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Correlation Between Femoral Neck Shaft Angle and Surgical Management in Trainees With Femoral Neck Stress Fractures

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Abstract

The most common overuse injury leading to medical discharge of military recruits is a stress fracture. One of the high-risk stress fractures is of the lateral femoral neck which risks osteonecrosis of the femoral head, the need for arthroplasty and permanent disability. To prevent fracture progression early surgical intervention is recommended. Surgical repairs are performed in about 25% of cases of femoral neck stress fractures at military treatment facilities. Hip geometry is an important intrinsic risk for stress fractures. Loads in the average loading direction will not cause a fracture, but loads of extreme magnitude or extreme orientation may. The purpose of this study was to determine if, in the presence of femoral neck stress fracture, there is a correlation between femoral neck shaft angle, surgical treatment and outcomes. The results of this study suggest there is no correlation between return to full military duty rates, treatment, femoral neck shaft angle or fracture grade on MRI. Patients who underwent surgical fixation had greater fracture grade and pain than those that did not have surgery. Individuals who did not return to duty tended to have higher pain scores at initial evaluation.

The most common overuse injury that leads to the discharge of new military recruits is a stress fracture.[1] Stress fractures are associated with abrupt changes in physical activity level, such as the increase in activity some recruits are exposed to as part of military basic training.[1] Stress fractures result from repetitive, submaximal loads on normal bone that cause bone formation to lag behind bone resorption, leaving bone prone to microtrauma.[2] A subset of stress fractures, subject to high tensile forces and limited vascularity, are prone to delayed healing and are at risk for complete fracture, delayed, or nonunion, and require a more aggressive treatment approach.[3] One of the high-risk stress fractures is of the lateral femoral neck which risks osteonecrosis of the femoral head, the need for arthroplasty, and permanent disability.[4,5] Early surgical intervention for these high risk stress fractures is recommended to prevent fracture progression.[3-5] The cost of a recruit sustaining a femoral neck stress fracture that requires surgery is estimated to exceed $100,000 per injured recruit. At military treatment facilities (MTFs), surgical fixation is performed in about 25% of cases of femoral neck stress fractures.[6]

Femoral neck stress fractures make up less than 10% of all stress fractures.[4,5,7-10] These injuries are most common in female military recruits.[2,7] Overall, complications occur in 10% to 40% of all femoral neck stress fracture patients. Complication rates increase with displacement and varus surgical reduction.[11]

Both intrinsic and extrinsic factors have been associated with an increased risk of femoral neck stress fracture. Extrinsic factors may include the type of physical activity, prior training regimens, footwear, and environment.[7] Intrinsic factors include sex, bone density and size, muscle size, foot shape, leg length, and hip geometry.[5,7-9,12]

Hip geometry is an important intrinsic risk for stress fractures. Clinically, loads in the average loading direction will not cause a fracture, but loads of extreme magnitude or extreme orientation may.[13] In cases of altered femoral neck geometry, the joint load orientation becomes more vertical with coxa valga and more horizontal in coxa vara.[13] Coxa vara is defined as a femoral neck shaft angle of less than 120°, coxa valga as an angle of greater than 140° average femoral neck shaft angle ranges from 125° to 131°.[13] Femoral neck stress fractures are associated with coxa vara[14] and compression side femoral neck stress fractures are more common.[3]

The treatment of femoral neck stress fractures should first focus on correcting predisposing intrinsic and extrinsic factors. Treatment of most compression side femoral neck stress fractures involves not bearing weight on the affected extremity for 6 weeks.[3] Compression

side stress fractures that show chronic changes such as cysts or intramedullary sclerosis involve more than 50% of the neck on MRI, and those that are complete may require surgical fixation.[1,2] Sariyilmaz et al used coxa vara and the resulting mechanical abnormality as an additional indication for surgery.[15] Tension side femoral neck stress fractures should be treated with increased vigilance to prevent progression to complete fracture.[2,8] Nondisplaced stress fractures can be treated with cannulated screw fixation or Pauwel osteotomy; however, displaced fractures would require dynamic hip screw placement or arthroplasty.[15]

The purpose of this study is to determine if, in the presence of femoral neck stress fracture, there is a correlation between femoral neck shaft angle, surgical treatment, and outcomes.

Methods

After approval from the MTF Institutional Review Board, we performed a retrospective study. Patients that had been evaluated by orthopaedics, had imaging of the hip, and diagnosed with a femoral neck stress fracture at the MTF between June 1, 2012 and May 31, 2014 were included. We reviewed hospital and clinic records and available imaging data from surgical scheduling, electronic medical records, and the Picture Archive and Communication System (PACS) application.

A potential subject list, shown in Table 1, was compiled using an electronic medical record search of ICD-9 codes which correspond to stress fractures of the femur, hip, and pelvis. Imagery available in PACS was reviewed to ensure the potential subjects did, in fact, have a femoral neck stress fracture and the necessary imaging studies were available for analysis. We then screened the potential subject list for other inclusion and exclusion criteria, shown in Table 2.

Table 1. The potential subject list of codes corresponding to stress fractures of the femur, hip, and pelvis.

ICD-9	Description
733.90	Disorder of the bone and cartilage unspecified
733.95	Stress fracture of other bone
733.96	Stress fracture of the femoral neck
733.97	Stress fracture of the shaft of the femur
733.98	Stress fracture of the pelvis
736.31	Coxa valga (acquired)
736.32	Coxa vara (acquired)
736.39	Other acquired deformities of the hip

Each subject's femoral neck shaft angle was measured on the anteroposterior radiograph by calculating the angle formed by the intersection of a line bisecting the midpoint of the femoral neck and the midpoint of the femoral head, and the anatomic axis of the femur, illustrated in the Figure. Each subject's MRI was then examined in order to grade the severity of the femoral neck stress reaction as indicated by bone edema and a frank fracture line (Table 3). Each subject's electronic medical record was examined for details on the clinical course, provider recommended activity restrictions, and ability to perform full military duty. Each subject was searched on the surgical schedule to determine whether they underwent surgery for a femoral neck stress fracture.

Table 2. Additional inclusion and exclusion criteria for subject screening.

Inclusion Criteria
Treated between June 1, 2012 and May 31, 2014
Diagnosis of a femoral neck stress fracture confirmed by MRI
Age: 18-45 years
Active duty
Treatment by orthopaedics
Available MRI and anteroposterior pelvis
Exclusion Criteria
Age <18 years
Age >45 years
Pathologic fracture
Electronic medical record not available
Imaging to evaluate stress fracture not available

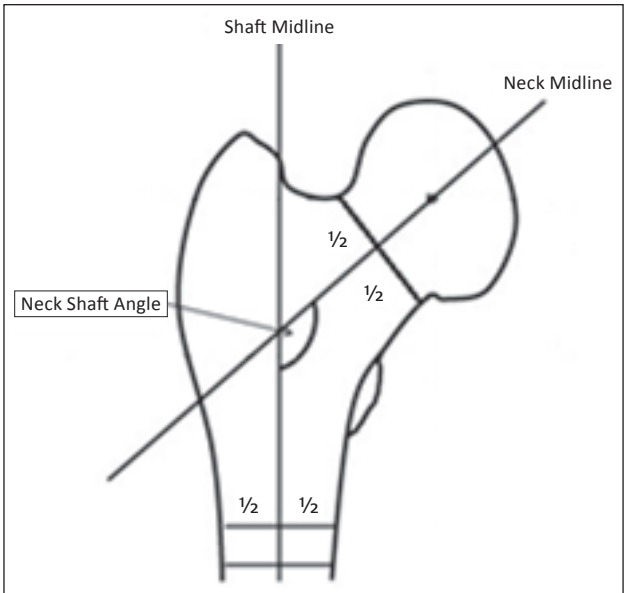

Illustration of the parameters used to measure the femoral neck shaft angle determined from an anteroposterior radiograph image.

Comparisons among groups were then made using unpaired student's *t* test and Pearson's correlation for continuous data, and 2-tailed Fisher's exact test for categorical data. All analysis was performed using GraphPad Prism 6 (GraphPad Software, Inc, La Jolla, CA).

Table 3. Criteria table used to grade severity of the femoral neck stress reaction based on examination of the subject's MRI imagery. Adapted from Arendt et al.[16]

Grade	STIR* Signal Change	T2 Signal Change	T1 Signal Change	Plain X-ray Film
1	Present	None	None	Negative
2	Present	Present	None	Negative
3	Present	Present	Present	Periosteal reaction
4	Present	Fracture line	Fracture line	Periosteal reaction or fracture line

*Short T1 inverse recovery imaging

Results

Search of orthopaedic encounters within the electronic medical record found 205 uses of the queried ICD-9 codes in 185 individuals. Of those, diagnosis of femoral neck stress fracture was found in 72 individuals. Nineteen individuals were excluded from the study because an MRI was not obtained as part of their workup, they had been treated at their previous duty station, had pathologic fractures, were not active duty, or had no fracture on MRI. This left 53 individuals as study participants, with 10 individuals having bilateral femoral neck stress fractures (63 total stress fractures).

Review of the 53 included individuals found that all of the affected individuals were initial trainees, and 12 were male (23%). The average age of the included subjects was 22.9 years (range 18 to 39 years) and there was no difference in age between male and female subjects (P=.3820). Thirty of the 63 affected femurs were right side (48%). All of the evaluated femoral neck stress fractures were compression side. One male presented with a complete fracture. Women had a greater mean femoral neck shaft angle compared to men (132.2°±0.6° versus 129.0°±0.8°, respectively; P=.0082). Normal is considered 125° to 131°. No correlation existed among femoral neck shaft angles, stress fracture grades, duration of symptoms, or pain scale results per hip.

Ten subjects (8 female, 2 male) had bilateral stress fractures. All bilateral stress fractures were noted on images obtained in a single encounter. In addition, the 7 patients who had surgical intervention for bilateral stress fractures had both sides fixed at one procedure. Having bilateral stress fractures did not affect surgery rates (P=.1563) or return to duty rates (P=.4639) compared to a unilateral stress fracture.

Twenty-four subjects (31 hips) underwent operative fixation. Percutaneous screw fixation was used in all 24 of the operative patients. One 19-year-old patient's course was complicated by chondrolysis and went on to total joint arthroplasty. Femoral neck shaft angles were not different between subjects who were not treated with surgery (131.6°±0.8°) and those who underwent percutaneous screw fixation (131.4°±0.7°, P=.8759). However, subjects with operatively treated hips had higher stress fracture grades on MRI (3.4±0.1) versus subjects who did not undergo surgery (2.9±0.1, P=.0059). Subjects who underwent surgery also had higher mean pain scores on presentation to orthopaedics (4.8±0.5) versus subjects who did not undergo surgery (3.4±0.5, P=.0412).

Two-thirds of surgical patients did not return to full duty (16/24), and 48% of nonsurgical patients did not return to full duty (14/29, P=.2660). There was no difference between femoral neck shaft angles among subjects who were able to return to duty (132.0° ±1.1°) and subjects who were not able to return to duty (131.2°±0.6°, P=.5081). Stress fracture grade was also not different between those who returned to full military duty (3.1±0.1) and those who did not (3.2±0.1, P=.4701). There was a trend, though not significant, towards individuals who did not return to duty having higher mean pain scores on presentation to orthopaedics (4.6±0.4 not return to duty versus 3.3±0.6 return to duty, P=.0575).

Comment

The results of this study suggest there is no correlation between return to full military duty rates and treatment, femoral neck shaft angle, or fracture grade on MRI. There was a trend toward significance in higher pain level at presentation and lower return to duty rates. Patients who underwent surgical fixation had greater fracture grade and pain than those that did not have surgery. The femoral neck shaft angle was found to be more valgus in women. Additionally, the mean angle in this cohort was more valgus than the previously cited normal range of 125° to 131°.[13] Bilateral stress fractures were found in 19% of study participants.

In this study, all of the patients who had stress fractures were trainees. This suggests initial training places added stress on the femoral neck that either does not continue after conditioning or results in the attrition of trainees prone to these fractures. Individual preconditioning and dietary variance would affect how the trainee reacts to the increase in physical activities unique to initial training. The programs that have shown to decrease training injuries, such as command awareness, provider training, and the Army Physical Readiness Training (PRT) program, should be continued.[6]

This study found no tension-sided femoral neck stress fractures. This is not surprising because compression-sided fractures are more common; however, the proportion of surgically-treated fractures was 49%. This percentage is greater than previously presented in the

literature (25%).[6] Although there was no statistically significant correlation between stress fracture grade and pain level, the stress fracture grade and pain level were higher for those operatively treated. While some literature supports treating compression side stress fractures with strict limitation of weight bearing,[3] our high operative rate is evidence that surgeon and facility considerations play a role in management of this condition. For example, surgeons at this MTF must consider whether strict nonweightbearing is reasonable for individuals with training demands within the military environment.

Clinically, providers should continue to have a high index of suspicion for femoral neck stress fractures in trainees presenting with hip pain. An MRI should be obtained if history warrants. When obtaining MRIs, the contralateral hip should be imaged to exclude asymptomatic stress reaction in the contralateral hip.[3,17] Care should also include identifying and treating any intrinsic factors that put the trainee at risk for stress fracture.[3] Treatment may need to include supplementation with calcium and vitamin D, or treatment of women with low-dose estrogen.[8] However, not all intrinsic factors are amenable to intervention and focus must remain on modification of extrinsic factors when possible.[8] Initial military training fitness programs that assess and gradually progress fitness levels are necessary for injury prevention.[8] These could include progressive resistance training and protective exercises such as the forward lunge, isokinetic hip extension, one-legged long jump, and isokinetic knee flexion.[8,18,19]

All retrospective studies have similar limitations including those imposed by querying records that differ in quality. Not all data that was desired was recorded in every medical record. Many lacked record of pain scale, duration of symptoms, and duration of restricted weight bearing. This study was unable to assess for female athlete triad due to the lack of records on the patient's menstrual cycle and diet. In post-hoc power analysis using Stata 13.1, we found we were adequately powered at 0.9519 for the comparison between return to full military duty and those that did not with regard to mean femoral neck shaft angle. A follow up study to obtain a power of 0.80 would require 424 subjects, with 212 subjects each in the surgical and nonsurgical groups, for the comparison between operatively treated hips and femoral neck shaft angles. So while we were adequately powered with this sample size to examine some dependent variables, we were not adequately powered to examine all of them. A study of such size would not be possible at this single medical facility.

Conclusion

Both intrinsic and extrinsic factors contribute to stress fracture. Extrinsic factors may include the type of physical activity, prior training regimens, footwear and environment.[7] Intrinsic factors include sex, bone density and size, muscle size, foot shape, leg length, and hip geometry.[5,7-9,12] Those charged with training design should work to minimize the contribution of modifiable factors to prevent stress fractures. Future studies that prospectively gather information on female athlete triad, metabolic work-up results, pretraining fitness levels, and seasonal differences in rates would be useful. Studies that randomize surgical treatment may not be possible, but nonoperative treatment modalities involving treatment of modifiable intrinsic and extrinsic factors would be helpful in helping care providers choose the best treatment to avoid the patient's separation. Stress modeling of the exercises preformed in initial training could also help tailor physical fitness program to prevent stress fractures. Future study is also necessary to limit the personal and financial effects of these costly fractures.

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Observed Rates of Lower Extremity Stress Fractures After Implementation of the Army Physical Readiness Training Program at JBSA Fort Sam Houston

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Abstract

Millions of dollars are lost each year to the US military in medical discharges from injuries sustained in the initial training of recruits. Most medical discharges in recruits are related to musculoskeletal overuse injuries, including stress fractures. Any strategies that can reduce injury rates are also likely to reduce rates of medical discharge. This study evaluated the Army Physical Readiness Training (PRT) program which was established to provide a method of physical fitness training that would reduce the number of preventable injuries. We conducted a retrospective study to evaluate the number of lower extremity stress fractures that were diagnosed in the 6 months prior to and 6 months following the implementation of the PRT program. Electronic medical records were queried for specific diagnoses of stress fractures to the pelvis, femoral neck, femoral shaft, tibia, fibula, tarsals and metatarsals. The observed number of diagnoses in each time period were compared using the χ^2 method. Decrease was shown not only in the overall occurrence of stress fractures, but specifically in the occurrence of stress fractures of the femoral neck, femoral shaft, and tarsals. Our study was able to show a correlation between the PRT program and a decrease in the observed occurrence of lower extremity stress fractures.

Millions of dollars are lost each year to the US military in medical discharges from injuries sustained in the initial training of recruits. According to the Government Accountability Office, the military loses an estimated $390 million annually in the recruitment and training of personnel who separate before completing the first 6 months of service.[1] Financial losses arise from the cost of initial recruitment; transport to the training location; uniforms and equipment; accommodation and rations; wages; instruction and supervision; administration; and medical, dental, and psychological care for recruits who are medically discharged.[1,2] Each recruit who fails to complete training costs the military thousands of dollars.[1,2] The loss of a single recruit costs between $7,000 and $16,000 per recruit depending on branch of service and specialty.[2-5]

Additionally, medical discharge of recruits compromises military readiness by reducing force strength and depriving the military of critical skills.[6] When overseas operations in Iraq and Afghanistan increased the demand for manpower, the attrition rate during initial military training became a serious and costly concern for all military services.

Medical discharge rates range between 16% and 53% of the total discharges of recruits.[2-5] Although medical discharges can be attributed to many causes, approximately 40% of medical discharges were related to musculoskeletal injury, and half of those were overuse injuries, including stress fractures.[2,7] Additionally, lower extremity overuse injuries account for more lost duty days and delays in completion of training than any other diagnosis.[8] In fact, those sustaining a stress fracture are 4 times more likely to be medically discharged. Sustaining a stress fracture during initial military training is the most powerful predictor of discharge.[4]

Given the association between medical discharge and lower extremity stress fractures, any strategies that can reduce injury rates are also likely to reduce rates of medical discharge during initial military training.[2,4] The Army Physical Readiness Training (PRT) program, implemented in October 2010, was designed to establish a more comprehensive and standardized method of physical fitness training in order to reduce the number of preventable injuries. Injury prevention measures included reduced running miles, a greater variety of exercises, and enforced progressive training.[9] The purpose of this

study is to evaluate the observed rates of lower extremity stress fractures diagnosed in recruits following the implementation of the PRT.

Methods

Our study was intended as a pilot study to evaluate the effect of implementing PRT on lower extremity stress fractures that could lead to discharge. Following Institutional Review Board approval, we queried the military electronic medical record (AHLTA) for ICD-9* codes corresponding to specific diagnoses of lower extremity stress fractures. We included diagnoses of stress fractures to the pelvis, femoral neck, femoral shaft, tibia, fibula, tarsals, and metatarsals, shown in Table 1. We limited our search to recruits seen at McWethy Troop Medical Clinic (TMC) at Joint Base San Antonio (JBSA) Fort Sam Houston, Texas. The TMC is the facility where recruits are initially evaluated for medical complaints.

Table 1. The ICD-9* codes used as search criteria.

ICD-9 Code	Description
733.93	Stress fractures of the tibia and/or fibula
733.94	Stress fractures of the metatarsals
733.95	Stress fractures of other bones (tarsals)
733.96	Stress fractures of the femoral neck
733.97	Stress fractures of the femoral shaft
733.98	Stress fractures of the pelvis

*International Classification of Diseases, 9th Revision

We divided our cohort into 2 groups based upon the implementation date of the PRT program at JBSA Fort Sam Houston. Group 1 was defined as lower extremity stress fractures that occurred during the 6-month period prior to implementation of the PRT program, from April to September 2010. Group 2 was defined as lower extremity stress fractures that occurred during the 6-month period following the implementation of the PRT program, from October 2010 to March 2011. The total number of diagnoses, the number of each ICD-9 diagnoses, and groupings based on anatomic region (thigh, leg, and foot) were analyzed. Anatomic regions were used to determine if PRT changes affected one body region over the others. The thigh region was considered the femoral neck and shaft, the leg region was the tibia or fibula, and the foot region was the tarsals and metatarsals. There were 5000 recruits assigned to Fort Sam Houston during the period of our study. The groups were compared using the χ^2 method of analysis with α=0.05 and β=0.8.

No protected health information and no patient demographic data were collected by investigators.

*International Classification of Diseases, 9th Revision

Results

There were a total of 408 lower extremity stress fractures diagnosed during our investigation. We observed that 234 lower extremity stress fractures were diagnosed during the 6-month period prior to the implementation of the PRT program (Group 1). We observed that 174 lower extremity stress fractures were diagnosed during the 6-month period following the implementation of the PRT program (Group 2). This represented 25.2% decrease in the overall occurrence of lower extremity stress fractures between the 2 groups (P=.002). Similarly, the occurrence of stress fractures of the tarsal bones decreased by 36.9% (P=.008), while femoral neck stress fractures decreased by 47.0% (P=.003). Despite the fact that we observed a 60% decrease in the occurrence of femoral shaft fractures, the difference did not reach statistical significance (P=.109). There was also no statistical difference in the occurrence of tibial (P=.720) and metatarsal (P=.876) stress fractures. No pelvic stress fractures were observed during the examined period. The data is presented in Table 2. The Figure shows the distribution of the stress fractures through the study period.

