 and 7 are board-certified clinical specialists in clinical electrophysiology by the American Board of Physical Therapy Specialties of the American Physical Therapy Association. Investigators 1, 6, and 7 are or have been credentialed by the US Army to perform clinical electrophysiological testing (NCS and EMG studies).

Table 1. Mean, standard deviation, and range of values for neural conduction measurements.

	Right Upper Extremity			Left Upper Extremity			Normal Values
Median Nerve	**Mean**	**SD**	**Range**	**Mean**	**SD**	**Range**	
Motor							
DML (ms)	3.5	0.4	2.8-5.3	3.4	0.4	2.7-4.3	<4.2
Amp CMAP (mV)	11.0	3.4	5-18	10.0	2.8	5-18	>5.0
MNCV BE-W (m/sec)	59.6	3.7	51-67	59.6	4.0	52-69	>50.0
Sensory							
Palmar DSL (ms)	1.9	0.2	1.6-2.5	1.8	0.2	1.7-2.8	<2.2
Palmar Amp SNAP (μV)	117.0	46.0	24-200	108.0	39.9	39-200	>15.0
2 Digit DSL (ms)	2.9	0.2	2.6-3.6	2.9	0.2	2.4-3.4	<3.5
2 Digit Amp SNAP (μV)	44.0	19.8	15-103	31.0	12	19-169	>15.0
Ulnar Nerve							
Motor							
DML (ms)	2.8	0.3	2.2-3.4	2.8	0.3	2.3-4.1	<3.6
Amp CMAP (mV)	9.3	2.5	5-17	8.4	2.3	5-14	>5.0
MNCV BE-W (m/sec)	63.9	4.1	54-73	62.2	4.4	51-74	>50.0
MNCV AE-BE (m/sec)	66.5	5.6	54-77	65.4	6.2	51-76	>50.0
Sensory							
Palmar DSL (ms)	1.7	0.1	1.5-2.1	1.7	0.1	1.5-2.1	<2.2
Palmar Amp SNAP (μV)	44.2	27.0	15-153	48.2	26.8	16-130	>10.0
5 Digit DSL (ms)	2.8	0.2	2.5-3.6	2.9	0.2	2.5-3.8	<3.5
5 Digit Amp SNAP (μV)	22.6	6.8	14-52	26.1	10.8	12-79	>10.0

Glossary:
AE - above elbow
Amp - amplitude
BE - below elbow
CMAP - compound motor action potential
DML - distal motor latency
DSL - distal sensory latency
MNCV - motor nerve conduction velocity
SNAP - sensory nerve action potential
W - wrist

DATA MANAGEMENT AND ANALYSIS

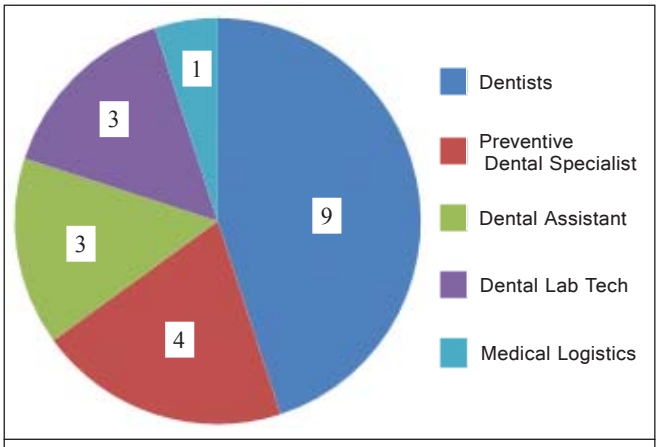
Descriptive statistics for subject demographics and nerve conduction study variables were calculated using SPSS V12.0 (IBM Corp, Armonk, NY). Subjects' median and ulnar nerve function was also ranked as 0 (normal nerve conduction studies) or 1 (abnormal nerve conduction or comparison studies). Significant ($P<.05$) differences between groups (abnormal or normal nerve conduction) for demographic and clinical examination items was also investigated with independent sample t tests for parametric variables and χ^2 tests for categorical data.

RESULTS

Twenty subjects participated in this study (14 male, 6 female). The subjects' ages ranged from 26 to 56 years (mean=38±9.8 years). All of the subjects were right hand dominant. The subjects' time in dental practice varied from 2 to 29 years (mean=13.3±7.96 years), indicating a high average level of experience in clinical practice. The time spent in the military was similar with a range from one to 26 years (mean=11.8±7.7 years). The majority of these dentists and dental specialists had joined the military specifically to be part of the Dental Command. Each dental specialty represented by individual study participants is shown in the Figure. The predominant specialty was dentists (n=9), followed by preventative dental specialists (n=4) who are the military equivalent of a dental hygienist, and dental assistants (n=3). The subjects all reported using dental tools in their daily practice. Three of the 20 subjects reported performing a regular warm-up prior to utilizing dental tools.

The results of the nerve conduction studies are presented in Table 1. The values for these electrophysiological variables for each subject were compared to a chart of normal values (Table 1). This chart of normal values was developed in the Clinical Electrophysiological Laboratory of the Texas Physical Therapy Specialists (San Antonio, TX), and validated at the Electrophysiological Laboratory, US Army-Baylor University Doctoral Program in Physical Therapy, Fort Sam Houston, TX. The chart of normal values depicted in Table 1 is similar to other charts of normal values.[28-31] Comparison of the results of the study with the chart of normal values revealed that 5 subjects had electrophysiologic evidence of mononeuropathy of the median nerve at or distal to the wrist (Table 2), while 2 subjects had electrophysiologic evidence of ulnar neuropathy at the wrist (Table 2).

Overall, 5 of the 20 subjects (25%) presented with abnormal electrophysiologic values suggestive of median neuropathy at or distal to the wrist (carpal tunnel). In addition, 2 subjects had ulnar neuropathy at the wrist (Guyon's canal). The total number of subjects in this study with electrophysiologic evidence of mononeuropathy in



Study participants by dental specialty.

Table 2. Subjects with Positive Findings on Neural Conduction Comparison Studies (all data are presented as milliseconds).

		Palmar DSL			Digital DSL			DML			D4 DSL		
Subject	Hand	Median	Ulnar	Difference	Median	Ulnar	Difference	Median	Ulnar	Difference	Median	Ulnar	Difference
4	R	2.3[a]	2.0	0.3	3.3	3.0	0.3	4.2	3.1	1.1	3.8	3.1	0.7
	L	2.3[a]	1.9	0.4	3.3	3.1	0.2	3.8	3.0	0.8	3.4	2.9	0.5
5	R	1.8	1.8	0.0	2.8	3.2	0.4	3.9	2.8	1.1	3.4	2.8	0.6
	L	2.8[a]	1.4	1.4	1.9	2.8	0.9	3.6	2.7	0.9	3.0	2.9	0.1
10	R	1.7	1.8	0.1	3.3	3.5	0.2	3.6	3.7[c]	0.1	3.4	3.1	0.3
	L	1.9	1.6	0.3	3.2	3.8[b]	0.6[a]	3.4	3.4	0.0	3.0	2.9	0.1
12	R	2.1	1.8	0.3	3.3	3.0	0.3	3.4	2.6	0.8	3.5	3.1	0.4
	L	2.2	2.0	0.2	3.3	3.4	0.1	3.9	2.7	1.2	3.3	3.2	0.1
13	R	2.5[a]	1.9	0.6	3.6	3.3	0.3	5.3[c]	3.3	2.0	3.4	2.8	0.6
	L	2.4[a]	2.0	0.4	3.5	3.4	0.1	4.3[c]	3.0	1.3	3.6	3.0	0.6
17	R	2.1	2.1	0.0	3.4	3.6[b]	0.2	3.9	4.1[d]	0.2	3.1	2.9	0.0
	L	2.1	2.1	0.0	3.1	3.1	0.0	3.9	3.4	0.5	3.1	2.9	0.0
19	R	2.1	1.7	0.4	3.2	2.7	0.5	3.9	2.8	1.1	3.1	2.8	0.3
	L	2.1	1.6	0.5	3.0	2.7	0.3	3.8	3.0	0.8	3.2	2.9	0.3

DSL indicates distal sensory latency. DML indicates distal motor latency.

Notes:

Prolonged DSL (palmar and digit) difference ≥0.6 milliseconds (normal ≤0.5)
Prolonged DML difference ≥1.1 milliseconds (normal ≤1.0)
Prolonged D4 median/ulnar difference ≥0.6 milliseconds (normal ≤0.5)
[a]Prolonged median palmar DSL ≥2.3 milliseconds (normal ≤2.2)
[b]Prolonged ulnar digital DSL ≥3.6 milliseconds (normal ≤3.5)
[c]Prolonged median DML ≥4.3 milliseconds (normal ≤4.2)
[d]Prolonged ulnar DML ≥3.0 milliseconds (normal ≤3.6)

the median and/or ulnar nerves was 7 (35%). The specific occupations of the 7 subjects with evidence of mononeuropathy were 4 dentists, 2 dental lab technicians, and one medical logistics specialist.

Of the subjects with electrophysiologic evidence of median neuropathy at or distal to the wrist, 3 of the subjects (Subjects 4, 5, and 13) had abnormal electrophysiologic values in both hands (Table 2). Of the 2 subjects with unilateral findings of median neuropathy at or distal to the wrist, Subject 12 had abnormal findings in the left hand and Subject 19 had abnormal findings in the right hand (Table 2). Subject 13 had electrophysiologic abnormalities of both the motor and sensory fibers, Subjects 4 and 5 had abnormal findings in only the sensory fibers, and Subjects 12 and 19 had abnormal comparison studies in the absence of abnormal distal motor or sensory latencies (Tables 2 and 3).

Subjects 10 and 17, both dentists, had electrophysiologic evidence of neuropathy of the ulnar nerve at the wrist (Guyon's canal). Subject 10 had abnormal electrophysiologic values in both hands whereas Subject 17 only had abnormal findings in the right hand. Both subjects had electrophysiologic abnormalities in both the motor and sensory fibers of the ulnar nerves (Tables 2 and 3). Both of these subjects with electrophysiologic evidence of ulnar nerve mononeuropathy at the wrist had normal motor nerve conduction velocity of the ulnar nerve in the forearm (BE-W) and across the elbow (AE-BE).

Table 3. Summary of Subjects with Abnormal Findings of Nerve Conduction Studies (NCS).

Median nerve distal sensory and motor latency	1
Median nerve distal sensory latency	2
Median nerve comparison studies*	2
Ulnar nerve distal sensory and motor latency	2
Total abnormal NCS findings	7

*In absence of abnormal distal motor or sensory latency.

Three of the 7 subjects with positive electrophysiological findings had positive findings on physical examination (Table 4). The 3 subjects had electrophysiologic evidence of median neuropathy at or distal to the wrist. Subjects 4 and 5 had a Tinel's Sign over the median nerve at the wrist, Subject 4 had a Tinel's sign over the ulnar nerve at the wrist, and Subjects 4, 5, and 12 had a Tinel's sign over the ulnar nerve at the cubital tunnel. Other than those, there were no positive findings on physical examination in the subjects with electrophysiologic evidence of median nerve mononeuropathy at or distal to the wrist. None of the subjects with electrophysiologic evidence of ulnar neuropathy at the wrist had positive findings on the physical exam. Many of these tests have been described in previous research to be indicative of carpal

tunnel syndrome. However, in the current study, none of the subjective or physical examination measures exhibited significant group differences for subjects with either median or ulnar neuropathy at the wrist upon analysis with independent *t* tests and χ^2 tests ($P>.05$).

COMMENT

This study builds on previous studies that investigated the relationships between medical history, physical examination, and NCS findings of median and ulnar neuropathy in US Army dental assistants and preventive dental specialists.[16-18] Our study adds to this base of knowledge by including the addition of different Army medical dental personnel to include dentists and dental lab technicians. Additionally, our study supports the assumption that dental personnel have a higher percentage of criterion-related validity-based diagnosis of median neuropathy at or distal to the wrist (25%). This is the first dental study to report electrodiagnostic findings of ulnar mononeuropathy at or distal to the wrist. Of note, 4 of the 9 dentists (44%) were found to have abnormal NCS findings, which is significantly higher than previously reported.[3,6-10]

The majority of previous research investigating the prevalence of median neuropathy in dental personnel has used survey data and not electrophysiologic testing (nerve conduction studies).[11,12] Nerve conduction studies are considered the gold standard (criterion-related validity) for diagnosing peripheral neuropathy.[28-45] Survey data of active duty military dental personnel found that the highest prevalence of 3 to 4 self-reported symptoms that were consistent with a high probability of having carpal tunnel syndrome were preventive dental specialists (33%), followed by laboratory technicians (28%), dentists (21%), and dental specialists (16%).[11,12] Our study confirms that dental personnel have a higher actual prevalence of CTS than nondental personnel. However, the difference between our research using NCS and the survey data indicating a higher prevalence of symptoms is likely understood by the low sensitivity of history questions and physical exam screening tests and measures in identifying true neuropathy. We believe that a focus on developing and identifying more sensitive screening measures for neuropathy is imperative for early detection of median and ulnar neuropathy in patients having mild clinical symptoms.

Our study is unique in that it is the first to identify ulnar neuropathy at or distal to the wrist in this population of dental personnel. Both subjects with abnormal electrophysiologic findings of ulnar neuropathy at the wrist were dentists. To our knowledge, only one previous occupational screening study has demonstrated the prevalence of ulnar neuropathy, and that was at the elbow (cubital tunnel syndrome, the second most common neuropathy of the upper extremity).[27] No other studies document the findings of ulnar nerve problems at or distal to the wrist in dental personnel.[16-18] Dentists and dental personnel are predisposed to ulnar neuropathy due to repetitive and prolonged wrist positioning, use of small diameter tools, and exposure to vibratory tools.[11-13] We encourage future researchers to include examination of the ulnar nerve at or distal to the wrist and elbow (cubital tunnel) in order to detect ulnar neuropathy.

A thorough history and physical examination are considered essential screening tools for detecting signs and symptoms of peripheral neuropathy.[28-31] Nerve conduction measurement is often performed on the median and ulnar nerves to determine whether certain entrapment neuropathies are present. It is considered the gold standard or has criterion-related validation when assessing the electrophysiologic status of the peripheral nerve.[28-45]

Table 4. Subjects with Positive Findings on Special Tests of the Upper Extremities.

Subject	Hand	Tinel's Sign at wrist (median)	Tinel's Sign at wrist (ulnar)	Tinel's Sign at cubital tunnel	Wrist Ratio	Vibrometry	Phalen's Test
1	R			X			
2	R			X			
3	L					X	
	R			X		X	
4	L	X*		X*			
	R	X*	X*	X*			
5	R	X*		X*			
6	R				X		
11	L			X		X	
	R	X		X		X	
12	L			X*			
	R		X	X			
14	R			X			
15	L				X		
16	L			X	X	X	
	R	X	X			X	
17	L				X		
	R						
18	R	X	X	X			X
20	L			X			
Total physical exam findings		6	4	14	5	6	1

Note: Subjects 10, 13, and 19 had abnormal nerve conduction velocity findings without positive physical exam findings.

*Denotes subjects with electrodiagnostic abnormalities on NCV.