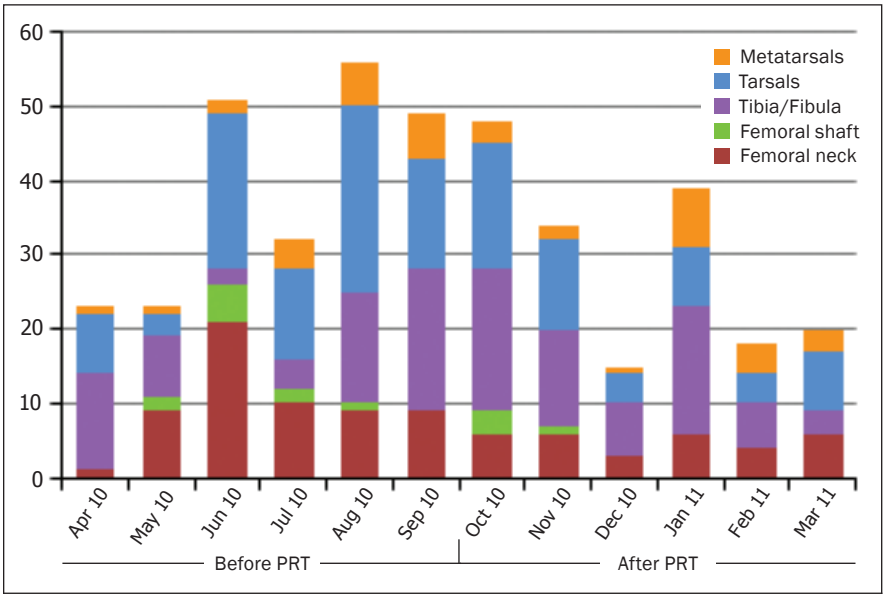
Table 2. Data of observed lower extremity stress fractures displayed by location and group. Negative percentage change represents a decline in the number of lower extremity stress fractures observed. Positive percentage change represents an increase in the number of lower extremity stress fractures observed.

	Group 1	Group 2	Change %	*P* Value
Pelvis	0	0	0%	N/A
Femoral neck	59	31	-47.0%	*P*=.003
Femoral shaft	10	4	-60.0%	*P*=.109
Tibia/Fibula	61	65	6.6%	*P*=.720
Tarsals	84	53	-36.9%	*P*=.008
Metatarsals	20	21	5.0%	*P*=.876
Total	234	174	-25.2%	*P*=.002

Groupings based on anatomic region were also analyzed. We observed 49.3% decrease in stress fractures to the thigh region (P<.001) and 28.8% decrease in stress fractures to the foot region (P=.023). Statistical significance for the leg grouping was not achieved (P=.720). The data is presented in Table 3.

Comment

The PRT program was introduced to reduce the number of preventable injuries by establishing a more comprehensive and standardized method of physical fitness training.[9] Our study demonstrated a decline in the diagnosis of lower extremity stress fractures under the PRT program. This decrease was shown not only in the overall rate of stress fractures occurrence, but also in stress fractures of the tarsal bones and the femoral neck. A significant reduction in femoral neck stress fractures is encouraging because these are a subset of high-risk stress fractures, prone to progression to complete



Distribution of diagnosed stress fractures by month for the study period April 2010 through March 2011.

Table 3. Data of observed lower extremity stress fractures displayed by region and group. Negative percentage change represents a decline in the number of lower extremity stress fractures observed. Positive percentage change represents an increase in the number of lower extremity stress fractures observed.

	Group 1	Group 2	Change %	*P* Value
Pelvis	0	0	0%	N/A
Thigh	69	35	-49.3%	*P*<.001
Leg	61	65	6.6%	*P*=.720
Foot	104	74	-28.8%	*P*=.023
Total	234	174	-25.2%	*P*=.002

fracture and possibly requiring surgical intervention.[10] While we found a meaningful decrease in the number of observed femoral shaft stress fractures, our study was likely underpowered, given the inability to show statistical significance. Our study was limited to one installation, JBSA Fort Sam Houston, and only extends to the 6 months immediately prior to and after implementation of the PRT program. A larger cohort could be derived from including more installations or from examining a longer period around the time of implementation.

In addition to an underpowered study, there are other limitations. The PRT program was only implemented for the Army recruits at JBSA Fort Sam Houston. As we collected no demographic information on the subjects, permanent party (nontrainee), Air Force, or Navy personnel that are also trained at JBSA Fort Sam Houston could be included despite not participating in the PRT program. Because the TMC is the entry point to the Military Health System for recruits, we are confident that we captured all recruits save those that presented primarily to the Emergency Department (ED). However, any post-ED follow up is performed at the TMC, regardless of subspecialty referral by the ED. All recruits are seen at this one TMC. We recognize that we could have missed stress fractures of individuals who chose not to seek treatment or delayed presentation until outside the study window. Furthermore, we would miss additional stress fracture diagnoses made following specialty care evaluation because initial evaluation by the primary care provider would have had a different ICD-9 code. Finally, given such as short study window, we could have missed potential seasonal variations similar to those seen in other injury patterns.

Conclusion

Our study demonstrated a decline in the diagnosis of lower extremity stress fractures in the 6 months following the implementation of the Army PRT program. This included a decrease in femoral neck stress fractures, which can be associated with worse outcomes. Continued investigation is warranted considering the high cost of training dollars lost to injury, treatment, and discharge of recruits early in their military training.

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What Soldiers Know and Want to Know About Preventing Injuries: A Needs Survey Regarding a Key Threat to Readiness

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Unintended injuries, in particular physical training-related injuries, continue to be one of the most significant threats to US military readiness.[1] As many of these injuries are considered preventable, this study was undertaken to help determine what additional information might contribute to reducing these injuries in the US Army.

Historical Review

Common musculoskeletal and orthopedic injuries (ie, strains, sprains, joint derangements, and stress fractures) are the leading threat to the medical readiness of our troops.[1] Almost 50% of all service members experience one or more injuries annually.[2] Each year, these injuries limit physical ability and cause disability among active duty service members, resulting in millions of medical encounters, lost or restricted duty days, and medical expenses.[1,3-6] These injuries, predominantly of the back, knees, and lower extremities, are most often due to repetitive overuse, not from acute trauma.[1,3-5,7-10] In fact, over half of these injuries result from unit or personal physical training activities like running or sports.[2] Even during wartime operations, medical air evacuations are more often for nonbattle injuries such as those caused by sports and physical training than for injuries resulting from combat.[11]

This problem has persisted for decades.[12,13] In 1992, an estimated 450,000 outpatient medical encounters resulted in several million days of restricted duty.[13] In 2012, 2.2 million Department of Defense (DoD) military medical encounters resulted from these same types of musculoskeletal injuries, resulting in an estimated 25 million limited duty days.[1] The Army accounts for about 40%—the largest portion—of these days of limited duty.[1,4] It has been estimated that a 1% reduction in incidence of lower back pain could translate to the retention of thousands of trained Soldiers, avoidance of countless lost training hours, and significant cost savings through fewer disability payments and less consumption of medical care.[13]

The continued high incidence of these common injuries is, in part, because Soldiers must routinely conduct physical training. Physical training is the cornerstone to enhancing physical fitness and overall human performance. Yet physical training and optimizing human physical performance includes minimizing injury. Scientific study and injury surveillance data have helped to identify risk factors and evaluate the effectiveness of some tactics for reducing these injuries.[14-19] Risks and interventions associated with running mileage, training programs, stretching, footwear, various braces (such as ankle, back, knee), gender, age, and medication use have been and continue to be investigated. In some cases, current evidence provides insights into training modifications that could reduce injuries. In other cases, scientific investigation has shown that evidence is inadequate to prove the benefits of some interventions. In fact, some scientific evidence shows that not all injury prevention (IP) tactics once believed to be effective are actually helpful. In reality, some may increase injury risks.[3] Unfortunately, anecdotal information often drives risk prevention decisions.

Scope of this Effort

Investigators at the US Army Public Health Center (Provisional)* (USAPHC(P)) theorized that a lack of awareness and confusion about risk factors and effective physical training techniques may be contributing to this persistent injury problem. In order to guide the development of IP educational materials to increase awareness and correct misinformation, a voluntary survey tool was used to assess current awareness about IP topics and identify specific information needs and interests among Army audiences.

Methods

A group of health analysts, health educators, and statisticians experienced with survey tools developed a

*Formerly the US Army Public Health Command.

29-question survey.[20] The survey, designed to be anonymous, focused on unintentional musculoskeletal injuries, but also included some questions about heat and cold injuries. Data requirements were balanced with the desire to limit the time burden for respondents. Survey topics included demographics and job roles, personal injury history (past 12 months), awareness of injury effects, risk factors, interventions, leadership perspectives (for nonsupervisor responders), and IP interests (ie, activities, injury types, and information sources and formats). Prior to disseminating the survey, documentation was submitted for review through the USAPHC(P) Human Protection Review Board. The collection of personally identifiable information was avoided through preestablished, broad categories provided in demographic questions.

Table 1. Demographics of Respondents Completing Survey (N=685).

	Total	Military	Civilian
Affiliation			
Military	527 (77%)		
Civilian	158 (23%)		
Gender			
Male	467 (68%)	377	90
Female	218 (32%)	150	68
Age (years)			
<20	10 (1%)	9	1
21-30	131 (19%)	123	8
31-40	192 (28%)	179	13
41-50	205 (30%)	165	40
>50	147 (22%)	51	96
Job Field			
Medical	265 (39%)	235	30
Nonmedical	420 (61%)	292	128

The survey was delivered using the Vovici software application (Vovici is now Verint Enterprise Edition (Verint Systems Inc, Melville, NY)). The voluntary online survey was dispersed to Army audiences through several venues between July 9 and August 26, 2014 (6½ weeks). Venues included postings on Army medical and nonmedical social media sites, websites, and through mass Army (S-1 Net) and individual emails. Posting of the survey link was voluntary for the proponent organizations. All responses were received in a protected data archive only accessible by selected project investigators.

To assess general awareness of the problem, 4 evidence-based statements regarding most common musculoskeletal injuries within the Army and leading causes of these injuries were provided for respondents to indicate their level of agreement (on a 5- point scale from Strongly Agree to Strongly Disagree). Respondents also scored the effects of various risk factors and prevention measures for musculoskeletal injuries by indicating whether they believed the measures decrease risk, neither increase/decrease risk, increase risk, or whether the respondent was not sure. The "correctness" of statements were evaluated based on previously published scientific evidence,[1,5,11] including a systematic review of physical training injury intervention conducted by DoD experts.[3] In addition, respondents were asked to choose activities about which they were most interested in receiving IP information. Sixteen options (including "other") were provided with the instruction to select all that apply. Responders who were not healthcare providers/educators were asked 4 questions regarding their experiences or beliefs regarding their leadership's support or interest in injury prevention. Other questions included asking respondents about preferred format and venue for obtaining additional IP information, and an open ended question for any additional comments.

Data analyses were conducted using IBM SPSS Statistics 21.0 and Microsoft Excel 2010. Only respondents who fully completed all questions were included in the final analysis. Quantified results were presented as frequencies and percentiles. Data cleaning of narrative free-text responses was completed by 2 investigators who separately reviewed all individual responses to determine whether responses could be grouped with preestablished response categories or into any newly created categories.

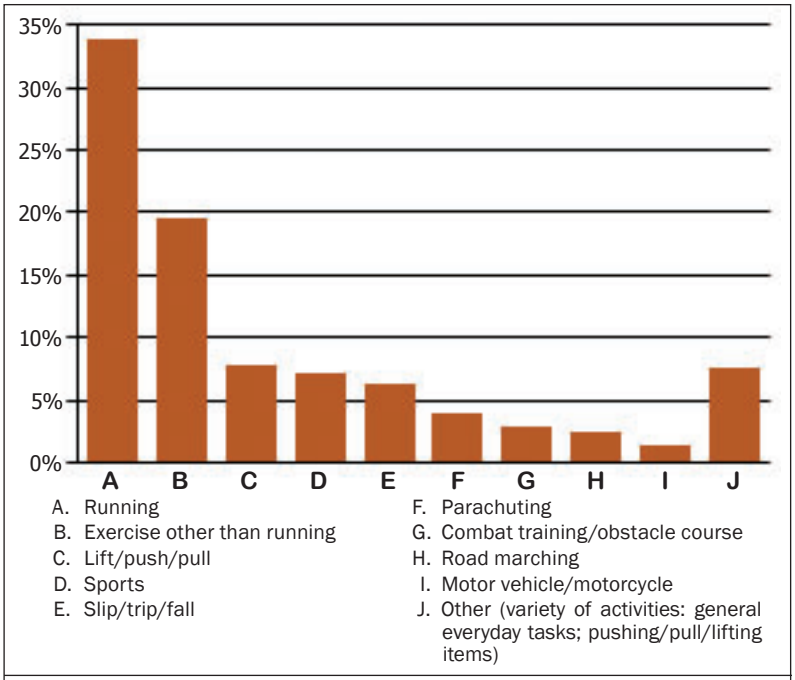

Figure 1. Percentage distribution of injury causes among respondents who reported injury (n=360) in response to the following question:
What was the cause of your most severe injury in the past 12 months?

RESULTS

General and Demographics

The survey was initiated by 926 persons and fully completed by 685 respondents. The average time taken to complete the survey was 14 minutes. A comparison of the respondents who completed the survey (685) versus those who did not (241) revealed no significant differences.

Table 1 summarizes key demographic characteristics. Most respondents (77%) were Army personnel (62% officers, 38% enlisted). More men (68%) than women (32%) responded. Very few responders were under 20 years of age, most falling between 21-50 years of age. Of the military respondents, almost half were of medical areas of concentration or military occupational specialties. Of these, the largest portions were physician assistants (32%), followed by physical therapists (18%). Nonmedical military personnel included chemical, biological, radiological and nuclear specialists, infantry, military intelligence, ordnance, and others.

Over half (53%) of respondents reported musculoskeletal injuries in the previous 12 months that affected their physical ability to do daily tasks or exercises. Of these, 61% were described as primarily associated with overuse. The most common cause reported was running (34%), as shown in Figure 1.

Knowledge and Awareness

The findings for musculoskeletal injuries are presented in Table 2. The responses of all medical respondents (ie, healthcare/educator providers) followed the same trends as the overall trends for all respondents, with slightly more accurate answers and slightly fewer unsure responses. Most respondents (62% to 78%) correctly chose "strong" or "very strong" agreement with each of the 4 evidence-based statements regarding the general magnitude and types of the injury problem. However, 7% to 14% disagreed with each question, and 11% to 23% neither agreed nor disagreed. Respondents were less likely to identify "correct" for responses pertaining to musculoskeletal injury risk factors and interventions than for those pertaining to heat and cold injury (data not shown). Responses for risk factors that were most incorrect included the increased risks that are associated with low body mass index (BMI), high flexibility, and smoking. For interventions, higher percentages of incorrect responses were found regarding the effectiveness of ankle braces and cotton socks, and the lack of IP effectiveness that has been shown with back braces, stretching, the use of anti-inflammatories prior to exercise, and wearing of minimalist running shoes.

Injury Prevention Interests

Figure 2 presents the types of activities about which respondents were most interested in receiving IP information. Respondents chose an average of 5 activities (mean 4.98, SD 2.84). Despite some minor variations, activity interests were very similar between medical and nonmedical responders.[20] Write-in responses for "other" activities not listed included yoga, biking, and soccer. Sprains/strains/torn muscles and tendonitis/bursitis were most frequently selected as being of interest by both those personnel not in the health community (78% and 74%, respectively) and healthcare/educators (84% and 88%, respectively). Of next greatest interest to both groups were torn ligaments (56% for those not in the health community and 59% of those from health fields) and fractures (48% and 54%). Other types of injuries of interest identified in free-text responses included chronic conditions such as arthritis.

A common topic appearing in free-text comments concerned overtraining, along with requests for more detailed guidance regarding athletic form and technique. Some respondents noted that because physical training is integral to optimizing Army readiness, Soldiers should be treated more as athletes and coaching or professional guidance about injury prevention should be provided. Likewise, many free-text responses requested guidance concerning the prevention of re-injury. One suggestion made by a few respondents was to provide guidance or training specifically to unit leaders so they would not require injured or formerly injured personnel to participate in activities that are likely to result in re-injury. Of the 265 healthcare/health educator responders, 81% indicated that they would like products to help communicate information about risk factors and IP tactics to their patients/customers.

Perceptions of Leadership and Medical Roles

The experiences or beliefs those not in the health community (providers and/or educators) regarding their leadership's support or interest in IP are shown in Figure 3. Only a slight majority (37% to 44%, depending on the statement) described positive leadership emphasis/support. Approximately a third (25% to 35%) had neutral perceptions and just under a third (22% to 32%) had negative views regarding their leadership's emphasis on and support for IP. Responses for all 4 questions correlated strongly with one another ($P<.01$, correlation >0.74 to 0.83; a strongly agree for one question correlated with a strongly agree for other questions). In addition, approximately one-third of respondents provided an additional written response to the last question of the survey, which was an open-ended request for any additional thoughts.

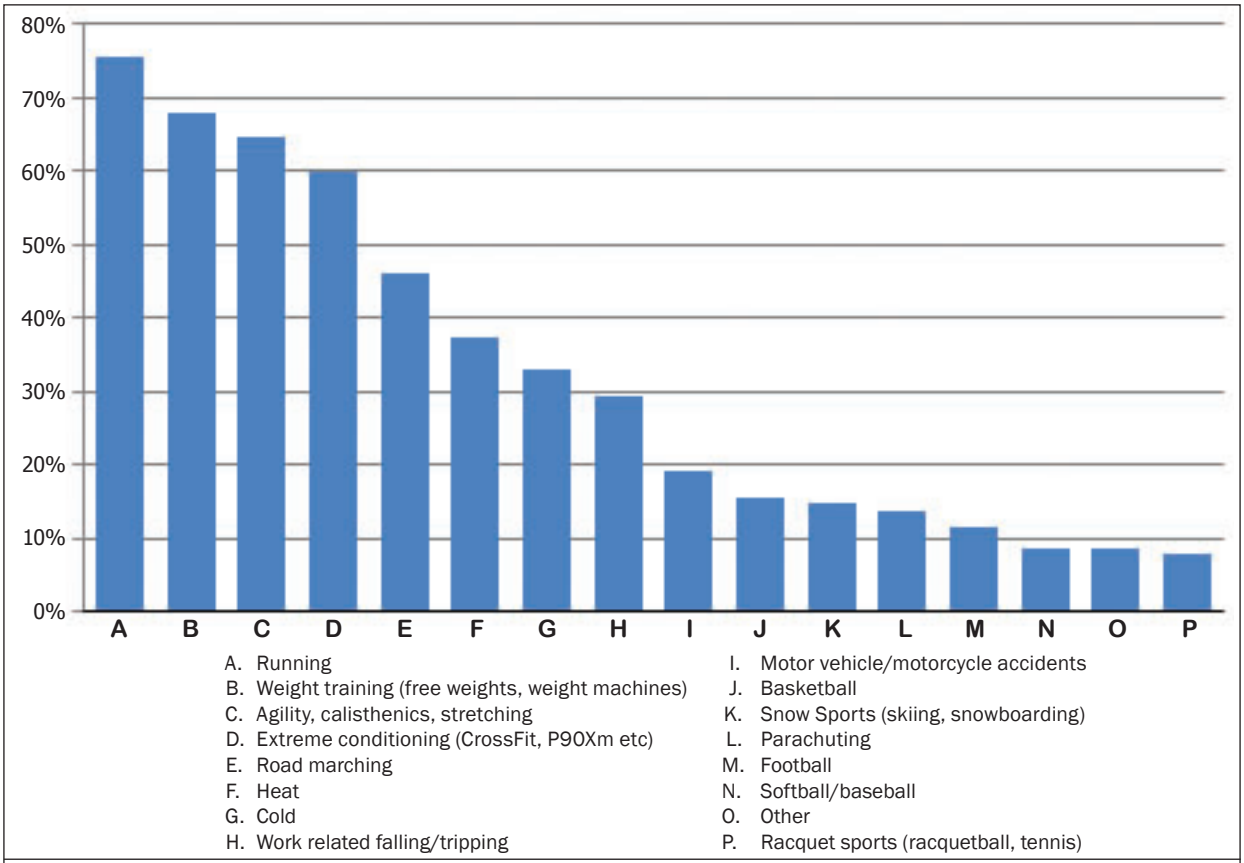

Figure 2. Percentage distribution of respondents' choices of activities for which they were most interested in receiving information related to injury prevention. Note: Since each respondent was allowed to select all activities that apply, the sum of percentages displayed exceeds 100%.

By far, the most frequently raised issue was concerns with leadership. Some examples of such responses are shown below. Despite awareness of the magnitude of the musculoskeletal injury problem, free-text responses suggested that many believe that such injuries are inherent to a Soldier's job, and are even a way to "screen out the weak." Specific concerns cited include the need for better unit leader IP training, specifically among Drill Sergeants and First Sergeants. Responders indicated that this was necessary to change what was described as a "suck it up" and "no pain is no gain" attitude and to improve awareness about the negative effect of training-related injuries on Army readiness. Inadequate time and guidance for reconditioning and recovery, especially after a profile, was also described as exacerbating the injury problem. Leaders were described as being unaware of the magnitude of the adverse impacts that unintentional injuries have on the Army, and not recognizing what they can do to reduce these injuries. Suggestions included leader IP training, mentorship, and certification.

Examples of comments written by respondents in the free-text area of the injury prevention survey.

"Changing the mentality of injury is a must within the military. Many of my patients report injuries weeks/months/years after the initial injury and the damage has been exacerbated from continued use.... Teaching people that it's okay to seek help because no one is Superman would do wonders for maintaining the fighting force as a whole."