Our history questionnaire included questions regarding the subjects' pertinent medical history, premilitary occupational background, military background, and extra-curricular activities (such as computer use and/or gaming), none of which were found to be statistically correlated with positive findings of median and ulnar neuropathy as determined by electrophysiologic testing. In addition, the physical exam findings in these dental personnel were not correlated with positive findings of median or ulnar neuropathy. Three of the subjects who were diagnosed with median neuropathy at or distal to the wrist had a completely negative physical examination. Similarly, 12 of the 20 patients who had no electrophysiologic evidence of median or ulnar neuropathy were found to have at least one positive physical exam finding. Thus, this finding further supports that the physical exam screening tests and measures used in this study were not sensitive for clinically detecting median and ulnar neuropathies.[22-25]

On physical examination, 2 subjects (3 hands) with abnormal electrodiagnostic findings of the median nerve at or distal to the wrist had a positive Tinel's test at the wrist for the median nerve, but otherwise had normal physical examination findings suggestive of CTS. It is also interesting to note that 3 subjects with abnormal NCS values consistent with median mononeuropathy at or distal to the wrist did not show any positive clinical tests on physical examination suggestive of CTS.

In a population such as US Army dental personnel, it is reasonable to expect that subclinical upper extremity mononeuropathies secondary to repetitive overuse may be present. In the early stages of a mononeuropathy of this type, many individuals with a clinically detectable problem are not aware that their neural function has been impaired.[43] Atroshi et al[43] examined 125 asymptomatic controls with NCS of the median nerves and they reported that 18% (n=23) had electrophysiological evidence of carpal tunnel syndrome.

Atroshi et al[43] reported that the estimation of prevalence of CTS in a general population may contribute to the early diagnosis and effective treatment of subjects, and provide useful data for the interpretation of results that estimate the prevalence of carpal tunnel syndrome in specific occupational groups. Franzblau and Werner[44-46] further suggest that performing NCS on individuals without symptoms of CTS is important because it permits the assessment of the overall relationship between the electrophysiological properties of the nerve and other clinical features of carpal tunnel syndrome. Although no strong evidence regarding the prevention or progression of CTS exists, theoretically it makes sense to identify a problem early, when a minor intervention such as a resting night splint or ergonomic changes in the work environment might rectify the dysfunction.[44-46]

One limitation of this study is the small sample size of 20 subjects who were recruited from a total pool of 27 possible subjects at Fort Sam Houston, TX, for a 74% participation rate. We suggest that further research employ a multisite approach to increase the total number of subjects and improve the likelihood of an accurate prevalence of these neuropathies. The specific population of active duty personnel also limits the study's external validity in comparing these findings to nonmilitary dental personnel due to different job demands, work schedules, and other duties, including deployment and mandatory physical performance training.

A valuable extension to the current study would be an expansion to multiple active duty and civilian sites to increase the diversity of the study population as well as its total size. We provided an informational briefing to the subjects of the study at its conclusion, which included theoretically preventive exercises such as nerve and tendon gliding. A long-term study of the population to assess prevention using exercise has not yet been performed and would be of benefit to the dental community. Additionally, a longitudinal study of these and other subjects may be valuable to assess the time course of median and ulnar neuropathies.

CONCLUSION

The prevalence of median mononeuropathies in our sample of US Army dental personnel far exceeded that previously reported in the general population.[43] Our findings also build on previous research suggesting increased prevalence of upper extremity mononeuropathies in US Army dental personnel.[16-18] This is the first dental study to report electrodiagnostic findings of ulnar mononeuropathy at or distal to the wrist. Physical examination and historical items such as wrist ratio measurements, age, and years of service in the dental profession did not exhibit meaningful diagnostic accuracy. Prospective research is required to validate our findings and future research examining additional examination items, intervention, and prevention techniques are needed to enhance performance and reduce upper extremity mononeuropathies in dental personnel.

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ARMY MEDICINE

Serving To Heal...Honored To Serve

Risk Factors Associated with Higher Body Fat in US Army Female Soldiers

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ABSTRACT

Increased body fat among US Soldiers is a continuing challenge that contributes to increased health risks and decreased combat readiness. Factors contributing to higher body fat among US Army female Soldiers have been minimally investigated.

Purpose: To investigate the risk factors associated with exceeding US Army body fat standards among active duty women in a light infantry brigade. Investigated risk factors include personal characteristics, physical training, physical fitness, and injury history.

Methods: Data were obtained by survey from women in 3 US Army infantry brigades. Body fat percentage was calculated, and the women were categorized as either meeting or exceeding the maximum Army body fat standard of 30% for ages 17-20, 32% for ages 21-27, 34% for ages 28-39, and 36% for age 40 years or more. Army Physical Fitness Test (APFT) results were converted into tertiles (T), where T1=lowest ⅓ of performance and T3=highest ⅓ of performance. Odds ratios (OR) and 95% confidence intervals (CI) were calculated from a multivariate analysis assessing risk associated with exceeding the Army body fat standards.

Results: Among the women surveyed (N=629), 22% exceeded Army body fat standards. Higher risk of being above the Army standard was associated with older age (≥29 years/≤23 years) (OR=2.47, 95% CI, 1.24-4.92), and poor aerobic fitness (APFT 2-mile run) (T1/T3) OR=6.11, 95% CI, 2.62-14.24), (T1/T2) OR=2.66, 95% CI, 1.12-6.33). A marginal association was found for poor muscular strength (APFT sit-ups) (T1/T3).

Conclusion: The results suggest that women who are older, and/or have poor aerobic fitness are more likely to exceed the maximum Army body fat standards.

Overweight and obesity can be defined as ranges of weight greater than what is commonly considered healthy for a given height, which can increase the prevalence of health problems and certain diseases.[1] One of the most common and feasible means to determine overweight and obesity is by calculating body mass index (BMI). Being overweight or obese can be defined as having a BMI of 25.0-29.9, or 30 or higher, respectively.[1,2] The number of overweight and obese individuals in the United States continues to increase and has now reached 63%.[2,3] One study suggested that if drastic intervention is not taken, 80% of US adults will be overweight or obese by the year 2022, and the associated health care costs could be as high as $956.9 billion by 2030, compared to $81.5 billion in 2001.[4]

This epidemic is also impacting Soldiers in the US military. A recent study indicated 27% of young adults aged between 17-24 years are unfit for military service based on height-weight requirements.[5] Obesity has been found to be the most common reason for Army applicant disqualification.[6] Prior to World War II, the military had concerns about Soldiers being underweight, which limited overall health and strength.[7] That was less than 75 years ago, and today the concern has shifted to the opposite end of the spectrum, with obesity affecting overall health and operational effectiveness due to lower physical fitness and adverse health effects such as high cholesterol, high blood pressure, diabetes or injury, and lost duty time as the result of these conditions.[8-11] Current data suggest 64% of men and 40% of women on active duty are clinically overweight or obese.[8] Higher body fat not only elevates the individual Soldier's health risk, but may also reduce Soldier combat readiness and physical performance; affects the Soldier's eligibility for command positions, promotion, and attendance at professional military schools; and/or may result in early separation from service.[12-14]

The US Army has enforced body fat standards to ensure Soldiers meet a certain level of physical fitness. These standards, outlined in *Army Regulation 600-9*, vary by age.[9,12,15] If the weight for a given height at a specified age is exceeded, then specific body circumference measurements are taken, and a body fat percentage is calculated.[12] If Soldiers do not meet the body fat standard, they are required to attend counseling and enter into a weight loss program.

Even though women make up a small portion of the overall Army population (14%), their contributions to the Army are crucial.[16,17] A recent policy change will permit women to assume certain infantry, armor, and special operations positions that were previously reserved for men only.[18] The limiting factor for female Soldiers to assume these positions is their ability to pass the same physical requirements as male Soldiers.[18] Addressing health concerns such as obesity within the female population would likely benefit the women's overall military performance and increase their opportunity to serve in these positions. This study investigated the risk factors associated with exceeding US Army body fat standards among active duty women in a light infantry brigade.

METHODS

Data Collection

Active duty US Army women in 3 light infantry brigades completed surveys as part of an ongoing physical training program evaluation. All of the women were located on a military post within the United States, with a majority of these women having been stationed at this location for more than one year. The surveys obtained data on the women's personal characteristics, physical training, physical fitness, and any injury that occurred during the previous 12 months. Military occupations were categorized according to *Field Manual 7-21.13*.[19] Age was calculated by subtracting the self-reported date of birth from the date the survey was completed. Smokers were identified as those who had smoked at least 100 cigarettes in their lifetime and had smoked at least 1 cigarette in the 30 days prior to the survey date.