"Most of patients that I see are musculoskeletal due to overuse (overtraining). One of the biggest things I see is the leadership not taking care of their 'Joes' and allowing them to modify their training according to their injury."

"Leaders need to be educated. They play a direct role in helping the junior Soldiers prevent and recover from injury. In many cases common sense is lacking...."

Table 2. Distribution by percentage of respondents' beliefs on musculoskeletal injury risks and interventions.

Factors/interventions that:	**%N** [685 total respondents] **%n** [268 healthcare/educators]			
Increase Risk Of Injury*	Decrease Risk	Neither more nor less	Increase Risk*	Not Sure
Increased running mileage	2% 2%	15% 10%	80% 86%	3% 2%
Dehydration	1% 1%	7% 8%	89% 90%	2% 2%
Prior injury	1% 1%	4% 2%	94% 97%	2% 0%
Cigarette smoking	1% 1%	16% 8%	75% 89%	9% 2%
High flexibility	71% 59%	16% 19%	10% 20%	3% 2%
Very thin body type	6% 5%	56% 53%	25% 33%	13% 9%
Does Not Decrease Or May Increase Risk*	Decrease Risk	Neither more nor less*	Increase Risk*	Not Sure
Back brace/lift belt (for job or weight training)	56% 44%	23% 33%	13% 18%	8% 4%
Over-the-counter anti-inflammatories before workouts	19% 16%	39% 48%	26% 26%	16% 10%
Stretching before exercise	58% 41%	27% 38%	12% 19%	3% 2%
Reduce Risk*	Decrease Risk*	Neither more nor less	Increase Risk	Not Sure
Ankle brace (for basketball, parachuting)	61% 59%	22% 27%	9% 9%	8% 5%
Cotton socks	22% 20%	57% 62%	8% 9%	13% 8%
Does Not Either Decrease Or Increase Risk*	Decrease Risk	Neither more nor less*	Increase Risk	Not Sure
Minimalist running shoes	5% 5%	22% 25%	58% 58%	15% 12%
Effect On Risk Not Evident/Is Variable*	Decrease Risk	Neither more nor less	Increase Risk	Not Sure*
Fatigue/lack of sleep	1% 1%	5% 3%	91% 95%	2% 1%
Older age (>40 years)	1% 1%	16% 15%	80% 83%	2% 1%
Male	6% 9%	63% 58%	20% 26%	11% 7%
Energy or dietary supplements	3% 2%	27% 28%	56% 61%	13% 9%
Older running shoes	1% 0%	6% 7%	91% 92%	2% 0%

*Current assessment of scientific evidence per Bullock et al[3]

Topic for improved education given more than 10% incorrect responses

Key concerns

Another major topic cited in free-text responses described a systemic lack of credibility in the Army Medical Profile system, particularly among unit leaders. Respondents indicated that although inconsistencies and misuse of the current Medical Profile system were due in part to individual Soldiers' motivations, some respondents suggested problems within the medical community itself. Specifically, inadequately or inconsistently supported diagnoses, inconsistencies in work and physical training restrictions, and the lack of specific rehabilitation guidance were cited as areas that could be improved.

COMMENT

The size of the response to the voluntary survey was larger than expected and thus was considered a positive

indication of interest in this topic. Though the respondents included civilians, the large portion of military personnel provides an indication of the knowledge and interests of the overall active duty Soldier population. This is supported in part by the similarities in the injury experience of the respondents to prior studies of specific Army Soldier populations. These prior studies have shown that, like the survey respondents, about one half of personnel are injured each year, and that leading causes of these injuries include running, nonrunning exercise, and sports.[2,17,18]

While most respondents demonstrated a fairly accurate awareness regarding the general magnitude of this Army injury problem, approximately one third either disagree or are neutral to acknowledgement of the documented evidence. This suggests a majority are aware of the problem. In addition, respondents indicated through free-text responses that there remains a common belief that these injuries are inherently "part of the job" and thus cannot be prevented. They indicate that part of this problem is many unit leaders may be unaware of the adverse impacts that training-related overuse injuries have on Army readiness or how they can help reduce these injuries.

The current level of awareness is further exacerbated by confusion about certain risk factors and effective techniques to prevent common musculoskeletal injuries among both nonmedical and medical respondents. Awareness of risk factors and interventions was greater for heat and cold injuries (not addressed in this article), perhaps due to existing policies requiring annual heat and cold injury prevention training and strict accountability for such injuries.[23,24] Though the overall magnitude of musculoskeletal injuries in the Army is much greater than that of heat and cold injuries, current policies do not require injury prevention training either annually or at any level of a Soldier's basic, advanced, specialized or leadership development. Scientifically-supported educational products are needed to increase the broader Army community's knowledge of injury causes, risk factors, and the effectiveness of interventions. These products must provide adequate details for medical personnel to educate patients, and be straightforward enough for their patients (Soldiers) to understand.

Key Activities of Interest

Injury prevention education and training needs can be framed in the context of specific activities that cause or contribute to common injuries. Key activities identified by respondents as top interests largely mirrored top causes of their own injuries (Figure 1) as well as top causes attributed to overall injuries to Army personnel[2]:

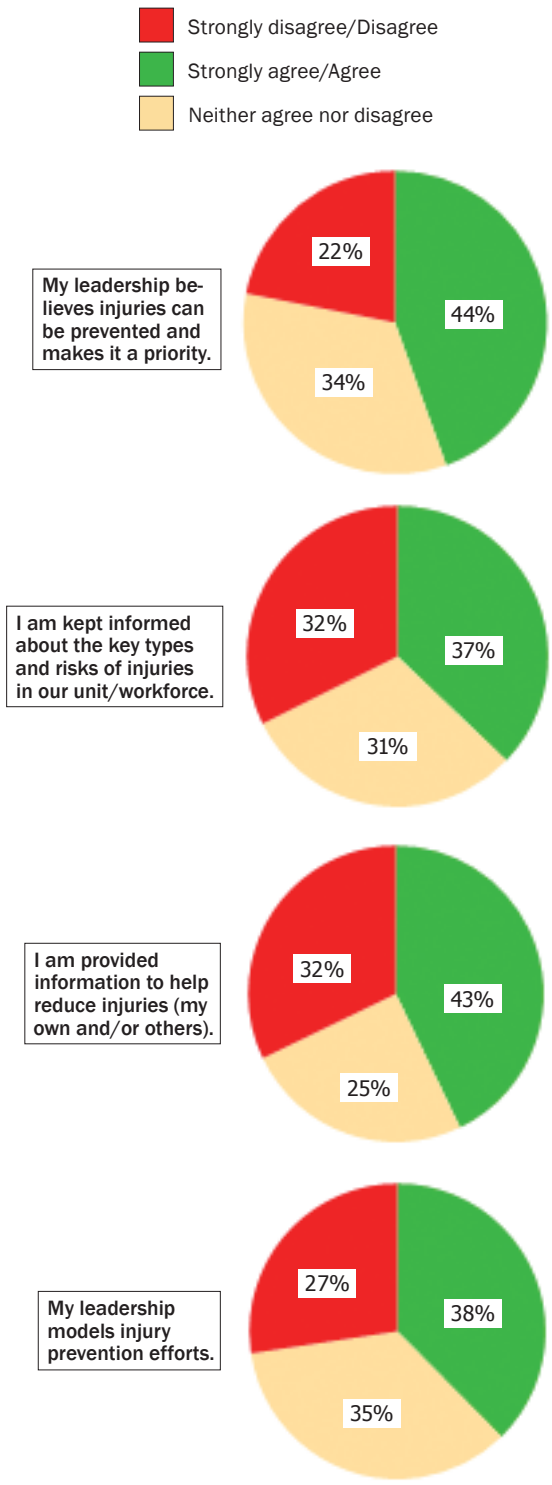

Figure 3. Percentage distribution of respondents' perceptions of leadership interest in injury prevention.

Running. Consistent with prior Army studies,[8,11,17,19] running was the most common cause of injury cited by survey respondents and was the IP topic of greatest interest. Though numerous respondents specifically desired more information about how to run correctly, evidence does not support a single "one-size fits all" running style or technique that will reduce injury. However, information on risk factors and guidance about proper conditioning and avoidance of over-training problems can be provided through educational materials.

Weight-training and Extreme Conditioning. Respondents also desired information regarding proper form and technique to minimize injury associated with weight training and extreme conditioning. While some education products can be developed to advise against certain techniques, specifically trained and certified personnel trainers are recommended to give proper individualized instruction for these activities, especially for persons who have had prior injury.

Agility, Cross-training, and Stretching. Many respondents recognized the importance of a mixed exercise program and desired additional information about cross training and warm-up techniques. For example, information is desired to explain different types of stretching techniques (ie, static versus dynamic) with guidance as to when and how to incorporate them into a training program.

Road Marches. About half of the respondents desired additional IP guidance for minimizing injuries resulting from road marches. The scientific research on this military training activity topic[25,26] may provide information for better educational products that describe key risk factors and injury types, with suggestions to minimize risks.

Risk factors and Interventions

Of the risk factors and interventions identified in this survey, the topics considered of greatest importance are those for which the majority of respondents exhibited lowest awareness as indicated by incorrect responses regarding the degree of risk associated with risk factors and interventions. While future study of effective interventions is still needed, increased awareness of current evidence is warranted for topics such as:

Body Type and Injury Risk. Many respondents (56%) were under the incorrect impression that a thin body type does not affect injury risk, and another 6% thought that it would even reduce risk. However, while poor fitness and high BMI have been shown by some to increase the risk of injury,[9] current evidence shows that low BMI will also increase risk to injuries especially stress fractures.[17-19] Products should be developed to help dispel myths that thinner means healthier.

Flexibility and Stretching. Though evidence has shown flexibility to be a bimodal risk factor (ie, those with low as well as those with high flexibility are at increased risk of injury),[9,18,19] 71% of respondents believed that having high flexibility decreases risk. In addition, while most respondents (58% total, 41% healthcare/educators) consider stretching prior to exercise to be a means of decreasing the risk of injury, the science is inadequate to support this.[3] Current data is rather mixed. The complexity of variables include different types of stretching (eg, static versus dynamic), different body types and flexibility levels, and different exercise regimens.[3,27-29] Given the unknowns, current expert guidance is to avoid static stretching prior to exercise and instead use dynamic and whole body warm-up techniques. Target audiences should be made aware of the variables and unknowns.

Footwear. Responses show confusion regarding risks resulting from use of cotton socks, minimalist shoes, and older running shoes. For example, the use of minimalist shoes (shoes with limited sole and "zero drop" heel to toe support) has been a popular trend in the past few years. While marketers have purported these shoes reduce injury risk, a majority of our survey respondents (58%) indicated they believe that minimalist shoes increase the risk of musculoskeletal injury. Evidence does not indicate they increase or decrease risk of injury compared to other shoe types.[30,31] Products that clarify existing evidence and dispel myths on these topics are needed.

Braces. Many respondents (56% total, 44% health care/educators) considered back braces/belts to be a means of decreasing injury risk. However, substantial evidence indicates that they do not reduce risk, and both military policy and national guidance advise against their use.[3] This is especially important since concerns suggest a potential for increased risk due to use. On the other hand, the use of ankle braces to prevent injuries in basketball and parachuting has been strongly supported by scientific evidence.[3,8,33-36] Products that clarify effectiveness of different types of personal equipment in risk reduction are needed.

Enhancing Unit Leadership Awareness

Essential elements of IP include leadership awareness, interest, and activity.[3] Consistent with prior evaluation,[13] the respondents in this survey pointed to leadership at the small unit level as frequently encouraging overtraining

(especially with running) and marginalizing those who are profiled or injured. Suggestions indicate that these leaders, who have direct oversight of physical training, would benefit from additional education, motivation, and/or policy requirements to prioritize IP objectives. As many unit leaders may not be reached without a direct mandate through their chain of command, respondent suggestions included requiring IP training or "IP certification" for leaders. A proponent agency with the authority to implement mandated training would help to effectively implement this recommendation.

Medical Profile Improvements

Based on responses from this survey and consistent with a prior study,[13] the lack of consistent documentation of diagnoses and rehabilitation procedures in Army Medical Profiles are still a problem. This may be part of the reason that unit leaders ignore or marginalize those on a profile and may not allow adequate recovery. This lack of consistency may also encourage misuse of the Army Medical Profile system. While policies and guidance cannot address all Soldiers' motivational differences, guidelines for documentation of profile determinations and inclusion of detailed rehabilitation and reconditioning procedures could improve the validity and credibility of medical profiles. This, in turn, could reduce the number of re-injuries and incidence of chronic injuries in what is a relatively young population.

Limitations

As it is not possible to determine the number of persons who were aware of the survey, response rates could not be estimated. A comparison of demographic data from this survey to that of the overall Army active duty population (eg, 86.4% male, 13.6% female; source: Armed Forces Health Surveillance data, 2013) shows the limited sample of respondents is not a cross-sectional representation of the Army. In addition, almost half of the respondents were from areas of concentration or military occupational specialties related to medicine, which is a much more substantial representation than that of the overall Army. However, the medical respondents referred to problems and interests on behalf of their patients, which at least indirectly represent the broader Army population. In addition, injury experiences of overall respondents reflected trends similar to that of the broader Army.[2,15-17] In addition, medical professionals are more likely to influence the IP knowledge.

Conclusion

Considering the long-standing magnitude of a problem that has been documented for decades, awareness among Soldiers regarding physical training injuries and prevention could be improved. The findings of this survey indicate that many personnel desire additional information. Scientifically supported consumer-oriented educational materials can empower individuals to help reduce common musculoskeletal injuries in the Army. Products should address both knowledge gaps as well as topics of particular interest to the audience. To achieve a population-level reduction in injuries, improvements in leadership awareness and possibly even policy-level accountability are needed. Because lack of awareness among unit leaders may inhibit Army human performance optimization, they should be a key audience for future IP educational efforts. The Army medical community can also become better partners with its operational and Soldier training counterparts. This includes finding ways to improve the medical profile system to mitigate the occurrence of re-injuries and ensure the most effective rehabilitation, as well as assisting with future IP awareness and education.

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Rhabdomyolysis in a Sickle Cell Trait Positive Active Duty Male Soldier

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Abstract

Exertional rhabdomyolysis is a complication of sickle cell trait (SCT) likely first reported in the military population over 40 years ago. Although commonly a benign condition, numerous studies and case reports have identified SCT positive patients to be at increased risk for rhabdomyolysis, compartment syndrome and sudden cardiac death. We report a recent case of an SCT positive African American active duty male Soldier who suffered exertional rhabdomyolysis following an Army Physical Fitness Test. His course was complicated by acute renal failure requiring hemodialysis, and he eventually recovered renal function. The diagnosis was significantly delayed despite a typical clinical presentation and available SCT screening results. The case highlights the importance of the recognition of SCT as a risk factor for severe rhabdomyolysis, and suggests more must be done for an effective SCT screening program for the active duty military population.

In 1970, physicians at William Beaumont Army Medical Center in El Paso, Texas, noted a series of 4 cases of sudden death in Army cadets associated with sickle cell trait (SCT).[1] Seven years later, Koppes et al[2] noted another 4 recruits, all with known sickle cell trait, were hospitalized for exertional rhabdomyolysis (ER) leading to myoglobinuric renal failure. These reports prompted further evaluation, leading to a military study which noted that among a total of 2 million recruits at army basic combat training, there was a higher incidence (40 times) of unexplained sudden death in black recruits compared to the general military population. In addition to these findings, exercise-related death in black recruits with SCT was 30 times more common than black recruits without SCT.[3] Even after prior identification of this risk factor, patients in the military and athletic settings with SCT continue to suffer injury and even death due to this underlying condition.[4-8]

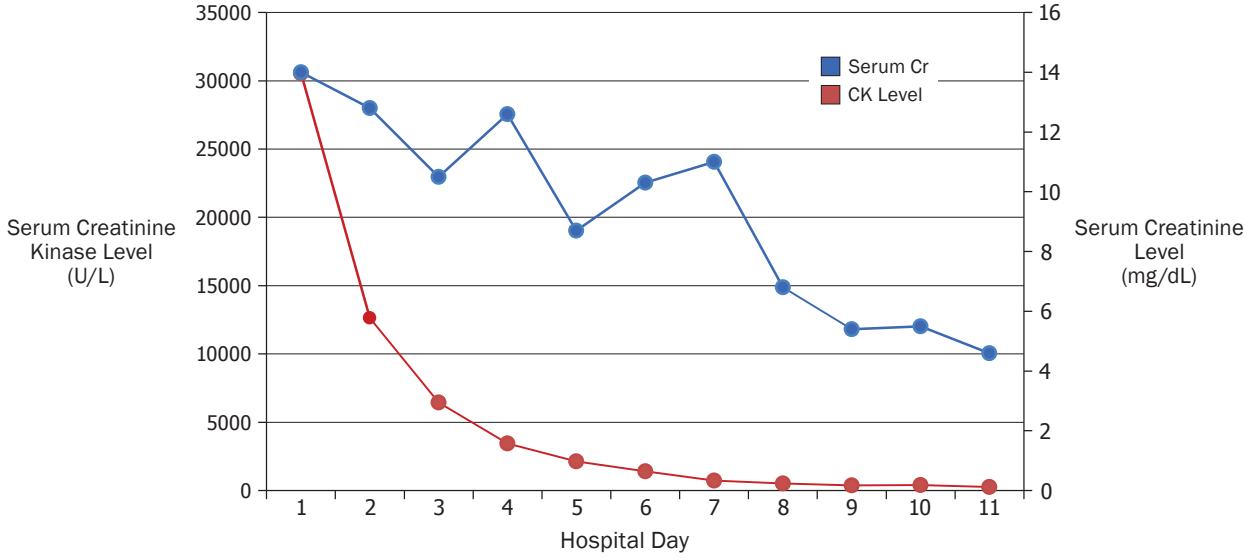
We report the case of a young, active duty SCT positive African American male presenting with exertional rhabdomyolysis complicated by myoglobinuric renal failure requiring hemodialysis. The diagnosis was significantly delayed despite a typical clinical presentation and available SCT screening results. This case highlights the importance of the recognition of SCT as a risk factor for severe rhabdomyolysis, and suggests the need for a more robust and effective SCT screening program.

Case Report

In May 2015, a 26-year-old active duty African American male Army Soldier stationed in El Paso, Texas, experienced sudden severe leg and back pain while performing the Army Physical Fitness Test. Symptoms onset occurred after completing the pushup and sit-up portions. Cramping occurred while undergoing the 2-mile run and quickly progressed to such intensity that he was unable to ambulate, requiring a wheelchair for transport. He subsequently presented to an acute care clinic the following day and received Ketorolac 60 mg intramuscularly for intense back spasms prior to being released to home.

Four days later, he presented to the emergency room for progressive cramping, nausea, and oral intolerance. Despite clinical evidence of rhabdomyolsis with classical urine dipstick finding (+3 blood with 5 red blood cells), he was given a prescription of sulfamethoxazole/trimethoprim for suspected urinary tract infection and discharged from the emergency room.

The following day, he represented to the emergency room with worsening muscle pain, oral intolerance, and the new complaint of inability to urinate or defecate. On initial physical exam, the patient was found to have significant tension in his quadriceps bilaterally, as well as the lower back. No signs of altered mental status, asterixis, or paresthesia were noted on physical exam, and peripheral pulses were intact throughout. He denied any recent viral illness or prodrome. Initial laboratory evaluation in the emergency room was significant for serum CK of 37,069 U/L, serum urea nitrogen (SUN) 113 mg/dL, serum Cr 13.6 mg/dL, AST of 704 U/L, ALT 424 U/L, and serum potassium of 4.4 mg/dL (most recently 4.2 mg/dL 2 years prior). Urinalysis again demonstrated classic findings of rhabdomyolysis. An abdominal and



Patient's serum creatinine kinase and serum creatinine trend during hospitalization.

pelvic CT-scan was performed showing mild right perinephric stranding with no hydronephrosis or hydroureter. The patient was subsequently admitted to the internal medicine service with a presumptive diagnosis of rhabdomyolysis-induced acute kidney injury. It was not until this time that the patient's SCT positivity was documented while being evaluated for his acute complaints, despite positive screening history and family history of exertional rhabdomyolysis.

Upon arrival at the general medicine floor, the patient initially received aggressive intravenous hydration, but remained anuric in the first 24 hours with a continued uptrend in his serum urea nitrogen and creatinine levels. Hemodialysis was initiated on hospital day 2 for symptomatic uremia manifested by asterixis and nausea. The patient underwent 5 sessions of hemodialysis with improvement of his clinical function, as well as laboratory findings. His clinical course is presented in the Figure. At time of discharge, urine output was approximately 3 liters of urine daily, and his labs had shown a significant improvement in SUN (42 mg/dL), serum creatinine (4.6 mg/dL) and CK of (250 U/L). During admission, serum electrophoresis was ordered and would later be reported as 39.4% HgbS, 57.3% HgbA, and 3.3% HgbA2.

The patient was seen in follow-up a month after his initial insult and continued to show significant improvement with a SUN creatinine to 18 mg/dL and 1.6 mg/dL respectively. He is currently in the medical evaluation board process for discharge in accordance with the provisions of *Army Regulation 40-501*[9] regarding exertional rhabdomyolysis in the setting of known sickle cell trait requiring dialysis.