Each Soldier's BMI (kg/m^2) was calculated from self-reported weight (kg) and height (m). Self-reported height and weight have been shown to be highly correlated with actual height and weight (r>0.97).[20] The BMI was categorized based on the Centers for Disease Control and Prevention classifications for "underweight" (<18.5), "normal" (18.5-24.9), "overweight" (25.0-29.9), and "obese" (≥30).[21] For this study, US Army body composition standards are based on the percentage of body fat estimated by means of the Deurenberg formula.[22]

The gender variable in this formula is 0 for women.[23]

$$\text{Body Fat Percentage} = (1.20 \times \text{BMI}) + (0.23 \times \text{Age}) - (10.8 \times \text{gender}) - 5.4$$

The physical training (PT) weekly running distance was calculated from average running frequency per week multiplied by average miles per run. Physical fitness was assessed by means of performance on the Army Physical Fitness Test (APFT) in which scores consisted of a timed (2 minutes) push-up event, a timed (2 minutes) sit-up event, and a timed 2-mile run. Those scores were converted into tertiles (T) where T1 represented those Soldiers with the lowest ⅓ of performance, and T3 represented those with the highest ⅓ of performance. Two-mile run times were converted into minutes and fractions of a minute. An injury was defined by a self-report of having been injured in the previous 12 months.

Body Fat Standards

Army Regulation 600-9 was developed to ensure that Soldiers are capable of meeting the physical demands of Army missions/tasks.[12] The Army body fat standards require Soldiers to be measured and weighed during the semiannual APFT.[21] In the Army, if a female Soldier exceeds her weight standard based on her height, her actual body fat is calculated by measuring the circumference of her neck, waist, and hips.[12] After their body fat percentages were calculated, the women in this study were categorized as either meeting or exceeding the Army maximum body fat standards of 30% for ages 17-20, 32% for ages 21-27, 34% for ages 28-39, and 36% for ages 40 years or more.

Data Analysis

Data were analyzed using IBM SPSS Statistics (V 19.0) software (IBM Corp, Chicago, IL). Descriptive statistics for demographics were calculated. Comparisons of BMI and body fat percentages by age and fitness were made using χ^2 and analysis of variance to determine any differences between categorical and continuous variables, respectively. An independent-samples t test was conducted to compare aerobic training between the 2 groups. Logistic regression was used to assess the association of personal characteristics, physical fitness, and unit physical training with risk of exceeding Army body fat standards. Risk ratios and 95% confidence intervals (CI) were presented. Potential risk factors for the inability to meet Army body fat standards were entered into the multivariate logistic regression model based on univariate model results. Risk factors significant at the P<.10 were entered into the starting model for a backward stepping logistic regression model. Odds ratios (OR) and 95% CI from the backward stepping

multivariate analysis were calculated and reported. Risk factors at the $P<.05$ were considered statistically significant in the multivariate model.

Table 1. Mean BMI and Estimated Body Fat by Age Group Among Female Soldiers Surveyed (N=629).*

Age Group (years)	n	Mean BMI†	n	Mean Estimated Body Fat Percentage‡
17-20	67	23.9±3.0	67	27.8±3.7
21-27	364	24.2±3.4	360	29.2±4.1
28-39	162	25.0±3.2	161	31.9±4.0
≥40	25	26.2±3.3	25	36.1±4.0

*Age and/or BMI not reported for 11 women.
†BMI ANOVA $P<.01$
‡Body fat percentage ANOVA $P<.01$

Table 2. Proportion of Female Soldiers Surveyed Exceeding Army Body Fat Standards by Age Group (χ^2 $P<.01$ for all groups)

Age Group (years)	No. of Female Soldiers (n)	Percentage of n Over Maximum Body Fat Percentage*
17-20	67	24%
21-27	364	19%
28-39	162	25%
≥40	25	48%
Total	618†	22%

*Maximum body fat allowed for age groups: 17-20, 30%; 21-27, 32%; 28-39, 34%; ≥40, 36%.
†BMI (height and/or weight not reported for 11 women).

Table 3. Comparison of Physical Fitness by Body Fat Status Among Female Soldiers Surveyed (n=629).

Fitness Measures*	Met Body Fat Percentage Standard	Did Not Meet Body Fat Percentage Standard	Mean Difference	Pearson χ^2 P value
Sit-ups (repetitions)	66.8±12.9	60.1±13.3	-6.7	<.01
Push-ups (repetitions)	41.4±13.0	35.2±11.8	-6.2	.36
2-Mile Run (minutes)	17.2±1.9	18.9±2.3	+1.7	.04

*From Army Physical Fitness Test

RESULTS

A total of 629 women were surveyed, representing 64% of the total female population in the 3 light infantry brigades surveyed. Women accounted for 8% of the total brigade population. Mean (±SD) age was 26.3 (±5.9) years. A majority of these female Soldiers were enlisted personnel (90%) and were serving in combat support military occupational specialties (98%). Of these women, 54% had reported an injury within the previous 12 months. Using Centers for Disease Control and Prevention (CDC) BMI categories, 38% (n=238) of the women were overweight (BMI=25.0-29.9 kg/m²) and 5% (n=29) were obese (BMI≥30 kg/m²). Using the estimated body fat formula, 22% (n=135) of the women were over the maximum Army body fat percentage for their age group. Of the 135 women over the maximum body fat standard, 79% were overweight and 21% were obese according to the CDC BMI categorization. Table 1 shows the BMI and mean body fat percentage by age groups. BMI and mean body fat percentage were higher with older age groups. Table 2 displays the proportion of women, by age group, who exceeded the Army body fat standard. There was a statistically significant difference in the proportion of women exceeding the standard between age groups ($P<.01$), with the highest proportion exceeding the standard in the 40 or more years of age group (48%).

Table 3 compares average physical fitness as measured by APFT performance for women who did and did not meet the Army body fat standards. There was no difference in push-up performance ($P=.36$). However, statistically significant differences in performance on the sit-up and running events were observed. On average, women above the maximum body fat standard performed 6.7 fewer sit-ups ($P<.01$) and were 1.74 minutes slower on the 2-mile run test ($P=.04$).

Table 4 shows the association of personal characteristics, physical training, physical fitness, and prior injury with the risk of exceeding Army body fat standards. The risk of exceeding Army body fat standards was lower for officers and warrant officers. Risk was higher among women over the age of 29 and women who did not run with their unit. Women who performed in the lowest tertile for sit-ups and push-ups and in the slowest 2 tertiles of 2-mile run time were also at higher risk. There was a dose-response relationship for all 3 components of the APFT ($P\leq.01$) indicating that for successively lower fitness levels, the risk of exceeding Army body fat standards increased. Prior injury and other unit physical training measurements were not risk factors for exceeding the Army body fat standards in women. We also investigated the average number of miles run per week for the women whose estimated body fat was above standards and those who met the standards. The average number of miles run per week was not significantly different between the groups (12.0 miles for those above body fat standards versus 11.3 miles for those meeting the standards, $P=.10$).

Variables entered into the multivariate logistic regression model included age, weekly unit running mileage, and all 3 APFT events (push-up, sit-up, 2-mile run). Rank was not entered into the model as it was correlated with age. Table 5 shows independent risk factors associated with female Soldiers exceeding the Army body fat standard for their age category. Female Soldiers over

Table 4. Risk Factors for Exceeding Army Body Fat Standards Among Female Soldiers (n=629, unadjusted).