Comment

Sickle cell trait is an inherited, incompletely dominant hematologic disorder that causes red blood cell sickling during low oxygen states. It is present in 80,000 to 100,000 Americans, with a presence in African Americans at a rate of 8% to 10%.[10] The majority of individuals who are SCT positive experience no deleterious effect to their life span and often do not encounter medical complications during exertion. Many cases have been reported of sickle cell trait in athletes and military recruits for whom physical exertion results in severe medical morbidities such as rhabdomyolysis.[4,5,8] The incidence of SCT associated ER is unknown, the incidence of ER in military trainees is 22.2 cases per 100,000 trainees.[11]

The precise mechanism of ER in SCT carriers is unclear. It has been speculated that the combination of severe hypoxemia, lactic acidosis, hyperthermia, and red cell dehydration that occur in muscles being exercised precipitates an environment in which red blood cells will sickle. Martin et al[12] produced evidence of this by showing that exercise and physical exertion resulted in increased sickling in venous blood when testing military recruits performing arm exercises.

Another hypothesis is that increased sickling leads to vasooclusive crisis in the muscle that leads to muscle cell breakdown and injury. Injured muscle cells release cellular contents, including myoglobin into the blood stream. Myoglobin subsequently causes renal injury via renal vasoconstriction, formation of intratubular casts, and direct toxicity to the tubular cells of the kidney.[13]

In a recent study on the genetic polymorphisms associated with ER, Deuster et al[14] corroborated the link between SCT and ER. However, they also noted that a causal pathogenic link remains unclear. The study indicates that, in contrast to an exertional sickling hypothesis, SCT may instead be a surrogate for some other genetically linked risk, or, alternatively, part of a 2-hit phenomenon. The uncertainty of the precise role SCT has in ER is the foundation of an ongoing debate concerning the premise of sickle cell screening.

The American Society of Hematology (ASH) guidelines oppose universal screening for SCT, stating that it does not properly address the issues at hand and places a stigmatization on SCT-positive individuals.[15,16] The association instead supports administering universal precautions to reduce exercise induced injury and heat-related injury such as those implemented by the US Army. The ASH policy of universal precautions and the omission of a requirement for SCT testing has also been supported by clinicians and some professional medical organizations.[16] Also of note, the ASH recommends increased research into the relationship of SCT with exertion-induced illness such as rhabdomyolysis before further policies are established.[16]

The opposing view supporting testing for SCT notes that universal precautions are ineffective and further intervention and screening is needed to properly identify this patient population. In 1996, the Department of Defense dropped its regulation requiring all military divisions to screen for SCT, leaving the decision to each military branch. The Army is the only branch that does not specifically test for SCT, but rather employs universal precautions with its recruits in an effort to reduce morbidity and mortality. In the past 5 years, numerous studies have noted significant medical complications in military recruits with SCT who suffered medical complications while undergoing strenuous exercise ranging from rhabdomyolysis, compartment syndrome, and even sudden cardiac death. In the civilian sector; following the death of a college football player in 2010, the National Collegiate Athletic Association adopted a policy* of mandatory testing for sickle cell trait in all athletes who seek to participate in Division I athletics[15,17]—a population similar to the active duty military population. Further, a recent (2012) study of approximately 2 million athlete years showed that the risk of exertional death of Division I football players with SCT was 37 times higher than those athletes without SCT.[18] These studies all describe medical conditions for which timely diagnosis and treatment are imperative in improving medical outcomes.

Our case report illustrates that despite universal precautions for Army Soldiers, severe negative outcomes with exertion can occur in SCT-positive individuals. In fact, guidelines written by the Uniformed Services University Consortium for Health and Military Performance calls for referral of active duty military personnel with a concomitant diagnosis of ER and SCT to the medical evaluation board for review of their military status.[19]

Sickle cell trait status is an invaluable clinical determinant, which, when identified early, can prevent significant morbidity associated with ER. Improvement in SCT screening programs with emphasis on rapid identification of SCT status will dramatically decrease incidence of adverse outcomes and ultimately improve patient care. This could be aided with a policy by which SCT status is made more apparent on patient medical records and hospital electronic medical records, such as alerts in past medical history or allergies. Sickle cell trait positive patients should not be given nonsteriodal anti-inflamatory drugs for exertional muscle pain or cramping until after a workup for ER, including renal function assessment. Also, SCT screening tests should be easily accessible. Finally, all clinicians, including physician extenders, must be aware of the association of SCT and ER. Prompt recognition and proper treatment of exertional rhabdomyolysis is essential to avoid significant complications.

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Hydration Status in US Military Officer Students

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Abstract

Relocation from a cool to a hot climate is a frequent occurrence in military service. Acclimatization requires time and exposure to heat. Nonacclimatized individuals frequently consume inadequate fluid leading to hypohydration, which can quickly result in dehydration with increased risk of heat illness/injury. This descriptive cross-sectional study assessed the hydration status of 196 officers attending the US Army Medical Department's Officer Basic Course (67%) or Captain's Career Course (33%) in San Antonio, Texas, prior to taking the Army Physical Fitness Test (APFT). Consenting Soldiers provided a first morning void urine sample and demographic survey (age, rank, sex, previous geographic location, etc) prior to the APFT. Height, weight, and APFT event scores were collected from a subject-coded, APFT scorecard without personal information data. Binary logistic regression was performed to identify variables that contribute to predicting hypohydration status. The sample population was 54% male, a mean age of 30 years, 5.2 years of military service, and a mean body mass index of 25 kg/m^2. Nearly one-third met the criteria for hypohydration (≥1.02 urine specific gravity). Soldiers who relocated from a cool environment within 9 days of taking the APFT had 2.1 higher odds of being hypohydrated compared with individuals who had resided in a hot environment for more than 9 days. Women had a 0.5 lower odds of being hypohydrated as compared to males. Significantly more Soldiers were hypohydrated on Monday compared to those tested on Tuesday (33% vs 16%, P=.004). Given these findings, the authors provided 5 recommendations to reduce the number of Soldiers exercising in a hypohydrated state.

Relocation from northern to southern climates is a routine occurrence for US military service members. It is also common for newly relocated individuals to participate in physical and/or field training almost immediately after reporting to a new unit. Acclimatization to a hot and humid environment typically requires 7 to 14 days of exposure to the new climate.[1] During this period of time, unacclimatized individuals exercising in a hot environment frequently fail to consume adequate fluids.[2] Individuals who commence exercise in a hypohydrated state can quickly become dehydrated once activity begins.

Dehydration is a contributing factor in the onset of heat-related illness. Dehydration reduces skin blood flow and sweating responses during exercise, increasing core temperature and cardiovascular strain; any hindrance to thermoregulatory mechanisms increases the potential risk for heat injuries.[3] Dehydration levels as small as a 2% loss in body mass can negatively affect physical performance, increasing perceived exertion levels and impairing mental functioning.[4,5]

Although each of the armed services have heat injury mitigation programs, heat illness and injury continue to affect US military service members and pose a significant threat to mission readiness.[6] There were 2,025 documented incidences of heat stroke and/or heat injury in active service members in 2013.[7] Service members in healthcare related fields were not immune to heat stroke and illness, with 128 documented cases reported in 2013.[7]

The US Army Medical Department's basic (Basic Officer Leaders Course (BOLC)) and advanced (Captains' Career Course (CCC)) officer training is conducted at Joint Base San Antonio (JBSA) Fort Sam Houston, Texas, where the average summer month temperature range is 86°F to 90°F.[8] Officers attending these courses typically take an Army Physical Fitness Test (APFT) within one week of arrival. Soldiers relocating from cooler climates are known to be at greater risk for developing heat illnesses,[9] thus hypohydration may also be an exacerbating concern for those in that category.

The purpose of this study was to determine if Soldiers relocating from northern climates were at greater risk for being hypohydrated prior to the APFT. This paper presents study results along with recommendations to reduce Soldiers' risk for heat injury and illness when relocating to a hot training environment.

Methods

The study was a cross-sectional descriptive design. Recruitment briefings were given to all BOLC and CCC students in July 2012. Inclusion criteria for participation: active duty military officers, aged 18 years and older, attending BOLC or CCC at JBSA in July 2012.

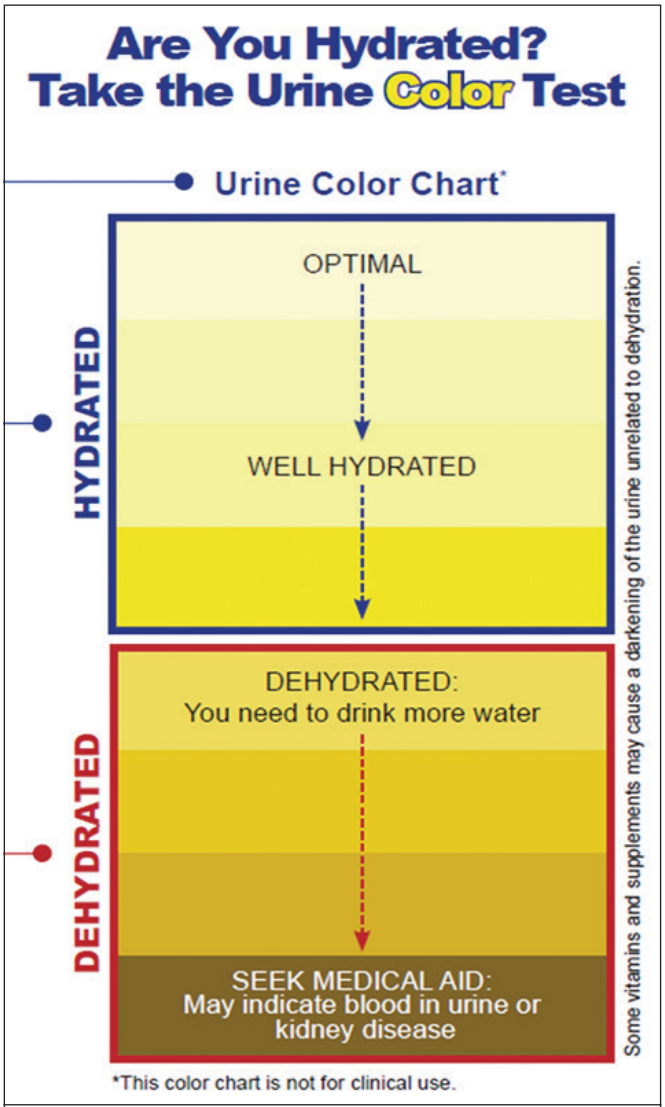

Figure 1. US Army Public Health Command Urine Color Hydration Chart.

Pregnant women and those not completing all 3 APFT events (2 minutes of pushups, 2 minutes of sit ups, and a 2-mile run) were excluded from the study. Volunteers were provided with a survey, urine specimen cup, hydration status card (Figure 1), identification sticker for their APFT card, an informed consent information paper, and data collection instructions. Flyers were placed at student lodging locations the night prior to data collection reminding the participants to bring their surveys and urine samples. On the morning of testing, participants provided their first morning void urine sample and provided a completed survey to the research team prior to undergoing physical testing. The urine sample was assessed using a handheld refractometer (Atago USA Inc, Bellevue, WA) to ascertain hydrations status, the primary outcome variable, via urine specific gravity (USG) levels. The urine sample was then discarded. Urine specific gravity of first morning void is a field expedient yet valid method to determine hydration status.[10] Specific gravity values were categorized as euhydration (USG<1.02) or hypohydration (USG≥1.02).[11-14]

The survey collected secondary outcome variables including the following demographics: age, rank, sex, previous geographic location (categorized as northern or southern region), commissioning source, time in military service, and current length of stay at JBSA. Height and weight, used to calculate body mass index (BMI), and APFT event scores were collected from a subject-coded, APFT scorecard (DA Form 705) without personal identification information. The study followed a protocol approved by the Army Medical Department Center and School and reviewed by the Brooke Army Medical Center Institutional Review Board.

Statistical Analysis

Data were analyzed using SPSS version 21.0 (SPSS Inc., Chicago, Illinois). Descriptive statistics were completed for demographic data and reported as frequencies for categorical data and mean plus/minus standard deviation for continuous data. The data were categorized and analyzed by military course (BOLC vs CCC), sex (male vs female), and hydration status (hypohydrated vs hydrated). Independent t test evaluated differences between groups for descriptive demographic and APFT results. Binary logistic regression was performed to identify if significant independent variables contributed to predicting hypohydration status. Nonparametric correlational analysis was performed using Spearman's ρ or Kendall's τ to assess associations with hydration status, APFT day of the week, sex, prior climate, and other demographic characteristics. Power was set at 80%, α=.05.

Results

Subject Descriptive Data

Of the 552 Soldiers attending training (BOLC, n=360; CCC, n=192) in July 2012, 297 (58% of BOLC; 45% of CCC) students volunteered to participate; however, 196 participants (132 BOLC; 64 CCC) completed data collection (34% attrition). Table 1 presents the demographic descriptive results by course, sex, and hydration status. Approximately half of BOLC (53%) and CCC students (56%) were male. As expected, CCC students were older (mean: 34 vs 28 years; P<.001), had more years in military service (mean: 8.8 vs 3.5 years; P<.001), and were higher ranking than BOLC students (CPT vs 2LT; P<.001). Significantly more BOLC students had resided for a minimum of 9 days in the San Antonio area prior to the APFT compared to CCC students (89% vs 16%;

Table 1. BOLC and CCC Student Demographic Descriptive Results.

	BOLC (N=132)	CCC (N=64)	Male (N=106)	Female (N=90)	Hydrated (N=135)	Hypo-hydrated (N=61)
	Mean±SD					
Age (yr)	28.3±5.0*	34.3±6.2	31.0±6.4	29.4±5.6	30.0±6.2	30.8±5.7
BMI (kg/m^2)	24.8±3.0	25.6±3.2	26.1±3.1*	24.0±2.8	24.9±3.1	25.5±3.2
Time in service (yr)	3.5±4.8*	8.8±5.6	5.7±6.0	4.7±5.1	5.2±5.5	5.3±6.0
	n (%N)					
Male*	70 (53%)	36 (56%)			66 (49%)	40 (66%)
Female*	62 (47%)	28 (44%)			69 (51%)	21 (34%)
Rank						
2LT	73 (55%)*	0 (0%)	35 (33%)	38 (42%)	53 (39%)	20 (33%)
1LT	8 (6%)	1 (2%)	5 (5%)	4 (5%)	6 (4%)	3 (5%)
CPT	49 (37%)*	58 (90%)	60 (56%)	47 (52%)	71 (53%)	36 (59%)
MAJ	2 (2%)	4 (6%)	5 (5%)	1 (1%)	4 (3%)	2 (3%)
LTC	0 (0)	1 (2%)	1 (1%)	0 (0)	1 (1%)	0 (0)
Commission Source						
ROTC/academy	51 (39%)	28 (44%)	47 (44%)	32 (35%)	58 (43%)	21 (34%)
Direct (from civilian)	44 (33%)	15 (23%)	32 (30%)	27 (30%)	37 (27%)	22 (36%)
Prior enlisted	37 (28%)	21 (33%)	27 (26%)	31 (34%)	40 (30%)	18 (30%)
Cool climate origin	65 (50%)	25 (41%)	51 (49%)	39 (44%)	61 (47%)	29 (48%)
In Texas 9 days or more	117 (89%)*	10 (16%)	66 (62%)	61 (68%)	95 (70%)	32 (53%)

*P<.05

P<.001), but a higher percentage of BOLC students relocated from a cool geographical location (50%) than CCC students (41%). There was no difference in commissioning source between groups.

Body mass index significantly differed between male (mean, 26.1±3.1 kg/m^2) and female (mean, 24.0±2.8 kg/m^2) participants (P<.001). Additionally, older participants were associated with a higher BMI (r=0.283; P<.001), lower APFT score (r=-0.236, P<.02), and exceeding weight (r=0.231; P=.002) and body fat (r=0.248; P=.001) standards according to the Army Body Composition program.

Minimum temperatures in San Antonio on the testing days (July 9, July 16, July 17, 2012) ranged from 74°F to 77°F.[15] Rain persisted throughout the APFT on the CCC test day, with a precipitation accumulation of 0.26 inch for the day.

Hydration Status

Thirty-one percent of Soldiers met the criteria for hypohydration prior to the APFT, with significantly more participants hypohydrated on Monday (33%) compared to those testing on Tuesday (16%) (P=.004). More students residing in Texas for 9 days or less were hypohydrated at the time of the APFT than those who resided longer in Texas (42% vs 25%; P=.015). More men were hypohydrated than women (62% vs 38%; P=.03). More CCC participants relocating from a cool climate were hypohydrated compared to those from a hot climate (56% vs 22%; P=.007); while no such observance was found in BOLC participants (23% cool vs 36% hot climate; P=.096).

A logistic regression analysis was conducted to predict hydration status as either hydrated (USG<1.02) or hypohydration (USG≥1.02) using statistically significant demographic variables as predictors. Table 2 details the 2 independent variables meeting the Wald criterion as predictors of hydration status: days in Texas (P=.021) and sex (P=.040). Despite the significant model, Nagelkerke's R^2 of 0.071 indicated a small relationship between prediction and hydration grouping. The Exp(B) odds ratio value indicates that women had a 0.5 lower odds of being hypohydrated, and Soldiers who had less than 9 days to acclimate to the Texas environment had a 2.1 higher odds of being hypohydrated.

APFT Performance

The relationship between hydration status and APFT performance was not significant (P=.063). There was also no difference in APFT run, sit-up, or push-up scores between BOLC and CCC participants; higher BMI was associated with lower APFT scores (r=-0.299,

Table 2. Logistic Regression of Variables Predicting Significant Hypohydration.

Independent Variable	B (SE)	Wald	Sig	Exp(B) Odds Ratio	95% CI for Exp(B)	
					Lower	Upper
Days in Texas (1)	0.745 (0.322)	5.349	0.021	2.106	1.120	3.958
Sex (1)	-0.665 (0.324)	4.210	0.04	0.514	0.272	0.971
Model χ^2=10.118						
Pseudo R^2=0.071 (Nagelkerke)						
Goodness-of-Fit χ^2=0.998, df=2, P=.607 (Hosmer-Lemeshow test)						

Notes:
The dependent variable is hydration status, coded:
0=Well hydrated or mild hypohydrated (USG<1.02)
1=Significant or severe hypohydration (USG≥1.02)
The independent variables used in the model:
Sex, coded 1=female; 2=Male
Days in Texas, coded 0=<9 days; 1=≥9 days

P<.001). More participants who failed the Army Body Composition Program body fat test also failed the APFT (*P*=.027) with more failing the APFT on Monday compared to Tuesday (*P*=.014).

Comment

This study examined hydration status of Army officers newly relocated for basic and advanced officer training. Students were classified by course type, sex, and hydration status. Students who had less than 9 days to acclimate to the Texas environment had a 2.1 higher odds of being hypohydrated. Only the CCC group exhibited a relationship between previous location and hydration status. This association may be attributed to the shorter period of time (less than 9 days) in San Antonio for the majority of CCC students (84%) compared to only 11% of BOLC students. Acclimatization occurs within 7 to 9 days when individuals are physically active in the hot environment (active acclimatization), while passive acclimatization (no physical activity conducted) requires additional time.[1] The USG data from CCC students relocating from a cool environment suggest that they did not have adequate time to acclimatize.

First morning void USG is an accepted method to evaluate hydration status, however, there is a fair amount of individual variance in USG levels that equate to a 2% dehydration level. There is some evidence that a large amount of muscle mass is associated with higher USG readings regardless of hydration status due to an increase in urine protein metabolites.[11] However, the exact amount of muscle mass needed to cause increased urine protein metabolites is unknown at this time. In this study, women had a 0.5 lower odds of being hypohydrated; a higher percentage of men (62%) were hypohydrated compared to women (38%) (*P*=.03). It is unclear if this observed effect on urine specific gravity is truly related to gender differences or some other factor.

We are not able to explain why this study found a difference in the prevalence of hypohydration between Monday and Tuesday. There are a myriad of factors that could impact hydration status including weekend activities that increase fluid losses or weekday activities that increase consumption of nondiuretic fluids. Activities that increase fluid loss could include participation in outdoor activities leading to high sweat losses, or consumption of alcoholic beverages. Copious amounts of nondiuretic fluids consumed to aid in staying alert during classes and briefings the previous day could also contribute to the lower prevalence of hypohydration seen on Tuesday morning. Additional investigations are required to determine why differences are seen in the prevalence of hypohydration on Monday mornings and to determine if there is a specific day of the week when the percentage of hypohydrated Soldiers is lowest.

As expected, hydration status was not found to have an effect on APFT performance due to the short duration, moderate temperatures, and precipitation during the testing. A common military practice on the day of the APFT is to obtain Soldier height and weight measurements, either immediately before or after the APFT, in conjunction with the Army Body Composition Program.[16] Unlike many units, Soldiers in this study completed body composition assessment several days prior to their APFT, most likely eliminating intentional dehydration as a method to comply with weight standards. Future topics to investigate include prevalence of intentional dehydration and severity of dehydration levels in this population.

Several study limitations exist, including descriptive study design, a high attrition rate, no assessment of body weight and/or body composition change pre- to posttest, or a method to collect data to understand the dissonance between sexes and APFT days of the week. The high attrition rate was possibly attributed to a week's delay between the briefing and data collection. Although flyers were posted at student lodging locations the night prior to data collection, many participants may have forgotten or simply changed their minds.

Despite the study limitations, our research provided an opportunity to highlight several recommendations for units to consider regarding the physical requirements placed on Soldiers newly assigned to hot environments and reduce the number of Soldiers exercising in a hypohydrated state. Leadership should consider 5 simple recommendations for inclusion in their heat-injury mitigation program:

1. Inform Soldiers prior to reporting to their new duty station that conducting high intensity interval training in the cooler northern climate may help them prepare to exercise in a hot environment.[1,17]
2. Wait 10 days to conduct an APFT or to require Soldiers to participate in long-duration or multiple bouts of physical activity in a hot environment.
3. Implement an active acclimatization plan. This plan should include 2 hours of heat exposure (at one-bout or as 2 one-hour exposures) per day.[17] Along with heat exposure, include endurance exercise beginning at 50% VO_{2max} intensity (such as marching), and gradually increase intensity and duration.[1,17]

4. Encourage Soldiers to monitor the color of their first morning void and increase daily fluid intake if urine appears darker than a golden honey color. As the first void is an indicator of their prior 24-hour hydration status, this can inform Soldiers if their daily intake of fluid is adequate. Training aids such as pocket urine color assessment cards (Figure 1) or posters are available free of charge from the Public Health Command (https://usaphcapps.amedd.army.mil). Using photographs of actual urine samples comparing euhydrated and hypohydrated alongside of a urine hydration color charts may further assist visualization (Figure 2).[18]
5. Conduct APFTs on Tuesday morning rather than Monday mornings, immediately following a holiday, day of unscheduled activities, or temporary duty.

Conclusion

Hypohydration was identified in AMEDD officers attending BOLC or CCC courses within 9 days of relocating from a northern climate. Waiting ten days to administer the APFT after Soldiers report to JBSA will give those relocating from a cooler climates time to acclimatize and may reduce the number of Soldiers starting the event in a hypohydrated state. Additionally conducting APFTs on Monday mornings may result in more Soldiers testing in a hypohydrated state. Unit leaders can use these finding and recommendations to refine their heat mitigate programs.

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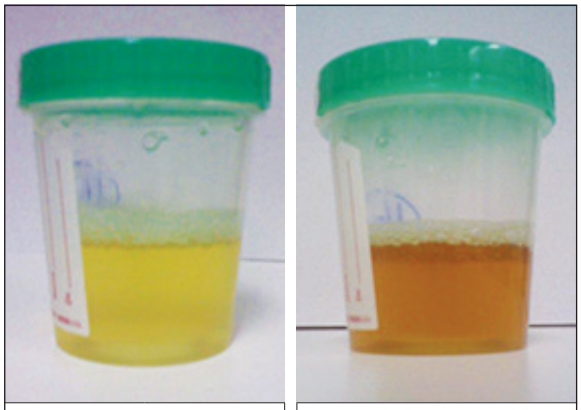

Euhydration		Hypohydration	
USG	1.016	USG	1.035
Osmolality	522	Osmolality	1252
Color	4	Color	7

Figure 2. Samples comparing USG and color of urine from subjects in euhydrated and hypohydrated hydration status respectively.

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Muscle-related Disability Following Combat Injury Increases With Time

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Abstract

Background: Combat injuries are most often to the extremities, resulting in a majority of long term disabilities being of orthopaedic nature. Some injuries are expected to improve with time. The Army Physical Evaluation Board (PEB) gives consideration for conditions that may improve with further care by placing eligible patients on a temporary retirement list. While this may be appropriate for some conditions, injuries such as those to skeletal muscle can be irrecoverable. We aimed to examine combat injured subjects with known muscle injuries who were placed in temporary retirement status to determine if their muscle conditions improved. We hypothesized that muscle-related disability would not improve despite additional time for recovery.

Methods: The PEB results of 33 combat wounded service members were reviewed to determine what individuals were placed in temporary retirement status. We compared what muscle conditions were present at each PEB examination including the initial review, internal temporary retirement reexaminations, and the final adjudication. We also compared if the disability rating assigned to the muscle condition changed with time.

Findings: Eighteen of the 33 subjects were placed in temporary retirement status prior to their final retirement. None of the subjects experienced improvement in their muscle condition as measured by disability ratings. Seven subjects worsened while 9 subjects had muscle conditions recognized at their final disposition that were not recognized at initial exam. Two subjects have muscle disability ratings that were unchanged.

Conclusions: While temporary retirement status provided opportunities for injured service members to experience additional improvement prior to permanent retirement, not all conditions can be expected to improve. This study demonstrates that the Army PEB ratings for muscle conditions did not improve despite additional recovery time being granted to the subjects on temporary retirement status.

Combat extremity injuries frequently result in lasting disability. Recent publications from our Institution have helped delineate the nature of war wound sequalea, highlighting the prevalence of specific types of orthopaedic-related disability.[1,2] Among those is the irrecoverable loss of skeletal muscle, or volumetric muscle loss (VML), which clinically can result in loss of motor power, fatigability, and cosmetic aberrations.[3] Animal models of VML indicate that strength loss after small VMLs (10%-20% loss of total muscle volume) is disproportionately high (30%-90% deficit).[4,5] Furthermore, loss of overlying muscle can adversely affect fracture healing because of multifactorial contributions skeletal muscle supplies to the fracture biology.[6-9] That VML is clinical significant entity is further supported by our recent findings that muscle-related disability is present in 24% of wounded service members with Type III open tibia fractures who are medically retired from the military.[10]

Currently, the loss of skeletal muscle is not a clinical target due to the lack of available therapies to address the volumetric defect and due to the clinical emphasis on bone healing rather than the overlying muscle injury. However, VML may present ramifications for the remaining skeletal muscle and limit the ability for the muscle group to optimally rehabilitate. This supposition is supported by limited clinical observations of patients with VML that present chronic functional deficits, which are unresponsive to traditional physical therapy.[3,11,12] A preclinical rodent study demonstrated that VML-injured muscle strength can increase in response to physical therapy (ie, wheel running). But no evidence of muscle fiber hypertrophy or hyperplasia was observed, raising questions regarding the maintenance of plasticity of the traumatized musculature.[13] Lastly, of significant concern is a protracted repair and remodeling response after VML injury that may eventually exhaust the regenerative potential of the remaining portion of the injured musculature and lead to a progressive further loss of function. Preclinical animal studies have documented some evidence of this potential condition, such as the prolonged presence of centrally located nuclei within the remaining muscle fibers, increased intramuscular fibrosis, and prolonged TGF-ß1* expression.[3,4,14] All told, growing evidence suggests that VML injury may present a progressive degenerative condition.

* Transforming growth factor beta 1

Unfortunately, the natural history of an injured limb's function after VML injury is unknown. We aim to explore preliminary evidence on the natural history of VML injury by examining disability outcomes over time in a cohort of wounded service members with muscle-related disability. We hypothesize that VML injuries result in deterioration of muscle function with time.

Methods

This study was conducted in accordance with an Institutional Review Board approved protocol. We examined the Army Physical Evaluation Board (PEB) results of previously published cohorts of medically retired service members to determine how disability designations for muscle injury change with time for service members who underwent more than one examination by the PEB. In brief, a 450 service member cohort's overall disability characteristics were published by Cross et al[1] and disability related directly to muscle conditions is described by Corona et al[10] for 36 service members (8%). Of the 36 individuals with muscle-related disability, 33 had documentation in their medical records describing the volumetric loss and persistent weakness, allowing us to confirm that for these 33 service members, VML was the cause of their muscle-related disability. The disability designation itself is assigned by the PEB as any condition that detracts from an injured service member's ability to perform his or her military occupational specialty on active duty, therefore rendering the individual "unfit" for duty. Each unfitting disabling condition is also assigned a percentage rating which, on a spectrum from 0%-100%, reflects the degree to which the condition detracts from the service member's fitness. A high rating indicates a significant degree of disability.

Once the PEB determines an injured service member is unfit for return to duty and his or her unfitting conditions are enumerated and rated, the service member may be medically retired or separated from active duty. The PEB can also determine that the service member's injury is not stabilized enough to determine to what degree the injury will affect permanent fitness for duty. In this case, the PEB expects that the illness or injury will improve with additional care and that the service member has not yet met "maximal medical benefit." The assumption is that the condition will improve and the service member should not be separated or medically retired from active duty prematurely. In this case, the PEB places the service member on Temporary Disability Retirement List (TDRL). The service member continues to get care for the conditions and is reevaluated periodically by the PEB to determine if the condition is stable enough for final adjudication. At each evaluation leading up to either return to duty (if sufficient recovery is reached) or medical retirement/separation, the PEB still enumerates potentially unfitting conditions and assigns each a disability rating.

We examined the PEB database outcomes for the 33 subjects with confirmed VML as their disabling muscle condition to identify which subjects were placed on TDRL for any period of time prior to being medical retired. Because the assumption for TDRL placement is that the conditions in question may improve, we examined the changes in disability ratings for the muscle conditions between the initial PEB evaluations, iterative TDRL evaluations if applicable, and the final PEB disposition at the time of each service member's medical retirement. This allowed us to determine if, from the PEB evaluation standpoint, disabling muscle conditions improved, deteriorated, or stayed the same as reflected by the assigned disability rating. The time between the evaluations was noted in an attempt to describe how VML injuries change with time in terms of increments of disability ratings. Comparisons between subjects with different PEB outcomes were made using student's 2-tailed *t* test. Linear regression analysis was performed to determine if disability rating increased as a function of time postinjury. To perform regression analysis, patients who did not have a VML disability rating upon initial TDRL were given a disability of 0%. Statistical significance was achieved at an alpha of 0.05.

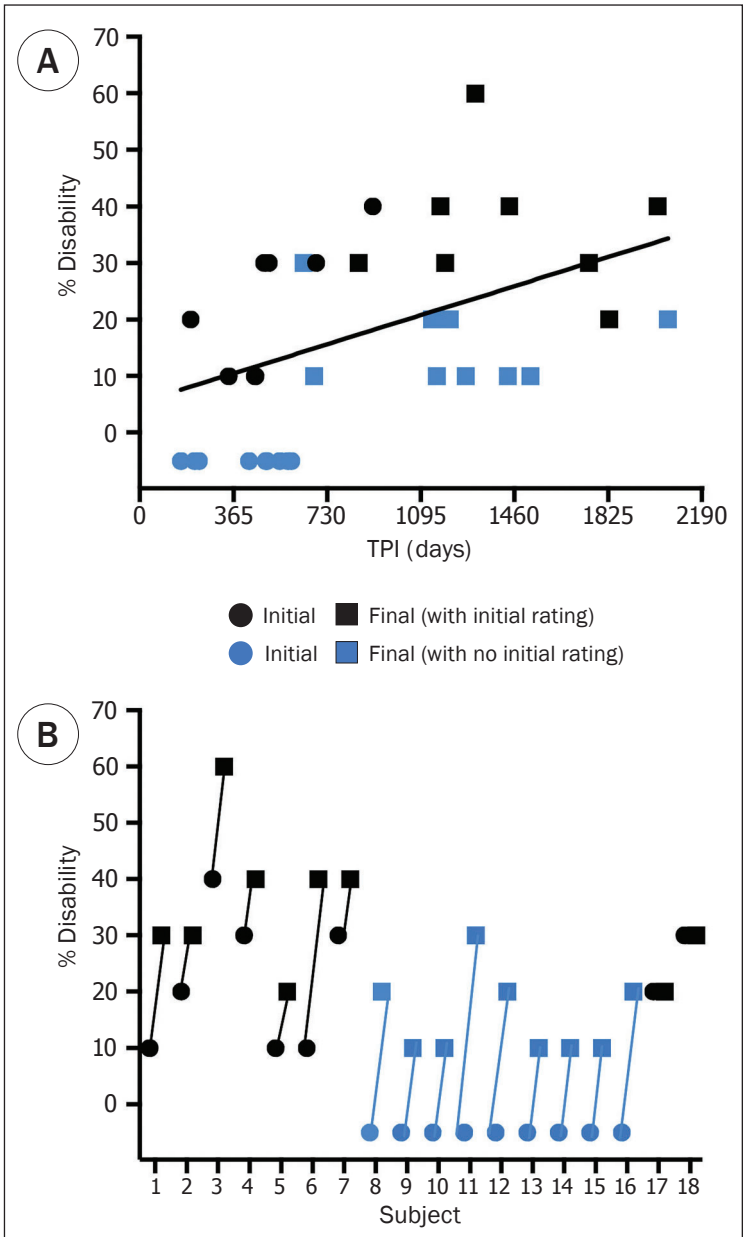
Results

Of the 33 subjects with confirmed VML, 15 (45%) subjects were medically retired at their first PEB evaluation. Their average age was 28.2±1.7 years (range 22-44 years) and median rank was E6 (range E4-O6). Combining each of their unfitting conditions, their average overall disability rating was 64% (range 20%-100%) and average individual disability rating for just the VML was 29% (range 0%-60%). The average time between their dates of injury and respective medical retirement was 681 days (range 246-995 days).

Eighteen (55%) subjects were placed on TDRL during at least one of their PEB evaluations prior to final medical retirement. Their average age was 24.5±1.2 years (range 19-35 years) and median rank was E4 (range E4-E6). Age was not different compared to service members who were medically retired at their first PEB evaluation (P=.0784) but service members placed on TDRL prior to retirement were of significantly lower rank (P=.0140). Their average overall disability rating combining each of their unfitting conditions was 48% (range 20%-70%) and average individual disability rating for just the VML was 25% (range 10%-60%). The overall rating for service members who were medically retired

at their first PEB evaluation compared to service members placed on TDRL prior to retirement was significantly higher (P=.0463) but the disability rating assigned to the VML alone was not different (P=.5140). The average time between their dates of injury and respective medical retirement was 1,293 days (range 630-1,986 days). Because of the additional time allowed for maximal medical benefit to be reached, service members placed on TDRL at any point had a significantly longer duration between date of injury and date of medical retirement (P<.0001).

Of the 18 service members that were placed on TDRL, 7 subjects with an initial muscle condition rating were granted a higher (more disabling) rating at their final retirement evaluation compared to their initial evaluations (35% final rating [range 20%-60%] versus 20% initial rating [range 10%-40%], P=.0313). The charts in the Figure demonstrate the increase in the disability ratings for each service member. Nine additional service members were not assigned a muscle-related disabling condition at their initial PEB evaluation but went on to have a VML disability at their final evaluation. All of these service members had a pain or loss of motion rating initially which was recognized as a muscle condition at their follow up evaluation as shown in the Table. The remaining 2 service members had VML disability ratings which did not increase or decrease between their initial TDRL evaluations and their final medical retirement dispositions, one with a 20% VML disability rating and one with a 30% VML disability rating.



Disability rating due to VML injury of patients on TDRL. Disability ratings due specifically to VML are plotted as a function of time postinjury (chart A), and per subject evaluation (chart B). Ratings are stratified by TDRL review (initial and final) and by whether the patient had a muscle rating upon initial TDRL review. Regression analysis indicates a significant increase in disability rating as a function of time (R^2=0.24, P=.0032).

COMMENT

These results indicate that, for a portion of service members with VML related disability following combat injuries, some are medically retired at their first PEB evaluation and some are placed on TDRL for a period of time prior to medical retirement. Despite the intent of TDRL which is to allow for improvement until maximal medical benefit has been reached, subsequent PEB evaluations for service members placed on TDRL result in worsening VML disability. Sixteen of the 18 (89%) service members placed on TDRL either had an increase in their VML disability rating at their final dispositions or were recognized to have a VML related disability at their final dispositions which was not assigned at interval evaluations.

Some differences existed between the service members that were medically retired at their first PEB evaluation and those who were placed on TDRL. First evaluation retirees were of higher rank, tended to be older but not significantly so, and had higher overall disability ratings. This could reflect a perception that the older, more senior service member would not improve given additional time. However, the "first pass" medical retirement was probably due to the cumulative amount of injury and disability for these individuals as reflected by

their higher overall disability rating. The contribution of VML to the overall rating was not different between the groups, suggesting that other injuries contributed in part to their medical retirement at their first PEB evaluation.

Nine subjects were given disability rating for nonmuscle conditions at their initial evaluation only to have recognized muscle-related disability at their final evaluation.

Subject	Initial Rated Clinical Condition, Rating	Final Muscle Rating of VML	Site of VML
1	Limited range of motion of the ankle, 20%	20%	Posterior Leg
2	Pain and decreased range of motion in the ankle, 20%	20%	Posterior Leg
3	Decreased range of motion of the shoulder along with sensory deficits in the hand, 30%	10%	Deltoid
4	Chronic thigh pain, 0%	10%	Quadriceps
5	Shoulder pain, 20%	30%	Deltoid
6	Healing tibia fracture, 30%	50%	Posterior Leg
7	Hand weakness and chronic pain, 10%	10%	Volar forearm
8	Chronic Pain, 0%	10%	Posterior Leg
9	Neuralgia, 10%	10%	Quadriceps

The VML disabling conditions of service members placed on TDRL did not improve but rather deteriorated. This is anticipated for a number of potential reasons. Volumetric muscle loss is not addressed during acute stages of care and, therefore, the remaining muscle mass is left to undergo continued degeneration and prolonged remodeling.[3,4] During this time, VML injury propagates extensive compartmental fibrosis, which progressively restricts range of motion. It is likely under this condition that the injured musculature exhibits reduced or disuse atrophy. Coupled with the clinical observations that physical rehabilitation of VML injuries does not significantly restore limb function or muscle strength of the injured musculature, it is predictable that VML presents a deteriorating condition. Prospective investigation is needed and warranted to define the pathophysiology of VML injured muscle.

Limitations to our study include the use of the PEB disability designations as surrogates for true disability and our small sample size. The PEB ratings are assigned in accordance with the Veterans Affairs System for Rating Disabilities (VASRD), which at minimum provides a uniform guidance to how the PEB designations should be assigned. While every grading system contains some level of subjectivity, the VASRD guidance is enforced to attempt to minimize interrater differences. The PEB ratings may also fail to reflect increments of true loss of function or other true deterioration in clinical status. We used the PEB disability rating as a surrogate for worsening muscle condition, however, because the ratings are intended to reflect what percentage each condition detracts from a service member's ability to perform on active duty job. As such, we feel that the increased disability rating between time points for any given service member provides some measure of decreased functional status attributable to the VML. Finally, our small sample size may not allow us to make accurate statistical inferences. This is a limitation imparted by the availability of retrospective data. However, when taken in total with the overall description of the larger published cohort, this data adds to the granular detail of the long-term sequelae of extremity injury not found in a vast majority of descriptive studies on war injury.

In conclusion, these data are consistent with growing body of preclinical literature demonstrating whole muscle unit deterioration following VML injury. The natural history of VML in human subjects has not been described. This is foundational preliminary evidence that the natural history of combat sustained VML injury is also one of deterioration.

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War and Rehabilitation: Occupational Therapy's Power to Transform Disability Into Ability

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The Global War on Terror has left an indelible mark on Americans, particularly on US military personnel who have served on multiple overseas deployments. The media has highlighted stories of Soldiers with amputations, traumatic brain injuries, and posttraumatic stress disorder. The Army's response to ensure provision of total care for wounded Soldiers following serious injuries is the Warrior Transition Unit (WTU), a comprehensive program designed to house, rehabilitate, and return Soldiers to duty or foster a transition from military to civilian life. Occupational therapists have historically been agents of social change related to disability, and occupational therapy practitioners provide care at the WTU as part of an interdisciplinary team. An examination of the WTU provides insight into disability, and knowledge gained from an analysis of the benefits and considerations of the WTU helps inform future practice.

Establishment of the Warrior Transition Unit

In response to the recognition in 2007 of the extent of substandard care for wounded military personnel,[1] the Army established 35 WTUs at major bases in the continental United States and overseas to ensure the availability of professional services for those Wounded Warriors.[2]

The mission of the WTU is to "heal and prepare [the Soldier] for transition," and it aims to accomplish this by providing each Soldier with a Comprehensive Transition Plan (CTP).[3] While working through the CTP, the Soldier has access to a system called the Triad of Care. This Triad includes a squad leader, a nurse care manager, and a primary care manager who is either a physician or physician's assistant.[3] The Triad is supplemented by an interdisciplinary team of occupational therapists, physical therapists, social workers, transition coordinators, and career counselors, among others.[2]

The command structure of the WTU provides oversight and accountability. While assigned to the WTU, the Soldier maintains his or her military benefits, receiving housing, normal pay and allowances, and healthcare services. The Soldier's daily responsibilities are to attend medical appointments, engage in therapy to learn new life skills, and seek career counseling to transition out of the military or to a new military occupational specialty, as appropriate for the Soldier's future plans.

Active Duty, National Guard, and Reserve Soldiers who have sustained physical and/or mental health injuries while serving and who require at least 6 months of intensive medical care are accepted into the WTU. A fact sheet published by the Warrior Transition Command[4] states that as of February 2, 2015, the majority (84%) of the 4,001 Soldiers remaining in the WTU have been deployed at some point, but only 167 were injured in combat. Currently, the WTU success rate of returning Soldiers to duty is approximately 45%. The WTU recognizes that work is important to the Soldier's mental and physical well-being, therefore, returning the Soldier to a purposeful worker role is emphasized within occupational therapy treatment.

Evolution and Adaptation

Fulfillment of meaningful roles and participation in occupations to restore mental and physical health are foundational tenets of occupational therapy. One fundamental example of this is the "moral treatment movement" in Europe in the 18th and 19th centuries. That movement marked a critical paradigm shift when individuals with mental illness began to participate in work tasks, or meaningful occupations, rather than being restrained. Adolph Meyer, the psychiatrist recognized as the "father of occupational therapy," acknowledged the link between meaningful occupations and overall health, an idea ahead of its time.[5] Since its creation and throughout its growth, occupational therapy has long been rooted in social justice, fostering cultural change related to disability. Presently, occupational therapy and healthcare provision continue to evolve within the WTU.