Variable	Variable Level	n	Percentage of n Not Meeting Army Body Fat Standard	Risk Ratio (95% CI)	*P* value
Age (years)	≤23	236	17%	1.00	
	24-28	217	22%	1.31 (0.89-1.92)	.16
	≥29	160	31%	1.85 (1.28-2.68)	<.01
Enlisted Rank	E1-E3	139	20%	1.00	
	E4-E5	354	24%	1.19 (0.82-1.74)	.36
	E6-E9	55	29%	1.44 (0.85-2.45)	.18
	Officer/Warrant Officer	60	7%	0.33 (0.12-0.90)	.02
Military Occupational Specialty	Combat Arms	10	0%		
	Combat Support	168	24%	1.10 (0.80-1.52)	.56
	Combat Service Support	430	22%	1.00	
Tobacco Use	Nonsmoker	427	21%	1.00	
	Smoker	184	25%	1.17 (0.86-1.61)	.32
Unit Weekly Running Distance	Did not run with unit	186	25%	1.42 (0.98-2.06)	.06
	<10 miles	230	18%	1.00	
	10-20 miles	128	20%	1.14 (0.73-1.77)	.56
	>20 miles	42	26%	1.47 (0.82-2.62)	.21
Unit Road Marches per wk	None/< 1 a wk	365	21%	1.00	
	1-2 times a wk	93	24%	1.12 (0.74-1.70)	.59
	3-4 times a wk	131	23%	1.09 (0.75-1.57)	.67
Road March Distance	No Road Marches	72	18%	1.00	
	1-3 miles per wk	129	26%	1.42 (0.80-2.51)	.22
	4-6 miles per wk	233	21%	1.17 (0.67-2.02)	.58
	7 or more miles per wk	49	20%	1.13 (0.54-2.37)	.75
Unit Resistance Training	None	419	20%	1.00	
	1-2 times per wk	142	26%	1.28 (0.92-1.80)	.15
	3 or more times per wk	36	25%	1.23 (0.68-2.24)	.50
APFT Pushups repetitions (tertile)	≤34 (T1)	186	50%	2.44 (1.55-3.83)	<.01
	35-46 (T2)	190	31%	1.48 (0.90-2.43)	.12
	≥47 (T3)	164	18%	1.00	
APFT Sit-ups repetitions (tertile)	≤60 (T1)	205	57%	2.29 (1.49-3.53)	<.01
	61-71 (T2)	157	22%	1.17 (0.69-1.97)	.56
	≥72 (T3)	169	21%	1.00	
APFT 2 mile minutes (tertile)	≤16.50 (T3)	147	12%	1.00	
	16.51-18.20 (T2)	144	32%	2.65 (1.33-5.30)	<.01
	≥18.21 (T1)	142	56%	4.76 (2.50-9.07)	<.01
Injured in the past 12months	No	286	20%	1.00	
	Yes	326	24%	0.95 (0.87-2.55)	.23

the age of 29 were 2.47 times more likely to exceed the Army body fat standards. Women who performed the least amount of sit-ups were 1.77 times more likely to exceed the Army body fat standards, although results were marginally significant. Women in the 2 slowest APFT 2-mile run tertiles were 2.66 (T2) and 6.11 (T1) times more likely to exceed the Army body fat standards.

COMMENT

In this population of US Army women in light infantry brigades, it was found that 38% were overweight and 5% were obese, based on the CDC BMI classifications. Twenty-two percent exceeded Army body fat standards for their age group. Considering a variety of personal characteristics, unit physical training, and physical fitness, this study showed a higher risk of exceeding Army body fat standards among women over age 29 and those with lower levels of aerobic fitness (ie, those running more slowly on the 2-mile run).

The Army relies on height, weight, and BMI to screen for body composition in men and women, thus limiting direct knowledge of the association of body fat with fitness or job performance in women.[23] As a result, there have been few investigations that have studied women and measured percentages of body fat in the military. Similar to the findings of this analysis, a study by Bathalon et al analyzing active duty Soldiers (n=1,257) also found

that 22% of female Soldiers did not meet the Army body fat standards.[24] In a study by Friedl et al, 17% of women in an operational Army unit (n=347) were overweight according to military standards.[9]

This analysis found that women of increasingly older age exhibited higher average estimated body fat percentages. Other studies have reported similar results among female Soldiers.[24,25] One investigation reported that 53% of women between the ages of 17 and 20 exceeded the Army body fat standards compared to 64% of women over 40 years of age.[24] There is limited information on body fat percentage and age in women, but there are several studies on BMI and age in women. One study showed a significant correlation between age and BMI; women between the ages of 20 and 39 had an average BMI of 25.9 kg/m^2, while the average BMI was 27.0 kg/m^2 among women aged 40-59 years.[25] Another study, published in 2010, also reported BMI in women to increase with age and plateau at about 50 years of age.[23] Specifically, women aged 20-29 had an average BMI of 24.3 kg/m^2, women aged 30-39 years had an average BMI of 25.6 kg/m^2, and women aged 40-49 had an average BMI of 26.3 kg/m^2.[26] One explanation as to why body fat increases with age in military women is a decrease in physical training with increasing rank and entry into more sedentary supervisory roles.

Regarding the effects of body fat on fitness, the APFT provided an overall assessment of health-related fitness. According to *Army Regulation 350-1*,[21] participants acquiring a score of 270 (with a 90-point minimum per event) and passing the body composition standards will be awarded the Physical Fitness Badge for excellence.[2] A previous investigation found 24% of female Soldiers exceeding body fat standards were able to score over 270 out of 300 on the APFT. The study suggested that physiological differences in body fat thresholds could explain how participants exceeding body fat standards still performed well on the tests. The study characterized such participants as "fit fat."[9] An earlier study of body composition and fitness reported low but significant correlations between BMI and measured body fat percentage and run times, sit-ups, and push-ups.[28] Another study showed little correlation between body fat percentage and obstacle course performance. The investigators found those with greater fat mass also had greater fat-free mass, allowing them to carry excess fat without leading to a decrease in performance.[29] However, this investigation found the average APFT total score for women exceeding the body fat standard was 228.8 ± 38.40, (n=78), with only 9 (12%) of them scoring 270 and above. Women who did not exceed the body fat standard had an average total APFT score of 255.6 ± 2.6, with 84 (25%) scoring 270 and above.

Table 5. Multivariate Regression Results: Independent Risk Factors for Exceeding Army Body Fat Standards Among Female Soldiers (N=629).

Variable	Variable Level	n	Odds Ratio (95% CI)	*P* value
Age (years)	≤23	163	1.00	
	24-28	155	1.47 (0.78-2.76)	0.23
	≥29	86	2.47 (1.24-4.92)	0.01
APFT Sit-ups Tertiles (repetitions)	≤60 (T1)	142	1.77 (0.91-3.46)	0.09
	61-71 (T2)	119	0.87 (0.40-1.88)	0.73
	≥72 (T3)	143	1.00	
APFT 2 mile run Tertiles (minutes)	≤16.50 (T3)	132	1.00	
	16.51-18.20 (T2)	136	2.66 (1.12-6.33)	0.03
	≥18.21 (T1)	136	6.11 (2.62-14.24)	<0.01

Note: APFT indicates Army physical fitness test.
Variable(s) entered on step 1: Age, total unit weekly running miles, APFT 2-mile run, APFT push-ups, APFT sit-ups

Women in this investigation who did not meet Army body fat standards on average did not perform well on the APFT 2-mile run. Fortunately, aerobic endurance is a modifiable risk factor that also affects body composition. One study with nearly 4,000 participants found endurance training for 4 weeks or longer reduced body fat by 1.4% on average ($P \leq .01$).[30] Gradually increasing the frequency of aerobic training in the participants' training program, with supervision, may help to reduce the number of individuals exceeding the Army body fat standard. In contrast, several studies have shown increased running leads to an increase in injury incidence.[31-33] Therefore, care must be taken when increasing running frequency and mileage.

Alternatively, similar military populations have established new physical training programs that include alternatives to running for aerobic conditioning. A study by Walker et al describes a new physical training program that reduced running distance by 50% and replaced it with interval running and agility drills. With this program, overall injuries decreased by 67% while aerobic capacity increased.[34] Another military study evaluated a new physical training program using cross-training and aerobic training by ability groups compared to a more traditional program with more distance running. Results showed women in the traditional program had a 1.8 times greater risk of a time loss injury.[35] Other aerobic exercises, such as swimming, should also be explored as alternatives to running.

STRENGTHS AND LIMITATIONS

Data were collected through self-reported surveys, which can be subject to recall bias as well as concerns about honesty in answers and lack of comprehension of

the questions. However, prior analyses have found high correlations between actual and self-reported APFT data.[36] In this study specifically, actual unit-collected APFT data were available for a subset of the study sample (n=83 Soldiers). A comparison of actual (unit-collected) and self-reported APFT scores showed correlations over 80% for 2 of 3 APFT events: r=0.87 (n=87), r=0.83 (n=83), and r=0.54 (n=83), for the 2-mile run, sit-ups, and push-ups, respectively.

In this analysis, body fat percentage was estimated using the Deurenberg formula, which has been found to have less than 2% mean difference between reported and predicted body fat percentage.[22] Even though the Deurenberg formula is a validated formula with regard to its accuracy, it remains an estimation tool only. Other body composition formulas were considered, however, they required the identification of ethnicity, which was unknown in our database. Using a body composition formula developed by Gallagher et al that was derived using Caucasian and African-American data,[37] a comparison with estimated body fat percentages calculated using the Deurenberg equation indicated a correlation of 0.96. Body mass index is considered to be a fairly reliable indicator of body fatness for population-based analyses.[38] However, the BMI of some individuals may have increased from the 25-29.9 range as a result of increased muscularity. In addition, CDC BMI cut points may not be appropriate for all ethnic groups due to evidence showing associations between BMI, percentage of body fat, and body fat distribution among different populations.[39]

Given that the average miles run per week did not differ between the group that exceeded the body fat standards and the group that met the body fat standards, further investigation into modifiable behaviors such as dietary habits is warranted, but was beyond the scope of this study. Physical training and dietary environments may also vary by location, so further investigations in other military populations are needed in order to address increased body fat concerns within specific populations.

CONCLUSION

This study found the leading contributors for increased risk of exceeding the Army's body fat standards in women were older age and low aerobic fitness. Weight control and health promotion initiatives specifically geared toward women over 29 years of age may help reduce the number of women failing to meet the Army's body fat standards. Fortunately, appropriate physical training improves aerobic fitness and should reduce body fat. With increases in Army and nationwide obesity rates, weight control efforts should continue to be an important focus for Army medicine and public health activities.

RELEVANCE TO THE PERFORMANCE TRIAD

Encouraging optimal physical activity and appropriate nutrition within the Army community are key aspects of the Army Surgeon General's Performance Triad.[40] More specifically, this study addresses APFT performance, a metric identified for the Activity component of the Triad, as well as body weight, a key outcome of interest.[40] Results of this study provide further evidence of the link between body weight and performance on the APFT run event, a measure of aerobic fitness, in a population of active duty Army Soldiers, thus supporting Triad efforts designed to enhance aerobic fitness in order to attain or maintain a healthy body weight.

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Act Resilient

Genie Joseph, MFA
Wynona Bice-Stephens, EdD, RN

Before Act Resilient, I was seriously thinking about suicide. Now I don't think about it anymore.

Anonymous service member

Act Resilient is an innovative educational program that has been improving the lives of service members and their families. Created in 2009 by author Genie Joseph, the program uses coping skills, emotional flexibility, expressive arts, improvisation, and laughter to teach stress management. As a volunteer with the Tripler Army Medical Center's (TAMC) Care Provider Support Program (CPSP), she and the dedicated CPSP Team present resiliency training which focuses on self-care and wellness for TAMC civilian and military staff.

Joseph is an award-winning filmmaker, with a background in cognitive behavioral therapy, creative writing, dance and drama therapy, expressive arts, and meditation mindfulness. She has drawn together components from several disciplines to create a training program targeted to military needs.

Act Resilient has been offered in several formats, both offsite and onsite, in one-hour, stress-breaking mini-classes and day-long workshops. The preferred method of delivery is a one-hour class meeting once a week for 4 to 8 weeks. The program has been shown to be effective for all types of people, from those most shy to total extroverts.

BACKGROUND

Act Resilient was originally designed when Joseph encountered individuals with traumatic brain injury (TBI) among her college class students. Some of the students had been told they would not be able to pass college classes. Joseph considered this a pedagogical challenge, and believed that flexible teaching styles and "a trauma-informed classroom" could better serve the Soldier population dealing with challenges such as TBI or posttraumatic stress disorder (PTSD). Act Resilient is based on the concept of neural plasticity which explores the idea that with the right restimulation, a traumatized brain can begin to heal.

As Kleim notes:

> The brain is the most complex biological system on the planet, and the sources of functional impairment are many, ranging from the sudden loss of tissue due to a stroke or traumatic injury, or to the decades long neurodegeneration associated with Parkinson's or Alzheimer's disease.[1(p521)]

Research continues to discover unknown aspects of the human brain with increasing regularity. Much ot that new research has been focused on "neural plasticity," defined in 2008 by Kleim and Jones as:

> The mechanism by which the brain encodes experience and learns new behaviors. It is also the mechanism by which the damaged brain relearns lost behavior in response to rehabilitation.[2(pS225)]

In a theoretical discussion of brain plasticity after a TBI, Bach-y-Rita noted:

> Evidence has been accumulating that the brain can reorganize extensively after damage and that reorganization can be obtained even many years after the trauma with appropriate late rehabilitation.[3(p643)]

Research has delved into the influence of genetic factors on brain plasticity and recovery after neural injury. Pearson-Fuhrhop et al points out that:

> After neural injury, significant reorganization of brain networks occurs to a variable extent and can be associated with substantial behavioral recovery. Animal studies have provided important insights into the mechanisms of this plasticity, with molecular and cellular findings based on direct examination of neural tissue. These molecular studies are of pivotal significance…."[4]

Learning-dependent neural plasticity has been demonstrated with transcranial magnetic stimulation on subjects' increase in human motor cortex such as those trained in one-handed, 5-finger piano playing.[1(p522)]

Applying the concept of neural plasticity, Act Resilient uses a number of techniques that encourage the brain to use new motor skills, discover new ways of thinking and

perceiving, and find new choices for responding to stimulus. A basic principle of this method is to use the body to move emotions out of the system, because emotions are not just "in the head." They exist in nerves and cells and the body as a whole, often as "fight or flight" responses. Animals can be seen "shaking out" the adrenaline of a stressful experience, and then quickly regaining homeostasis . In Act Resilient, participants learn to "shake out" energy and stressful emotions by vigorously shaking to a favorite song. This may help release the cascade of stress chemistry, and participants report feeling renewed and invigorated after this activity.

COMMENT

The Act Resilient Training method consists of 27 principles that inform over 100 interactive activities. One guiding principle is the idea that being in the present moment is very beneficial for healing. Many of the activities are designed to bring people more fully into present time. One of the methods to create reengagement with the present is through humor. Laughter is a fast way to get people oriented to the present moment, which defeats the recurring lure of the past. As one Soldier explained, "It's hard to be sad when you're laughing." There is no need to revisit or talk about painful or difficult events in order to succeed with this process. In fact, one of the strengths of the program is that additional ruminations on "bad things" are avoided, and not reinforced by repetition. Trauma pulls people into thinking about the past and worrying about the future. "Act Resilient" reengages attendees with the present.

One of the fastest ways to reset the brain is through improvisational comedy, which is essentially a team sport where individuals connect to each other through play and laughter. The spontaneity of theater games helps stimulate the brain, and the repeated alternation of high-brain stimulation with relaxation seems to help the brain become more flexible, and may restore neural plasticity. Another key strategy of the Act Resilient method is the use of team building and group cohesion, a concept that is very familiar to service members, in which the group supports individuals to perform at their highest level, rather than at their lowest. Act Resilient is social, builds team cohesion, is highly interactive, and addresses the sense of isolation experienced by many people suffering with PTSD.