As of 2015, the WTU has downsized from 35 to 25 units in operation with 11 Community Care Units, smaller units for Soldiers with less complex care needs which allow them to heal closer to home.[2,4] Fewer service

members are deploying and returning with injuries as the military's current presence and involvement in overseas conflicts subsides. As a result, the Army has initiated the closure of select WTUs while "ensuring no degradation to the care and services provided to Soldiers and their families."* The WTUs at 5 regional medical commands have been designated for inactivation by August 2016. Consequently, Soldiers within those WTUs will be transferred to other units.* As the WTU structure continues to evolve and downsize, there is an opportunity to critically evaluate it.

Lessons Learned

The benefits of the WTU structure and function are noteworthy. Three key benefits are the maintenance of the military unit structure which fosters unit camaraderie among Soldiers, the interdisciplinary team of healthcare providers, and the inclusion of the Soldier's family members in the plan of care. Despite the benefits, criticisms of the WTU are worth consideration as well. As shown in the inset, these include the potential that receiving a medical disability rating may incentivize "sick role" behavior, financial compensation for disability may foster symptom exaggeration, and the multilayer administrative and clinical processes may cause extended lengths of stay, perhaps beyond the ideal time required for rehabilitation goals to be reached.

The criticism that the WTU may create a climate that fosters identification with the sick role is counterintuitive, since the language was purposefully written so the Soldiers would identify themselves as "Warriors in transition." Regardless of intentions, Soldiers learn about the medical disability rating system and the fact that additional diagnoses in their medical record can result in greater financial gain. Insights into the system processes during the transition and recovery stage may influence susceptible Soldiers to identify with their diagnoses, and even seek additional diagnoses to add to their medical disability claim. Occupational therapy practitioners who work closely with Soldiers vulnerable to identifying with the sick role must be proactive. As creators of change, therapists can facilitate an incentive to recover and identify with ability rather than disability.

Appeal to Action

It is necessary to create a shift relating to the Soldier mindset that surrounds the disability rating system. Disability ratings by Veteran's Affairs are assigned to Soldiers who have sustained injuries or diseases that are service-related, such as qualifying Soldiers receiving care within the WTU.[6] A disability rating is a percentage (0%-100%) assigned to a Soldier based on injury or illness severity. The higher the rating, the greater amount of compensation provided from the government.[6] Instead of promoting health, the system may inadvertently endorse disability, providing financial benefit for dysfunction. Reliance on a disability rating may provide a predictable, continuous income, but may also inadvertently decrease overall quality of life. Modifications to the system including the possibility of a lump sum disability payment (rather than a continuous payment), coupled with a release for all future disability claims, could effectively deter system misuse. After acceptance of a lump sum with a release, there may be less incentive for discharged Soldiers to revisit their disability claims and continue the cycle of dependence.

Benefits and Considerations/Concerns Involved With the Care and Services Provided by the Warrior Transition Unit.

Benefits
Interdisciplinary communication and teamwork
Individualized goal-setting and attainment with professional assistance
Availability and access to services
Assistance for family and caregivers
Sense of camaraderie among Soldiers in a military unit setting/ structure
Considerations/Concerns
Potential for extended care/recovery times
Receiving a medical disability rating may incentivize sick role behavior
Financial incentive of disability may create risk of secondary gain and symptom magnification

As rehabilitation professionals within the WTU, occupational therapists must hold themselves accountable for services rendered, as well as services withheld. Soldiers deserve compensation for injuries, but allowing Soldiers to advance towards a higher rating than warranted is a disservice not only to the Soldier, but to the ethical standards of the profession. The Army values and the occupational therapy code of ethics should be revisited frequently to regain focus for both Soldier and therapist.

Occupational therapists can steer the rehabilitation paradigm from the medical model to the social integrative model of disability. The medical model views disability as a negative occurrence, which can leave an individual dependent on supports and unmotivated to reintegrate into previous roles and responsibilities. In this model, the individual may assume the sick role and attempt to incentivize his or her disability. In contrast, the social integrative model views disability as a naturally-occurring phenomenon. Through full participation in occupations and roles, the individual will become more resilient, therefore regaining health and wellness.[7] Therapists

*US Army Medical Command OPORD 15-31, February 2015. Internal military document not readily accessible by the general public.

must be cautious in labeling clients as disabled. Instead, care must be taken to assist the Soldier in creating a new identity, one that promotes ability.

Finally, as with any system of multilayer administrative and clinical processes, there may be unexpected delays or breakdowns in coordination in regards to delivery of care. In-processing, out-processing, and any executive requests may be lengthy and not as efficient as one might find within a smaller system of care. The sheer size of the healthcare system may expose the Soldier to getting "lost in the shuffle," unnecessarily lengthening the amount of time the Soldier is receiving services. Specifically, the process of the Integrated Disability Evaluation System, which determines whether a Soldier can return to duty or separate from military service with a disability payment, is recognized as slow-moving.[8] Occupational therapists should strive to educate Soldiers on the functions of the WTU, while simultaneously keeping the Soldier motivated, goal-focused, and proactive towards discharge. Assisting Soldiers to take an active role in managing their own care provides accountability and a sense of purpose. Overall, lessons cultivated go far beyond the WTU, and identified considerations for renovation can be applied within the civilian sector of support systems.

Application Within the Civilian Sector

Civilian social supports provide similar opportunities to incentivize disability. With the implementation of the Affordable Care Act in 2010, Medicaid coverage was expanded, adding millions of individuals to this system of care.[9] Supporters stated the expansion provided assistance for individuals who, prior to the initiative, did not qualify. However, challengers of this expansion argue that it may promote dependence on the government's assistance. Social Security Disability Insurance is a highly criticized program which cycles around an individual's impairment(s) and inability to provide for oneself, possibly incentivizing disability and encouraging exaggeration of symptoms.[10] These systems of support are only a few of the civilian programs which are criticized for potential encouragement to remain in the system, accepting a dysfunctional disability role as part of one's personal identity.

The roots of occupational therapy and history have shown that individuals need meaningful roles and engagement in occupations to restore or maintain overall health. Occupation has been recognized as a means of treatment for mental and physical illness since the 18th century, long before the term "occupational therapy" was first used to label the method in the 1920s.[5] In 1915, Hall and Buck[11] discussed the importance of engagement, or "occupation" in occupational therapy lingo, as a means of recuperation, stating:

> For the well-to-do, work with the hands may be a potent remedy against the harmful effects of idleness.

As a profession, occupational therapists have known for nearly a century that participation in occupations is a way to restore health. Whether in the WTU or in the civilian sector, occupational therapists do well to remind clients that it is in their best interest to be engaged and fully participate in occupations. Furthermore, in pursuit of health for clients, occupational therapists may simultaneously discourage unnecessary reliance on social support and subsequent idleness.

Conclusion

In any social support system, loopholes will be found and resources may be unjustly over-utilized. As this is never the purpose of these programs, health professionals should transform unhealthy mindsets and behaviors toward independence. As the past has demonstrated, occupational therapy practitioners can be instrumental in analyzing and altering the future of such services. Through war and rehabilitation, Army occupational therapists have the unique opportunity to be actively involved in a large, evolving healthcare system. The WTU is simply one example of a support system developed when a vital need was identified. Whether in the military or civilian sector, it is the duty of occupational therapists to motivate clients to accomplish the mission of return to function, independence, health, and participation in meaningful occupations. In this way the focus is empowerment, not entitlement.

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Center for the Intrepid: Providing Patients POWER

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Never underestimate your POWER to change yourself…
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The Center for the Intrepid (CFI) at Fort Sam Houston, San Antonio, Texas, officially opened in January 2007. The 4-story, 65,000 square foot facility is one of the premier outpatient rehabilitation centers for the Department of Defense. The CFI provides advanced prosthetic and rehabilitative care for individuals following amputation, burn, and/or functional limb loss.[1] The CFI staff uses an interdisciplinary approach to provide holistic care with the goal of positively impacting the physical, psychological, and behavioral functioning of injured military service members and veterans. Over the past 8 years, a variety of clinical challenges have shaped the progress of rehabilitative care. Advancements in surgery have prevented limb amputation; however, limb salvage procedures can result in unique complications and disadvantages that challenge providers and patients. Because service members and military veterans are accustomed to (and often drawn to) high intensity, physically demanding pursuits, the request was made to address the gap between the actual versus desired level of function after limb salvage. Healthcare professionals at the CFI met this request with a custom orthosis, the Intrepid Dynamic Exoskeletal Orthosis (IDEO).

Intrepid Dynamic Exoskeletal Orthosis

The IDEO is a carbon fiber, energy storing ankle-foot-orthosis which enhances plantarflexion power, ankle stability, and agility.[2,3] To maximize the rehabilitation and training outcomes of patients wearing the IDEO after limb salvage, physical therapy, orthotics/prosthetics, and orthopedic surgery worked to develop a "Return to Run" program at the CFI. The program is based on sports-medicine principles and embodies a traditional rehabilitation mindset of improving strength and conditioning.[3]

During the initial successful implementation of the IDEO and Return to Run program, deficits and issues that went beyond traditional physical rehabilitation were identified and a health psychologist Fellow at San Antonio Military Medical Center was engaged to augment the existing program. Through creativity and collaboration, complementary components of health and wellness were incorporated into the Return to Run program. This professional collaboration transformed initial concepts into a comprehensive, performance-focused program titled POWER: Performance-Optimization Warrior Enhanced Rehabilitation.

Performance-Optimization Warrior Enhanced Rehabilitation

The POWER program is a play on words, built on the foundational belief that every individual has the personal power to act, achieve goals, make decisions, and triumph over life's obstacles. While it focuses on human optimization through cognitive, nutritional, and fitness enhancements comparable to other programs (eg, the Army's Tactical Human Optimization, Rapid Rehabilitation and Reconditioning program), the POWER program is unique in several ways:

- Focuses on improving self-efficacy
- Customized to the patient
- Injured service members and veterans are the target population
- Direct instruction from professionals across various disciplines is incorporated

The POWER program uses a practice-based evidence model to influence patients, seeking to apply the best available evidence-based research within clinical practice to achieve desired therapeutic milestones.[4]

Although the POWER program grew out of a desire to better meet the needs of patients with limb salvage, patients referred to the CFI with *any* diagnosis are eligible for enrollment. Patients are screened for POWER program eligibility during initial in-clinic treatment sessions; patient needs are then discussed weekly during interdisciplinary team meetings thereafter. The POWER program is recommended for patients with issues that may potentially interfere with recovery (eg, medication dependency, behavioral health issues, poor coping, low resiliency, or low self-efficacy). The timeframe for the program is dependent upon the patient and their individual needs.

Implementation of the POWER Program

The POWER program is executed through professional collaboration. This interdisciplinary strategy inspires CFI staff to motivate, challenge, and support patients as they strive to regain prior levels of function and return to duty. At the CFI, the following disciplines contribute skills, knowledge, and expertise to create a team-oriented rehabilitation approach as illustrated in Figure 1:

- Case Management
- Dietetics
- Health Psychology
- Occupational Therapy
- Orthotics/Prosthetics
- Physiatry
- Physical Therapy
- Recreational Therapy
- Research

The interdisciplinary team is headed by 2 physicians: a physiatrist and an orthopaedic surgeon (the Medical Director of the CFI). They lead weekly interdisciplinary team meetings to discuss patients with CFI staff. The rehabilitation team monitors the progress of each patient with respect to his or her treatment plan, and decides whether or not the POWER program may enhance recovery. Open communication is encouraged at the weekly meetings, including effective consultation with other services at any time during the patient's rehabilitation process. Due to widely differing injury patterns and patient requirements, engagement in the POWER program may span anywhere from 4 to 52 weeks. The POWER program's lessons are systematically divided into 3 distinct modules—health psychology, nutrition, activity—with corresponding submodules as shown in Figure 2.

Power Program Modules

Health Psychology

Beyond the physical trauma of the injury itself, combat injuries often have profoundly negative consequences including loss of health and military achievement potential. Specifically, combat injuries have the potential to create numerous psychological disturbances, including increased anxiety, depression, insomnia, anger, tension, and diminished quality of life.[5]

Significant advances in physical medicine and rehabilitation have created situations in which an individual service member may be physically ready to return to duty, but not yet psychologically recovered. Successful rehabilitation programs have increasingly recognized this trend and have integrated psychological interventions (ie, relaxation, mindfulness-imagery, goal setting, stress management) into their programs.[6]

Professions Integral to the POWER Program

Case Management	Management of cases by coordination of all services and facilities transitions surrounding patient discharge.
Dietetics	One on one and group sessions to promote healthy eating, dietary modifications, and illness prevention through proper nutrition.
Health Psychology	One on one and group therapy sessions with a focus on education of behavioral health techniques to imrove outcomes.
Occupational Therapy	Engages the patient in meaningful thearpeutic activities to return to their highest level of function and quality of life.
Orthotics & Prosthetics	Custom fabrication of prosthetic and orthotic devices.
Physiatry	Thorough and ongoing evaluation and holistic management of patients. Serves as the lead provider for the rehabilitation care of each patient.
Physical Therapy	Evaluation and treatment of neuromusculoskeletal conditions. Provides therapeutic exercises, modalities, and gait training.
Recreational Therapy	Facilitates emotional and physical health through leisure pursuits and community reintegration. Lead service for biofeedback training.
Research	Contributes to the objective assessment of outcomes to ensure/develop best practice.

Figure 1. An interdisciplinary approach provides specialized, holistic, practice-based patient care.

The Optimal Performance Program (OPP) is integrated psychological skills training to reduce the negative psychological consequences of injury and teach new techniques that improve performance. Regardless of diagnosis, OPP, as a component of the POWER program, aims to produce autonomous, highly functioning military service members with improved coping skills, decreased reinjury anxiety, and improved psychological flexibility.

Incorporating techniques from sports psychology, rehabilitation psychology, and health psychology, OPP

Health Psychology	Nutrition	Activity
1. Performance Education a. Stress management b. Sleep c. Pain I d. Pain II 2. Skill Acquisition a. Attention and self-talk b. Critical thinking and self-analysis c. Anger management d. Learned optimism	1. Nutritional Survey 2. Laboratory Evaluation a. CBC, iron-panel, sTfr b. Chem 7 c. Lipid panel d. 25-OH d 3. The 5 Rs a. Rehydrate b. Repair c. Rest d. Revitalize e. Reload 4. Individual Classes a. Review Labs b. Body composition c. Review supplements d. Goal setting e. Follow-up as needed	1. Evaluation and Screening Tools a. History and physical exam b. Biodex c. Biofeedback d. FCE-M e. Military performance lab 2. Restoration a. Strength training b. BFR c. Motion d. AlterG e. Edema recovery f. Flowrider 3. Return to Run a. Sprinting b. Plyometrics c. Cut dynamics d. Landing mechanics e. Power development f. Acceleration/deceleration 4. Return to Duty a. FCE-M b. MOS specific training c. FATS d. WFSC Freedom Park e. CAREN f. Community outings

Glossary

BFR - blood flow restricted training
CAREN - Computer Assisted Rehabilitation ENvironment
CBC - complete blood count
Chem 7 - basic metabolic panel
FATS - Firearms Training Simulator
FCE-M - Functional Capacity Evaluation-Military
MOS - military occupational specialty
sTfr - soluble transferrin receptor
WFSC - Warrior and Family Support Center
25-OH d - 25 hydroxyvitamin D

Figure 2. The main modules and corresponding submodules of the POWER Program.

consists of 8 distinct, 2-hour treatment modules that are administered over a 4-week period at a rate of 2 treatment sessions per week. Each 2-hour treatment group ends with a 15-minute group clinical hypnosis session. Before receiving a fabricated IDEO brace and entering the program, patients receive a 60-minute intake and program introduction that prepares them for the group treatment modules. During this initial group, patients complete baseline assessment forms and receive basic information about hypnosis, heart-rate variability biofeedback, physical self-regulation, the physiology of stress, and chronic pain management. All treatment modules are led by the CFI's health psychologist.

Concurrently, patients are issued a personal biofeedback device that measures heart rate variability, a key indicator of physiological resiliency and behavioral flexibility.[7] A trained biofeedback provider supervised by a health psychologist works with the patients both individually and collectively. Additionally, patients practice biofeedback training and the results are tracked digitally through the biofeedback device and logged by the biofeedback provider. Patients also attend individual appointments to address each patient's progress in the program, reinforce previous treatment interventions, and make goals for future progress.

Group treatments of OPP are divided into 2 distinct, primary subject areas: performance education and skill acquisition. Performance education specifically focuses on teaching preventive strategies to manage illness/disease in the midst of practicing and maintaining healthy behaviors. In an efficient and structured manner, patients are active contributors to their recovery. Performance education contains standalone submodules on 4 separate topics: stress management, sleep, pain I, and pain II.

Stress management is the first module addressed under performance education. During the stress management module, the physiology of stress response is discussed, including the role of cortisol and oxytocin, cultural-unique military stressors, the stress diathesis theory of disease/illness, and stress resilience. Patients learn energy conservation techniques and power posing, in addition to various practice strategies to apply and promote energy management including inducing the relaxation response through physical self-regulation.

Because poor sleep can impair quality of life, decrease the progression of the recovery process, and increase one's risk for other diseases,[8,9] patients in the POWER program learn the physiology of sleep, including the management of circadian rhythms, social and biological zeitgebers, and the connection between sleep and memory. The importance of maintaining healthy sleeping patterns along with the causes and types of insomnia and the effects of drugs on the sleep cycle are discussed. Recommendations for proper sleep hygiene are shared (eg, creating a relaxing routine before bed, developing a regular sleep-wake cycle) and strategies for how to manage intrusive, negative, anxiety-producing thoughts at nighttime are taught. At the completion of the treatment module, patients develop a sleep performance plan.

The first pain module explains pain as a subjective, multifaceted experience. Physiology of the pain response is reviewed, the biopsychosocial model of pain is introduced, and the differences between acute versus chronic pain are distinguished. Patients learn the biological purpose of pain, the role of emotions/thoughts in the pain experience, while also recognizing methods for better management of pain (eg, biofeedback, relaxation training, distraction, pacing, cranial electrical stimulation/Alpha-Stim).

The second pain module focuses on the neuroscience of pain and managing fear and avoidance following an injury. Patients learn about how pain is often a disconnect between the real body and the virtual body, the role of mechanoreceptors in a pain experience, introduction to the concept of proprioception, body maps, pain neurotags, mirror neurons, and the physiology of inflammation and stiffness.

Alongside performance education, skill acquisition is the second portion of the health psychology module. Skill acquisition uses a comprehensive, multimodal approach to teach patients how to consciously attend to and regulate individual thoughts, emotions, and behaviors. Patients are taught to be mindful of their circumstances, and are empowered with the ability to employ well-known psychological strategies to overcome environmental stressors. Skill acquisition contains submodules on 4 separate topics:

- Attention and self-talk
- Critical thinking and self-analysis
- Anger management
- Learned optimism

In the attention and self-talk module, the physiology of the brain in improving attention is discussed, and the sequence of information-processing within the human body is highlighted. Additionally, patients are lead through sports psychology grid training drills to improve their selective attention. The POWER program teaches patients how to better guide, regulate, and evaluate thought processes through the implementation of learned metacognitive skills, including monitoring and changing self-talk to improve performance.

The module on critical thinking and self-analysis asks each patient to thoughtfully consider his or her own self-concept (or the collection of beliefs a person holds about him or herself). This process includes evaluating past, present, and future self-identity, as well as the effects of the injury on the new self-identity. Therapists work with patients through this process to help detect thoughts, cognitive errors, and realistic versus idealistic thinking. Self-concept constructs are individually analyzed as they may function as reinforcement for certain undesirable behavior(s).

The mood and anger management training module challenges patients to critically analyze several adaptive and maladaptive responses to anger. Patients are educated on the physiology of anger, distinguishing between adaptive and maladaptive anger, consequences of those who demonstrate hostility/aggression towards self and others, and managing both anger directed at self and/or others. Problem solving, cognitive restructuring, relaxation activities, and interpersonal communication strategies are all discussed.

The learned optimism and performance module focuses on the science of optimism and performance. Optimism (dispositional versus situational) is defined, patients learn how to apply optimism in improving physical and emotional performance, how to use defensive pessimism to manage anxiety, fear, and worry, and how to use positive psychology techniques to enhance dispositional optimism.

Nutrition

The second component of the POWER program encompasses nutritional health and wellness. A dietician

conducts a nutritional survey to gather baseline information regarding the patient's diet. Also, blood is analyzed in the lab to provide information on vitamin deficiencies, cholesterol levels, and body system functions. The baseline survey and lab values are essential aspects of the program as they can be key identifiers of factors contributing to fatigue, weight gain, depression, and poor healing after injury. Furthermore, the information can assist the dietician in identifying nutritional needs and addressing deficiencies.

Education is delivered on the "5 Rs" of recovery nutrition (rehydrate, repair, rest, revitalize, and reload). Rehydration focuses on individual fluid needs before, during, and after rehabilitation. This component should always be individualized, establishing rehydration requirements on the physical exertion demands of each patient.[10] Repair emphasizes to patients the importance of consuming high quality protein, both prior to and after rehabilitation. Rest highlights sleep as a major factor in the recovery process; it is crucial to obtain 7 to 9 hours of sleep daily to maximize rest of exhausted muscles and minimize mental fatigue in preparation for the following day's training. Revitalize emphasizes the need to extract vitamins and minerals from whole grains, fruits, and vegetables to energize the body's systems. Similar to repair, patients are taught methods to reload their muscles with carbohydrates and protein for muscle recovery, growth, and heightened performance.[11] In addition to the 5 Rs, education is continually provided to ensure knowledge of healthy food choices, effective shopping habits, and importance of fueling the body with clean, nutritional food. Throughout the POWER program, patients routinely meet with a dietician to discuss the 5 Rs, identify areas for improvement, devise strategies to regain health, establish attainable goals, and follow-up with a provider as necessary.