Laughter and having fun together promote an uplifting experience. Using the benefits of camaraderie is pivotal in this context and is used to support healing. Act Resilient activities are whole brain exercises, which alternate brain activity from left to right, front to back, and with high and low stimulation levels alternating quickly. Using the body to express and move emotions is immediate, fun, and engaging, and rapidly counteracts some of the key symptoms of PTSD, such as avoidance and withdrawal.

The activities in Act Resilient are designed to induce the various parts of the brain to communicate with each other instead of being compartmentalized. A traumatized brain is analogous to working "off line." The brain needs to be reintegrated to work as a cohesive whole, instead of existing in fragmented sections. Act Resilient restores confidence in the attendees' own brain, because they are using many elements, such as observation, imitation, imagination, creativity, whole-brain memory, and spontaneity. Applying the concept of neural plasticity, Act Resilient promotes using the healthy parts of the brain to engage and heal the parts that are not working well.

Students learn to recognize their own emotional activation scale, from zero (0) stress to the highest level (10). For the service member, learning how to calibrate one's own emotional response level is very useful. When close family members take this training, they learn what to notice and how to pay attention to nonverbal cues indicating rising stress levels. This is especially useful to identify while those levels are low (level 3-4 on the 0 to 10 scale), as the early detection can prevent high level activations and strong triggers. This helps both the individual, as well as family members, who can then adjust their interaction to reduce the likelihood of intense reactivity. A person with PTSD may find it challenging to control triggers and responses at high levels such as 8, 9, or 10, when the stress chemistry may have hijacked the brain. Family members and friends can learn to prevent escalation by adjusting their behavior when they observe subtle changes in body language, and nonverbal cues in their spouse or parent. This is one way the program teaches spouses how to best interact with a partner with a TBI or PTSD. By understanding that a traumatized brain may respond differently than before injury, spouses who are now attentive to the nonverbal cues will have greater situational awareness of rising stress levels and may have more success in the prevention of further upset.

For example, something as simple as using too many words at one time, without a break, can become "data overload" and create an overwhelmed response, even if the information being delivered is mundane or routine. Spouses learn to watch for body cues such as changes in breathing rate or depth, eye movement, facial expression, posture, or changes in skin color. Correct observation of these nonverbal cues may indicate rising stimulation

and stress levels that have been triggered from attempting to absorb too much information. When such signs are detected, more talk will likely diminish successful communication, and additional stress could even lead to physical violence or destructive arguments.

An example of this situation was experienced by a Soldier who had returned to his family after 4 deployments, during which he was twice wounded/injured in combat. His PTSD made it difficult to adjust to the dull routine of garrison life. His wife was prior military who had become a stay-at-home mom. She spent long hours every day without any adult interaction. After he returned to the normal workday routine at his home station, daily she routinely attempted to describe the events of her whole day to him as soon as he arrived home from work. Neither of them could understand why he could not deal with this stream of data, as often it was pleasant information about their son. In the Act Resilient program, she learned a hand signal that she taught her husband to use when he had heard enough. Using nonverbal messaging was faster than trying to put his response into words. It gave him increased control over these interactions, which lowered his trigger-response. Later, when he was less overwhelmed, he was ready to listen. This allowed both of them to better control his level of stimulation. It was very useful to understand that he had trouble dealing with so much data and sound in those moments when he was at an elevated stress level.

A traumatized brain may be weakened or exhausted, which makes it more susceptible to rapid stress reactions, and may cause the stressed individual to avoid situations which demand choices. This can trigger PTSD symptoms and behavior. For instance, a spouse can cause mental overload by asking, "Do you want to stay home, do you want to go to the beach, do you want to go to the movies, or do you want to go out to dinner?" While these choices may seem simple enough for a non-traumatized brain, for someone experiencing high stress with all the possible triggers attached to even enjoyable events, this can be potentially overwhelming.

In Act Resilient, family members learn that it may be better to offer limited choices, such as 2 simpler choices at a time, "Do you want to stay home or go out?" Once that is resolved and the brain can settle into a simple decision, then another clarification can be offered. For example, if the choice is to go out, "Do you want to go to the beach or walk the dog?"

Act Resilient creates a positive response to facing choices, through the use of creative spontaneity. For children, play is how they learn, and the same is possible for adults. Spontaneous improvisation games restore the willingness to play, and this contributes to more flexible emotional choices and responses . Learning to make rapid-fire, imaginative choices in improvisational comedy games helps the brain to "reset," and even to enjoy the challenge. The program deploys a number of rapid and playful reset techniques that bring instant relief, and appears to help the brain "unstick."

Teaching the entire family these rapid-reset, body-based techniques helps the afflicted brain quickly come back to neutral. Some examples from Act Resilient are the use of nonverbal interventions that are body-based, such as jumping, shaking, wiggling, and patting/tapping the body on specific meridian points. While most Soldiers respond favorably to these playful activities, others simply need a brief explanation as to how it can quickly reset the brain. When they realize it is effective for stress-relief, they readily engage with the process. Typically about 80% quickly participate enthusiastically. Others overcome their own initial resistance to letting go in this way at a somewhat slower pace. When all members of the family learn these methods, they can support each other to minimize stress and restore a feeling of wellbeing in seconds. In this way, the brain does not have to go through the draining cycle of overload, which makes even simple family interactions almost unmanageable.

Educating family members about what it is like to live with a person whose brain has experienced significant trauma leads to understanding, builds compassion, and enhances more effective communication styles. The ironic realization is that a traumatized brain that has had to make too many life and death choices can become overwhelmed by making too many mundane choices.

SUMMARY

Attendees have reported changing from being fearful to serene, from listless to energized, from disengaged to connected, and becoming markedly less anxious in a few weeks. Anecdotally, self-reported stress levels have been reduced by over 50% after just one class. Attendees learn not to be afraid of their feelings by working with emotions in a playful manner. When a person can act angry, but separate himself from his personal story, the emotional energy exists in a separate form that is not attached to specific events, and can be more easily dealt with and neutralized. Attendees are taught to "take out the emotional trash" through expressive comedy. They become less intimidated by their own emotional intensity and triggers as they learn how even metaphorical buckets of anger, shame, guilt, and hurt can

be emotionally emptied. The added benefit is that this is accomplished without the disclosure of personal information or the requirement to reexperience past pain which can trigger its own cascade of stress.

Act Resilient is an innovative approach that has helped many handle their emotions and triggers to better cope with daily life. It teaches the entire family how to have a common vocabulary—verbal and nonverbal—to diminish the stress response. It has been highly successful in lowering stress and raising morale for active duty. It has renewed hope in veterans, spouses, and military children. Over time, the lessons learned help give an attendee a new start at home and on duty.

Future plans involve delivering Act Resilient through telemedicine, so that those in remote locations can benefit from these methods.

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The Tripler Army Medical Center is located in Honolulu, Hawaii. It is the only federal tertiary care hospital in the Pacific Basin. It also is the home of the Pacific Regional Medical Command.

THE US ARMY MEDICAL DEPARTMENT REGIMENT

The US Army Medical Department was formed on July 27, 1775, when the Continental Congress authorized a Medical Service for an army of 20,000 men. It created the Hospital Department and named Dr Benjamin Church of Boston as Director General and Chief Physician. On 14 April, 1818 the Congress passed an Act which reorganized the staff departments of the Army. The Act provided for a Medical Department to be headed by a Surgeon General. Dr Joseph Lovell, appointed Surgeon General of the United States Army in April 1818, was the first to hold this position in the new organization. The passage of this law marks the beginning of the modern Medical Department of the United States Army.