Activity

Physical activity is necessary to optimize health and performance of desired activities. The mission of the POWER program is to restore an injured service member or veteran, regardless of injury, to duty and/or highest level of independence. To accomplish this aim, focus is placed on achieving adequate endurance, strength, flexibility, and mobility necessary to perform daily activities.[12] Without these key components, the likelihood of reinjury may increase. The activity module consists of 4 distinct categories—comprehensive evaluation and screening, restoration, Return to Run, and return to duty—each of which includes 6 subdivisions of select treatment options for patient care.

The first module involves a comprehensive evaluation with additional screening tools (as deemed necessary) to obtain a holistic view of the patient's areas of movement dysfunction. A thorough medical history and physical examination is conducted. Supplementary measures may also be requested, such as biofeedback, Biodex (Biodex Medical Systems, Inc, Shirley, NY), functional movement screen, gait lab analysis, and/or a functional capacity evaluation-military (FCE-M).

The second module focuses on restoration and advancing the patient towards his or her prior level of function. Strength, endurance, joint range of motion, dynamic balance, and edema are addressed through means of blood flow restriction therapy, AlterG (AlterG, Inc, Fremont, CA), and Flowrider (Flowrider, Inc, San Diego, CA). One unfortunate reality of rehabilitating trauma patients is that they need strength training, but are often not able to withstand the high loads required to build strength in the typical fashion. Blood flow restricted training is a technique used to address this significant clinical challenge. It is important because it allows a patient to obtain muscle hypertrophy at 20% of his or her one rep maximum, thus allowing the individual to reap the benefits while performing significantly less work.[13] The AlterG Anti-Gravity Treadmill is an additional tool which requires less physical demand, decreasing the forces generated through the lower extremities while exercising and possibly enhancing recovery time.[14] Furthermore, the Flowrider incorporates excitement and entertainment alongside functional (dynamic) balance and core strengthening.

Return to Run is the third module under the scope of activity. Pairing the IDEO with a structured Return to Run clinical pathway addresses the need to return to basic activities of daily living as well as the high-level rehabilitation goals of limb salvage patients who aspire to attain or exceed the functional mobility of patients with transtibial amputations. While this module is implemented by a physical therapist and physical therapy assistant, orthopaedic and orthotic/prosthetic staff serve as interdisciplinary partners. The physical therapy practitioners engage and educate the patients in plyometric exercises, proper landing mechanics, sprinting, cut dynamics, power development, and acceleration/deceleration techniques. Objective data[15] and patient reports suggest that without the assistance of the IDEO, mobility and ambulation remain limited. The IDEO and Return to Run module allow patients to maximize use of their salvaged limb.

To complete the physical activity module, return to duty is addressed through 6 submodules of evaluation and

training, with each submodule systematically assessing patients' capabilities, both physically and mentally. In this part of the POWER program, a patient's military occupational specialty is scrutinized to identify the primary skills, roles, duties, and job tasks that are essential to perform within the identified military profession. A FCE-M, specifically designed for service members, may be completed for personnel who wish to return to duty. While wearing a Kevlar tactical vest, helmet, 35-pound rucksack, and carrying an M-4 carbine, patients are timed and graded on their ability to perform tasks such as dragging a 160-pound sled (to simulate a casualty), climbing walls, clearing stairs, and running a one-mile ruck. The components within the FCE-M are specifically designed to simulate the realistic demands of active duty service. Physical abilities are also tested and assessed through the Warrior and Family Support Center Freedom Park trail. The park contains fitness stations of varying difficulty and a trail that can be utilized for training and assessment.

The Firearms Training Simulator and Computer Assisted Rehabilitation ENvironment (CAREN) are used to assist with FCE-M evaluations. Firearms training in a simulated environment allows patients who wish to return to duty the opportunity for skill acquisition, remediation, and refinement through simple and complex scenarios.[1] In addition, the CAREN offers a multisensory virtual reality simulation where service members feel safe while being immersed in highly demanding scenarios that are comparable to those encountered in combat.[16] Finally, recreational therapy opportunities for outings are used to engage patients in leisure pursuits, reinforcing comradery, unity, and reintegration into the community.

Enhancing functional independence both physically, psychologically, and behaviorally requires a multimodal form of rehabilitation. Establishment and implementation of the POWER program encourages a holistic view of a patient through an interdisciplinary approach, building relationships between healthcare professionals and demonstrating to patients a model system of care.

Evaluation of the Power Program

Researchers in the CFI's Military Performance Laboratory are well into a multiyear effort to establish robust and clinically relevant assessments and outcome measures that allow objective determination of patient ability, support the prediction of outcomes trajectories, and allow validation of the various modules of the POWER program. Although assessments can include technologically sophisticated tools,[17] an emphasis is placed on assessments that are time-efficient, easy to implement, reliable, valid, and capture the effects of the clinical interventions in the POWER modules. As stated earlier, the POWER program is an extension of the Return to Run program, a specialized training program which has robust scientific evidence demonstrating its ability to return limb salvage patients to a higher level of functional independence.[15] For example, a retrospective analysis of limb salvage patients who had participated in the Return to Run program was conducted from October 2009 to June 2010. Researchers discovered 10 patients who met the inclusion criteria. Results reported that all 10 patients had resumed a weight-lifting program, eight returned to running (one completed a full and half marathon while two completed a minitriathlon), and three were redeployed with elite units.[3] It is the desire to equally demonstrate the effectiveness of the POWER program and its interdisciplinary approach to rehabilitation in returning individuals to their highest level of functional independence.

In addition to a range of objective measures of physical function, measures that characterize an individual's psychosocial makeup are also being actively pursued. Due to the interdisciplinary approach to care within the POWER program, and a growing body of literature supporting the importance of nonphysical factors on resulting recovery, areas such as self-efficacy, resilience, anger, and depression are being evaluated. By better understanding service member's nonphysical makeup, such as an individual's readiness to engage in the various components of the POWER program, intervention type and timing can be optimized to ensure maximal benefit in an individualized manner.

Value to The Military

In 2013, Army Surgeon General LTG Patricia Horoho, spearheaded a campaign to advance Army Medicine from a healthcare system to a "System for Health." LTG Horoho described the transition thusly:

> This means shifting the focus to prevention of disease, injury, and disability. More importantly, it means advocating a cultural shift to Soldiers and beneficiaries by encouraging them to develop a mindset that drives them to optimize their own health.[18]

LTG Horoho asked Soldiers and beneficiaries to take active roles in maintaining their own physical health through fitness and injury/illness prevention strategies.

Also during 2013, the Army introduced the Performance Triad to support Army Medicine's transition to a System for Health. Focusing on sleep, activity, and nutrition, the Performance Triad provides a comprehensive plan for

healthy, sustainable life roles and routines. The aims of the Performance Triad are for individuals to engage in daily physical activities, improve personal nutrition, and increase quality sleep.[19]

The CFI POWER program is congruent with the Performance Triad and resonates with Army Medicine's System of Health. The POWER program seeks to empower patients with a "skill toolbox" to positively affect their life space.* Various components of health psychology, nutrition, and activity are taught for patients to improve individual functioning levels while reducing negative psychological, emotional, and physical consequences often associated with injury. As the POWER program is individualized, each plan of care is tailored to fit the patient's needs.

Conclusion

The CFI implemented POWER as an innovative, comprehensive, interdisciplinary rehabilitation program to leverage clinician and patient assets to optimize individual functional performance. Although POWER is in the early implementation phase, researchers integral to the CFI continue to identify, evaluate, and implement measures to assess the program's effect on patient outcomes. Although it is the CFI's desire to demonstrate the program's unique contribution to patient healing, research is necessary to demonstrate the clinical effectiveness of POWER.

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*Life space is defined as the physical and psychological environment of an individual or group. Source: *Merriam–Webster Medical Dictionary*.

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Implementation of a Transition of Care Coordinator at a Military Treatment Facility

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Abstract

A patient's transition from the inpatient to the outpatient setting is complex and prone to medical errors. This subsequently increases patient morbidity and cost to the healthcare system.

Methods: Our quality improvement initiative used a licensed clinical social worker from within a Family Medicine residency clinic to serve as a Transitions of Care Coordinator (TOCC) with the goal of decreasing patient morbidity and system cost.

Results: The number of documented patient contacts by our primary care office in the postdischarge period increased significantly after implementation of the TOCC (3.1% vs 40.2%, P=.01). Pearson correlation during our postimplementation period suggested an inverse relationship between contact by a TOCC and emergency department (ED) and hospital utilization rates (r=-0.68, P=.05 and r=0.062, P=.005, respectively). However, the percentage of ED visits (11.9% vs 20.8%, P=.02) and hospital readmissions (5.6% vs 13.7%, P=.01) significantly increased overall between the pre-and postimplementation periods.

Conclusions: The implementation of a TOCC within a military Family Medicine residency clinic significantly increased the frequency of ED visits and readmissions to the inpatient service for patients discharged from the Family Medicine inpatient service.

Safety, quality, and the cost of healthcare are currently at the forefront of healthcare discussions in the United States. One of the most vulnerable periods for a hospitalized patient occurs during transfer of that patient's care among providers or between healthcare settings. This risk is particularly significant for ill or elderly patients, since these transitions of care are prone to confusion, miscommunication, and medical errors.[1,2]

Within hospital systems, discharge planning services aim to ease the patient transition from the hospital. Many studies suggest that these services decrease cost and utilization rates. A 2013 Cochrane review evaluated the value of hospital discharge planning and determined that individualized hospital discharge plans lead to reductions in hospital length of stay and readmission rates.[3] Additional evidence in the Cochrane review was inconsistent regarding the impact of discharge planning on cost, mortality, or other health outcomes.

When compared to the availability of hospital-based discharge planning services, fewer systems exist to assist patients after discharge from the hospital. Often, patients experience problems which arise after their hospital discharge, but prior to a follow-up appointment. During this time, hospital discharge planners are not always available, and the patient's primary care medical home may be unaware of the hospitalization. Specific problems that may arise during the transition of care from the hospital include inaccurately reconciled medication lists, inadequate access to appropriate social support or transportation to appointments, poorly coordinated postdischarge home medical services, or lack of access to a physician for follow-up outpatient care. Each of these issues can contribute to medical errors, patient morbidity, and rehospitalization rates.[4,5] As these problems have become more apparent, they have become increasingly studied in an attempt to decrease costs while improving patient safety and the quality of care delivered during the transition periods.

One of the strongest bodies of evidence supporting a deliberate approach to facilitating care transitions is described in Boston University's Project RED (Re-Engineered Discharge) research group (https://www.bu.edu/fammed/projectred/). Project RED researchers executed and evaluated strategies for successful patient transition from the inpatient to the outpatient care settings. Through the development and implementation of their first discharge protocol, Project RED significantly reduced both hospital readmissions and postdischarge visits to the ED.[6] As an additional part of their project, they published a tool kit for other health teams to employ when discharging patients.[7] Other studies demonstrated

similar evidence with regard to the effect of discharge planning protocols on ED utilization and hospital readmission rates.[8-11]

Studies such as these have led to campaigns throughout the United States designed to improve the quality of patient care delivered during this transition period. One of the largest such campaigns is the 2010 Partnership for Patients Campaign led by the Department of Health and Human Services. As part of this campaign, over 3,700 hospitals have collaborated in order to make hospitals safer, less costly, and more reliable. One of the 2 cornerstone goals of the Partnership for Patients campaign is to reduce hospital readmissions by 20%.[12] The Department of Defense and the Military Healthcare System (MHS) joined other federal agencies to support the Partnership for Patients campaign.[13] As part of its campaign, the MHS recommended adoption of the Project RED toolkit within its healthcare facilities.

Based on this MHS recommendation and other local mandates to improve the quality of healthcare within our institution, the leadership of the Womack Army Medical Center established a Project RED team to facilitate transitions of care throughout its health system. As part of this effort, the Family Medicine residency clinic implemented the use of a licensed clinical social worker to serve as the transitions of care coordinator (TOCC) for patients enrolled in the residency clinic and cared for by the Family Medicine inpatient team. The TOCC's primary role was to enable effective and safe transitions of care from the inpatient ward to the follow-up outpatient appointment. With the implementation of the TOCC, our objectives were to increase the number of patients that had follow-up appointments with their primary care manager (PCM) shortly after hospital discharge, identify and assist with patient problems post-hospitalization, decrease the frequency of emergency department (ED) visits posthospitalization, decrease hospital readmissions to the Family Medicine inpatient team, and improve the overall quality of care for our high acuity patients. Overall, we aimed to study the relative quality metrics associated with implementation of a transitions of care coordinator within an academic clinic in the MHS.

Methods

This study was conducted as a local quality improvement initiative. Within our Family Medicine residency clinic at a large Army military treatment facility, we implemented a TOCC to facilitate a smoother transition to outpatient healthcare for patients recently discharged from the hospital. We chose a licensed clinical social worker to assume this role.

The initial step in our transition of care protocol was for the TOCC to contact all patients discharged from the Family Medicine inpatient team within 48 hours of discharge. The TOCC used a structured interview script based on Project RED guidelines which reviewed the patient's diagnosis, discharge medications, follow-up appointments, consultations, and overall plan of care. The TOCC was also responsible for confirming that each of the patients had a follow-up visit in our clinic (preferably with the primary care manager), answering patients' questions about their hospitalization, ensuring patients received any indicated postdischarge services, bringing medication reconciliation questions to the attention of the inpatient team and the PCM, and addressing any additional patient concerns. The TOCC conducted these encounters telephonically and documented the results within the electronic medical record.

All adult admissions to the Family Medicine inpatient team from February 2013 through March 2014 were evaluated monthly for primary outcomes data. Chart reviews were conducted with the following primary outcome variables recorded:

1. Number of patients contacted by the TOCC within 48 business hours.
2. Number of patients who completed a follow-up visit within 7 days of discharge in our practice.
3. Number of patients who completed a follow-up visit within 7 days of discharge with their PCM.
4. Number of patients who completed a follow-up visit within 14 days of discharge in our practice.
5. Number of patients who completed a follow-up visit within 14 days of discharge with their PCM.
6. Number of ED visits within 30 days of admission.
7. Number of readmissions to our facility within 30 days of discharge.

A run chart was constructed from this data to identify any emerging trends. At 6 months following the TOCC implementation, the data was analyzed by run charts as well as via SPSS Statistics 20.0 (IBM Corp, Armonk, New York) analysis.

Results

Table 1 shows the demographic characteristics of the patient groups admitted to the Family Medicine inpatient adult medicine service during the preimplementation and the postimplementation periods. Outcome variables were assessed comparing the preimplementation and the postimplementation periods for the TOCC. During this analysis, we did not consider whether the TOCC actually contacted the patient during the postimplementation

period, as this happened within 48 hours in only 40% of cases. Table 1 also compares outcome variables for these periods regardless of TOCC contact. As expected, the number of documented patient contacts by our primary care office in the postdischarge period increased significantly after implementation of the TOCC (3.1% vs 40.2%, *P*=.01). Additionally, the percentage of ED visits (11.9% vs 20.8%, *P*=.02) and hospital readmissions (5.6% vs 13.7%, *P*=.01) increased during the postimplementation period.

Table 1. Comparison of patient outcome variables for preimplementation vs postimplementation of a TOCC.

	Preimplementation	Postimplementation	*P* value
Demographics			
Patients (N)	160	256	
Men (%N)	82 (51.2%)	125 (48.8%)	
Average Age (years)	57	61	
Outcome Results [n(%N)]			
48-hour Call	5 (3.1%)	103 (40.2%)	.01
7-day Appt	77 (48.1%)	128 (50.0%)	.71
7-day PCM Appt	47 (29.4%)	84 (32.8%)	.46
14-day Appt	106 (66.3%)	171 (66.8%)	.91
14-day PCM Appt	68 (42.5%)	121 (47.3%)	.34
ED Visits	19 (11.9%)	53 (20.8%)	.02
30-day Readmission	9 (5.6%)	35 (13.7%)	.01

Figure 1 shows the run chart of primary outcome measures after we implemented the TOCC. Over the course of 6 months, the number of patients from our practice contacted within 48 business hours after hospital discharge rose from approximately 20% to 70%. During this time period, the percentage of patients completing a follow-up appointment within 14 days of discharge also increased. This increase also included the number of patients that were able to see their PCM. The percentage of ED visits as well as the percentage of patients readmitted within 30 days appeared to have a declining trend after our implementation. No trends were identified for patients following-up within 7 days of discharge.

The postimplementation data was analyzed for correlations using Pearson product moment correlation. The Pearson coefficients between variables is presented in Table 2. In the post implementation period, receiving a phone call within 48 hours postdischarge from our TOCC correlated inversely with 30-day readmissions, as well as ED visits following hospital discharge (r=-0.68, P=.05 and r=0.062, P=.005, respectively). The 14-day PCM follow-up visit also correlated, though less strongly, with decreased ED visits and 30-day readmissions following discharge (r=-0.13, P=.017 and r=-0.31, P=.006, respectively).

The postimplementation period was also analyzed to determine if an actual contact within 48 hours by the TOCC or within 14 days by the PCM made differences in patient outcomes among this group. Tables 3 and 4 show this data. Contact by the TOCC within 48 hours did not significantly change the frequency of posthospitalization ED utilization or hospital readmission rates. Patient follow-up within 14 days of hospitalization with the PCM led to an increase in ED visits (14.9% vs 27.3%, *P*=.02), but did not lead to significant differences in readmission rates.

Finally, data from February and March of 2013 was compared to data from February and March of 2014 to identify possible seasonal variation. In 2014, there was a slight reduction in ED visits following implementation of the TOCC (Figures 2 and 3). Between 2013 and 2014, there was an absolute rate reduction of 3.2% and 2.4% for ED visits in February and March, respectively. Between 2013 and 2014, there was an absolute rate increase of 3.8% in February 2014 and reduction of 4.9% in March 2014 for 30 day hospital readmissions, respectively.

Comment

As part of our study design, we theorized that the implementation of a TOCC would decrease health care utilization within our system, specifically with ED visits and hospital readmissions within 30 days. However,

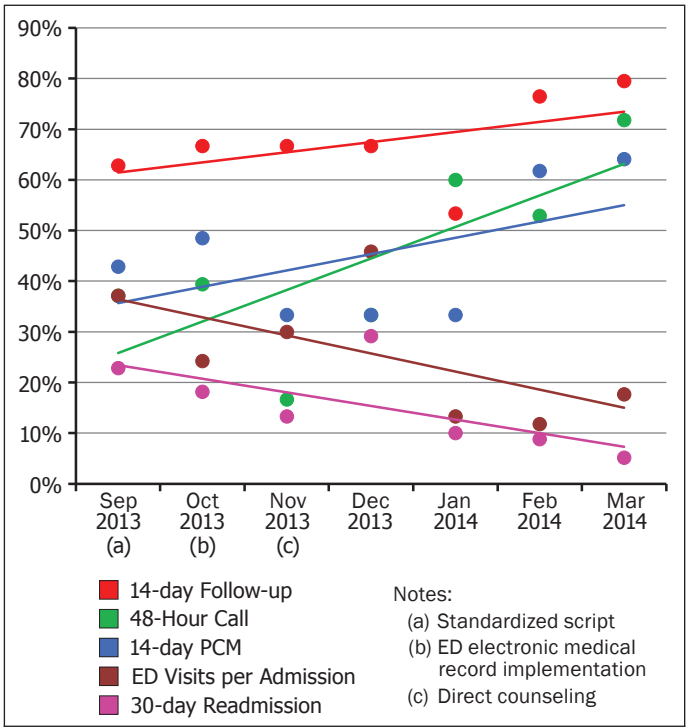

Figure 1. Trend lines for monthly reports of primary outcome measures following implementation of TOCC 48-hour call back.

Table 2. Pearson Correlation Coefficients between primary outcome variables post-TOCC implementation.

		Pearson Correlation Coefficients	
		r	*P* value
48-hour Call	14-day Follow-up	0.23	.016
	14-day PCM follow-up	0.63	.936
	ED visits per admission	-0.68	.050
	30-day Readmission	-0.62	.005
14-day PCM Follow-up	48-hour Call	0.63	.936
	ED Visits per admission	-0.13	.017
	30-day Readmission	-0.32	.001

Table 3. Comparison of emergency department and readmission outcomes between patients (N=256) who were contacted by the TOCC vs those who were not contacted.

48-hour Call	No n(%N)	Yes n(%N)	*P* value
Patients	153 (59.8%)	103 (40.2%)	
ED Visits	30 (19.7%)	23 (22.3%)	.62
30-day Readmission	22 (14.5%)	13 (12.6%)	.67

Table 4. Comparison of emergency department and readmission outcomes between patients (N=256) that completed a follow-up appointment within 14 days and those that specifically saw their PCM).