Throughout its early history, the size and mission of the US Army Medical Department would wax and wane in response to military events around the world. There was, however, no formal regimental organization until World War I. Then, in the late 1950s, the brigade replaced the regiment as a tactical unit. In the reorganization that followed, some Army units lost their identity, their lineage, their history. This loss did not go unnoticed. The US Army Regimental System was created in 1981 to provide soldiers with continuous identification with a single regiment. Department of the Army Regulation 600-82, The US Army Regimental System, states the mission of the regiment is to enhance combat effectiveness through a framework that provides the opportunity for affiliation, develops loyalty and commitment, fosters a sense of belonging, improves unit esprit, and institutionalizes the war-fighting ethos.

The US Army Medical Department Regiment was activated on July 28, 1986, during ceremonies at Fort Sam Houston in San Antonio, Texas, the "Home of Army Medicine." Lieutenant General Quinn H. Becker, the US Army Surgeon General and AMEDD Regimental Commander, was the reviewing officer. He was joined by general officers of the US Army Reserves and the Army National Guard, representing the significant contributions and manpower of the reserve forces in the Total Army concept.

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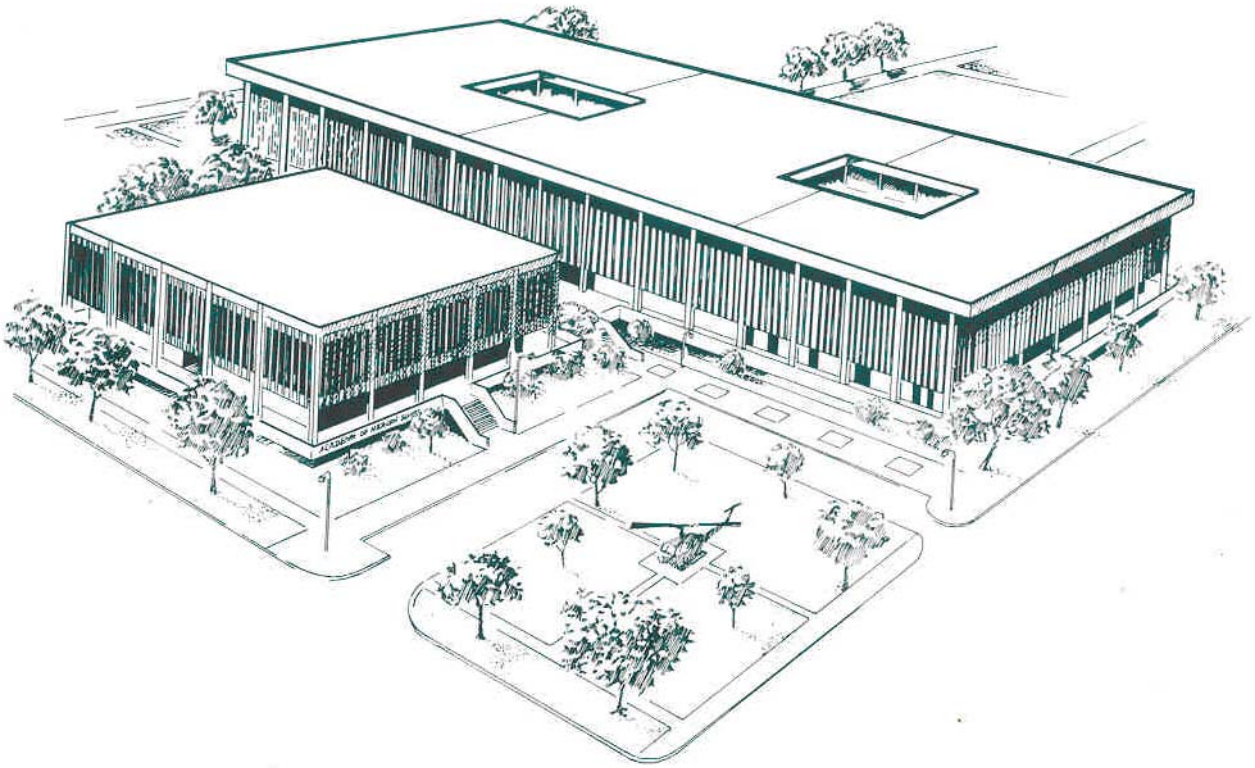

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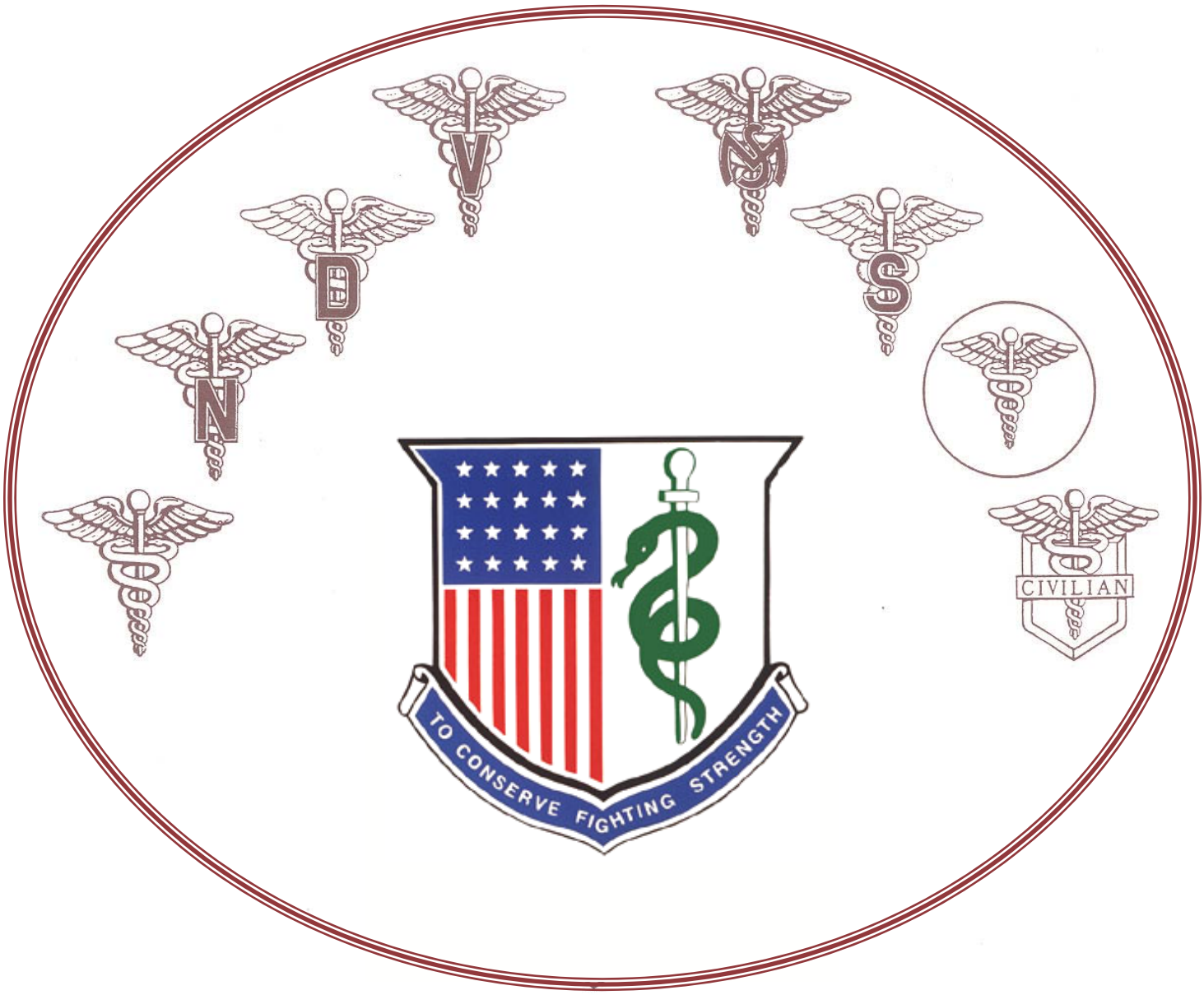

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