14-day Follow-Up	No n(%N)	Yes n(%N)	*P* value
Patients	85 (33.2%)	171 (66.8%)	
ED Visits	16 (19.0%)	37 (21.6%)	.63
30-day Readmission	13 (15.5%)	22 (12.9%)	.57
14-day PCM Follow-Up	**No n(%N)**	**Yes n(%N)**	***P* value**
Patients	135 (52.7%)	121 (47.3%)	
ED Visits	20 (14.9%)	33 (27.3%)	.02
30-day Readmission	18 (13.4%)	17 (14.0%)	.89

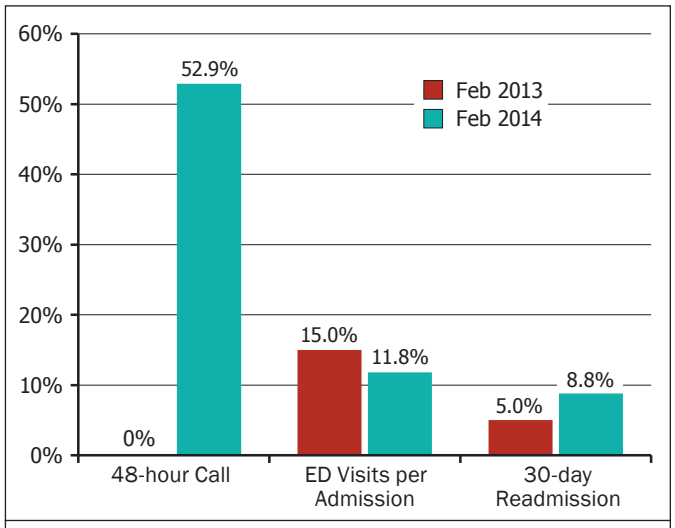

Figure 2. Comparison of outcome data between a preimplementation month (February 2013) and a postimplementation month (February 2014).

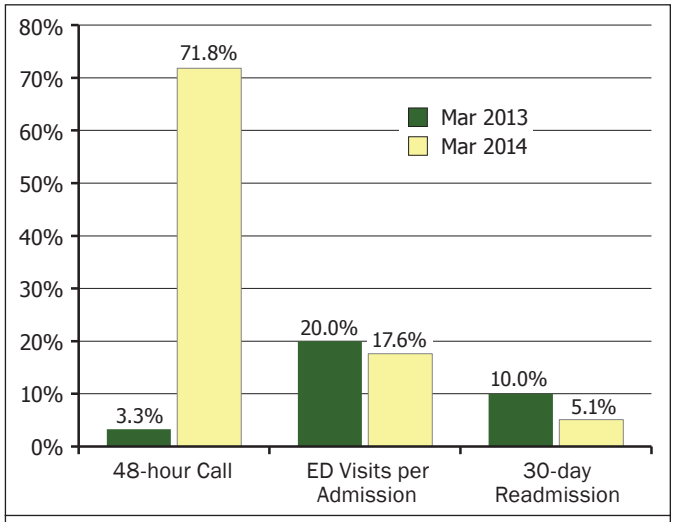

Figure 3. Comparison of outcome data between March 2013 (preimplementation) and March 2014 (postimplementation).

review of the overall preimplementation and postimplementation data suggests that our population's ED visits and readmissions actually increased after our TOCC initiative. Similarly, when considering the possible benefits of provider continuity in the postdischarge period, we theorized that higher rates of PCM visits would decrease utilization rates. This was not the case, however, as patients seeing their PCM within 14 days during our postimplementation period had significantly higher ED utilization and hospital readmission rates.

The cause of these seemingly paradoxical results is unclear. Patients typically have increased morbidity rates in the posthospitalization period. Increased contact by our outpatient practice may be simply identifying problems or complications at an earlier time period. Although this may negatively affect utilization rates, it may be providing improved quality of care in regard to long-term patient outcomes. This was not evaluated in our study. Also, examining data from across our entire medical center would generate stronger statistical power to assess the increased utilization rates.

In our postimplementation period, higher rates of timely contact by the TOCC was inversely correlated with the ED and hospital utilization rates, as evaluated by a Pearson correlation. However, χ^2 analysis of these measures in the same period did not show significantly decreased rates of utilization for those same patients. These trends still suggest promise of utilization and cost savings benefit to our hospital as the program continues to mature.

The implementation of a TOCC led to a significant portion of our practice patients being contacted within 48 hours of a hospitalization. The goal of 100% patients contacted with 48 hours of discharge was not met due to transfers to other facilities, deaths, and a myriad of administrative challenges.

Timely patient contact was hampered by incorrect phone numbers, patients who did not return phone calls, and the lack of an alternate TOCC when the primary TOCC was on vacation or ill. Despite these limitations, most patients not contacted within the first 48 hours following discharge were contacted by our practice within a week.

The use of a licensed clinical social worker as our TOCC is unique since most facilities use nurses for this function. The potential drawbacks of using a social worker in the role include unfamiliarity with the medications reviewed as part of the 48-hour telephone encounter. To mitigate this issue, when our TOCC identified a medicine reconciliation issue, he relayed the concern to both the discharging inpatient team as well as to the PCM. The advantages of using a social worker as a TOCC include an understanding of how to navigate a complex medical system, experience in the coordination of outpatient specialty referrals and appointments, and an appreciation of the influence of family dynamics on a patient. Additional benefits of employing a social worker in this role include professional training and experience with counseling patients and clear communication and emotional support.

There are several limitations to our study. We did not consider variables other than those described above. During the period that the TOCC was established, additional changes within our health system occurred which may have influenced our results. The Family Medicine inpatient team standardized the written discharge summary and instructions given to all patients. Additionally, the ED transitioned from a paper health record to an electronic medical record. Each of these changes may have independently affected our study's outcomes or the ability to capture data accurately. The standardized discharge summary was part of an overall quality improvement measure for the Family Medicine inpatient team and was designed in accordance with Project RED and Medicare documentation requirements with their emphasis on improved readability. Additionally, we only studied patients within our military medical system. Our practice patients who were admitted to hospitals other than our facility were not included in the analysis.

Despite the unanticipated outcomes involving ED utilization and hospital readmission rates after our intervention, the strategies used by our team within this quality improvement initiative subjectively enhanced communication and coordination of care within our practice. These benefits included clear communication of the study's objectives, a standardized script for the TOCC, a standardized discharge summary format for the Family Medicine inpatient team, and the establishment of common, obtainable goals. We believe that the value we derived from these strategies can be replicated, and should be used throughout the MHS.

Conclusion

The implementation of a TOCC within an academic clinic at a large MTF has significantly increased our patient population's frequency of ED visits and hospital readmissions after discharge. However, trends during our postimplementation period suggest possible future benefit of a TOCC if assessed over a longer period of time. The broader medical literature still largely supports an overall cost, quality, and utilization benefit by improving transitions in care. Therefore, the MHS should investigate the utility of this effort on a larger scale.

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Influence of Individual Determinants on Physical Activity at Work and During Leisure Time in Soldiers: A Prospective Surveillance Study

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Abstract

Quantified physical activity is an important parameter for evaluating the risk of the incidence of internal and musculoskeletal disorders. The objective of this study was to evaluate the physical activity of German Soldiers on duty and during leisure time with regard to individual determinants and to evaluate if factors associated with the risk of the incidence of internal or musculoskeletal disorders are of relevance for physical activity.

For this purpose, we conducted activity measurements on 169 subjects. The accelerometer-based activity sensor was worn for 7 consecutive days. The number of steps taken was evaluated as an activity marker.

We observed that a high body mass index and a large waist circumference were associated with a low activity level. Women were found to be more active than men, particularly during leisure time. Personnel under 25 years of age were more physically active than those between 25 and 50 years of age. Subjects with underlying musculoskeletal disorders were less active than those who had internal disorders or were healthy. Men and overweight people run a higher risk of developing musculoskeletal and internal disorders.

Health promotion should focus on raising the physical activity level with the aim of exerting a positive influence on the associated risk factors.

Individual body dimensions and derived characteristics are reflected in the physical activity level (PAL). For example, it has been shown that the body mass index (BMI) and body fat percentage of children correlate negatively with their physical activity.[1] If the PAL is changed by a daily target number of steps being set and the use of pedometers, parameters like BMI, body fat percentage, and weight can be influenced.[2] Data have been collected on the classification of physical activity and its importance for a healthy lifestyle.[3] It has been postulated that adults over 30 years of age should take an average of more than 10,000 steps a day to reduce their risk of developing disorders associated with inactivity.[3] Various disorders, eg, the risk of cardiovascular diseases, can be influenced positively by an adequate activity level.[4] Woolf et al have shown that, in addition to physical activity, age and diet have a significant influence on body dimensions and that there is a specific interdependence among these factors.[5]

Recommendations regarding exercise should be adjusted to specific factors. For example, it is recommended that children take up to 12,000-15,000 steps a day in order to be rated as active and to have a positive effect on their state of health.[6] Appropriate guidelines have also been published for older people.[7] Moreover, evidence suggests that the positive effects of exercise on body dimensions and health risks also differ between office workers and workers who do physical work.[8] Irrespective of this, it was shown that exercise during leisure time correlates with the level of training. Workers who do physical work and craftsmen exercise less during their leisure time than office workers.[9] Attitudes towards physical activity differ with gender. They are particularly associated with sociocultural influences. For example, men in southeast Asia show a higher level of physical activity, while no standard gender differences have been observed in Western industrial nations due to different factors influencing working and private lives.[9,10] In addition, office workers and executive personnel usually have a lower level of physical activity during working hours, and this entails health risks.[11] Soldiers need high PAL in their physical training to be prepared for deployment.[12] Studies from the US Army showed that physical activity is also dependent on the specific type of training the Soldier is conducting.[13] During deployment, Soldiers showed decreased physical activity compared to that experienced during predeployment preparation.[14]

The extent to which physical activity of Soldiers is influenced by factors such as age, BMI, waist circumference, gender, and job is not yet fully clear. For this reason, we conducted this study to evaluate the physical activity of a personnel cohort on duty and during leisure time with regard to individual physical determinants. Our study was also intended to evaluate how far above mentioned risk factors known to influence the incidence of musculoskeletal disorders, injuries, and internal disorders are of relevance in the case of Soldiers.

Methods

The study was conducted with 169 subjects (142 male, 27 female). Twenty-five subjects were officers, 89 were noncommissioned officers (NCO), and 55 were junior enlisted personnel. Ninety-seven subjects mainly did office work, while 72 mainly did physical work. The mean age of the subjects was 27.5±8.3 years, their mean weight was 84.3±16.4 kg, their mean BMI was 26.6±4.3 kg/m^2, and their mean waist circumference was 90.2±13.3 cm. The subjects underwent a medical examination. Only Soldiers who did not show any acute limiting disorder that prevents him or her from doing regular service were included. Health records of each participant were evaluated with regard to musculoskeletal disorders, injuries, internal disorders, and regular use of medication.

To be as precise as possible, an activity profile was produced which distinguishes for time spent walking, standing, or lying/sitting covering the duty hours and leisure time of the subjects 24 hours a day over a period of 7 consecutive days.[15] Physical activity was measured by using the wearable sensor activPAL (PAL Technologies, Glasgow, UK). The activPAL is an accelerometric sensor that can detect a person's body position, any changes in this position, the steps taken, and the step frequencies (measuring frequency: 10 Hz), as well as calculate the energy the person consumed on the basis of these data. Reliability of this sensor was tested by Dahlgren et al.[16] Following the manufacturer's instruction, after activation, the sensor was taped onto the midline of the right anterior thigh of the subjects. The participants were also asked to keep a daily activity log, which was correlated with the readings. These results were assigned to distinct measuring points in the activity log, eg, start of duty, end of duty, breaks, night rest, and exercise. The study was approved by the ethical committee of the University of Rostock (Reference No. A 2009 36) and we obtained a written informed consent from each participant.

Statistical Analysis

Descriptive statistics were determined (mean, standard deviation, minimum, and maximum). The statistical significance test between the groups was based on an analysis of variance (ANOVA and post hoc least significant difference test). Paired comparisons were checked using an independent sample *t* test. The level of significance was established at $P \leq .05$. F-statistic and eta^2 were reported. All the data were computed using the SPSS statistical program version 21.0 (SPSS Inc, Chicago, IL, USA).

Additionally, a bipartite analysis was conducted. First, the categorisation of the study cohort examined according to the various parameters (waist circumference, BMI, age, state of health, gender, and job) was conducted as a basis for assessing whether there was a difference in activity between built up groups. In a second statistical analysis, the relationships between the above-mentioned parameters and significant predictors of physical activity were determined in subsequent correlation and regression analyses. Therefore, the individual parameters were correlated with one another or whether there were specific predictors of physical activity. For this purpose, a correlation analysis was conducted, ie, the calculation of Pearson's correlation coefficient (r) for metric readings and Spearman's correlation coefficient for category readings (CS). A multiple linear regression analysis was conducted. The coefficient of determination (R^2), the standardized regression coefficient (β), and the nonstandardized regression coefficient (b) of the predictors together with the Pearson correlation coefficient and semipartial correlation squared (sr^2) were reported. The effect size was calculated with G*Power. According to Cohen, the effect size f^2 was interpreted as follows: $f^2 = 0.02$ minor effect, $f^2 = 0.15$ moderate effect, $f^2 = 0.35$ major effect.[17]

Results

The mean awake time for the 169 participants was 16.5 (±1) hours per day. As a mean, they passed 8,500 steps during that time. They were sitting or lying 65.6% (±7.5%) of that time. Only 10.2% (±2.91%) of the time awake was spent walking. and 24.2% (±5.6%) of the time awake was spent standing. Only 41 Soldiers reached the recommended step count of 10,000 steps/day.

Influence of Individual Physical Determinants

Age

Subjects were divided into 5 groups by age in years: <25, 25 to 30, 31 to 40, 41 to 50, >50. This classification was used to produce a distribution of participants such that there were enough participants in every group. Considering the subjects' ages, participants under 25 years of age were significantly more active than those between 25 and 50 years of age as shown in Figure 1 and Table 1. There were no significant differences among the subjects aged 25 years or more in the various age groups.

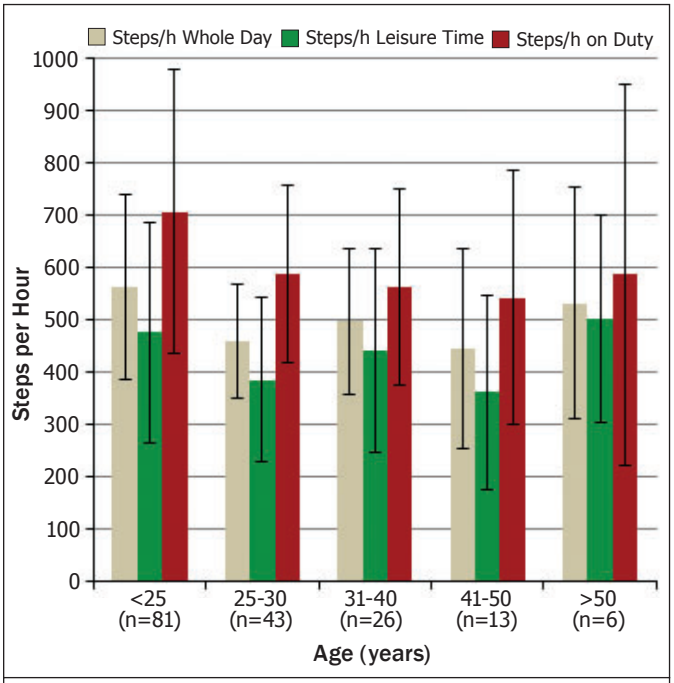

Figure 1. Influence of age on physical activity levels. Plotted steps per hour (steps/h) is the mean (±SE) of the detected steps of participants by age group over each daily measuring period category. Note: N=169 total participants.

Table 1 and Figure 1 shown that subjects over 50 years of age were just as active as those under 25 years of age. Increased activity during duty hours correlated positively with subjects of a young age (r=0.24; P=.002). A negative correlation was observed between a high PAL, particularly during leisure time, and older age ($r \leq$-0.177; $P \leq$.021). Older age correlated with a higher weight (r=0.314; P<.001), a larger waist circumference (r=0.444; P<.001), and a higher BMI (r=0.361; P<.001).

Job Position at Work

The number of steps taken per hour during work time decreased among subjects who had a higher or senior job position, shown in Table 2. During leisure time, officers were more active than NCOs, and junior enlisted personnel tended to be more active than NCOs (Table 1). Mean BMI of the NCOs was 26.7 kg/m^2, and thus tendentially higher than that of officers (BMI 25.5 kg/m^2, P=.071) and significantly higher than that of junior enlisted personnel (BMI 25.3 kg/m^2, P=.011). This trend is also evident with regard to waist circumference (officer and junior enlisted, 87 cm; NCO, 92.5 cm; P=.015 and P=.004, respectively).

Low-level positions at work correlated negatively with the incidence of internal disorders (CS=-0.339; P<.001) and disorders of the locomotor system (CS=-0.302, P<.001) and positively with high activity levels on duty (CS=0.278; P<.00

Gender

Altogether, women showed a higher activity level than men (F=3.91; P=.007) as shown in Figure 2. No relevant difference was observed during duty hours (F=1.834; P=.607). However, during leisure time the number of steps taken was significantly higher among the women than in the male comparison group (F=13.459; P<.001) (Figure 2). Female gender correlated with an increase in leisure activity (CS=0.205; P=.001). Furthermore, a high BMI correlated negatively with female gender (CS=-0.306; P<.001).

BMI

As shown in Figure 3, there was a significant difference in activity between Soldiers of normal weight (BMI<25 kg/m^2) and overweight Soldiers (BMI between 25 and 30 kg/m^2). Subjects of normal weight achieved a higher step count than overweight subjects (F=2.131; e^2=170760.611; P=.04). Participants of normal weight got up to 42 minutes more sleep a day than obese subjects (P=.048) and 24 minutes more than overweight subjects (P=.012).

Waist Circumference

Soldiers with a large waist circumference were less physically active. Additionally, as shown in Figure 4 and Table 3, significant differences in the number of steps taken during duty hours and leisure time were observed between the groups studied. The difference in leisure time activity was particularly clear. Soldiers with a waist circumference below 90 cm were markedly more active

Table 1. P-values of the comparison of activity levels in relation to age groups for whole day, leisure time period, and on duty period as shown in Figure 1.*

Whole Day				
Age Group (y)	25-30	31-40	41-50	>50
<25	.001	.07	.014	.0648
25-30		.0331	.0783	.0292
31-40			.0333	.063
41-50				.0268
Leisure Time				
Age Group (y)	25-30	31-40	41-50	>50
<25	.015	.0453	.051	.0739
25-30		.024	.0694	.0167
31-40			.022	.0493
41-50				.0141
On Duty				
Age Group (y)	25-30	31-40	41-50	>50
<25	.009	.009	.023	.0239
25-30		.0676	.0547	.0992
31-40			.0798	.0826
41-50				.0706

*Note: Whole day: F=3.901; e^2=397645.31; P=.005
Leisure time: F=2.212; e^2=334402989; P=.07
On duty: F=3.346; e^2=762120.334; P=.012

during their leisure time than those with a larger waist circumference. No significant differences in physical activity were observed among subjects with a waist circumference above 90 cm. A large waist circumference correlated negatively with female gender (CS=-0.412; P<.001) and fixed-term employment contracts (CS=-0.292; P<.001). A larger waist circumference correlated positively with a higher BMI (CS=0.744; P<.001), older age (CS=0.45; P<.001), the incidence of internal disorders (CS=0.327; P<.001) or orthopedic disorders (CS=0.302, P<.001), and use of medication (CS=0.241; P<.002). A negative correlation was observed between a high PAL, particularly during leisure time, and older age (r≤-0.177; P≤.021), waist circumference (r≤-0.253; P≤.001), and BMI (r≤-0.158; P≤.04).

Table 2. Mean (±SE) step counts per hour of participants by military rank status over each daily measuring period category, with *P*-values of comparison among rank groups.

Military Rank Status	Steps per Hour		*P*-values of Comparison With NCO Count		*P*-values of Comparison With Officer Count	
	On Duty	Leisure Time	On Duty	Leisure Time	On Duty	Leisure Time
Junior Enlisted	725 (±245)	411 (±130)	<.001	.057	<.001	.009
NCO	579 (±202)	434 (±208)			<.001	.008
Officer	541 (±219)	537 (±247)	<.001	.008		

State of Health

The analysis showed that the activity levels of subjects with preexisting chronic internal disorders (hypertension, hyperuricemia (n=22)) did not differ significantly from those of healthy subjects. Subjects with chronic orthopedic (n=24) or chronic internal and orthopedic disorders (n=15) took approximately 100 steps per hour less than healthy subjects (F=2.981; e^2=155.091; P=.017) or subjects who only had preexisting internal disorders (P=.03).

Subjects with a history of acute injury to the locomotor system (distortion of the upper ankle joint, muscle injuries) were less physically active. Subjects without a history of injury (n=135) were physically active (time spent waking) for 12.5% of their duty hours, while this figure was 10.5% for subjects with a history of injury (n=34) (F=0.597; P=.01). Regarding leisure activity, there were no significant differences between subjects with and without a history of injury. Short-term employment contracts (12 to 24 months) correlated negatively with internal disorders (CS=-0.459; P<.001), injuries suffered due to exercise (CS=-0.447, P<.001), use of medication (CS=-0.302; P<.001), and BMI (CS=-0.299; P<.001). There was no significant correlation between an increase in body dimensions (BMI and waist circumference) or low levels of physical activity and the number of visits to a doctor. The amount of exercise the subjects performed also did not correlate with the number of visits to a doctor. However, increased physical activity on duty correlated negatively with the incidence of injuries (CS=-0.152; P<.049).

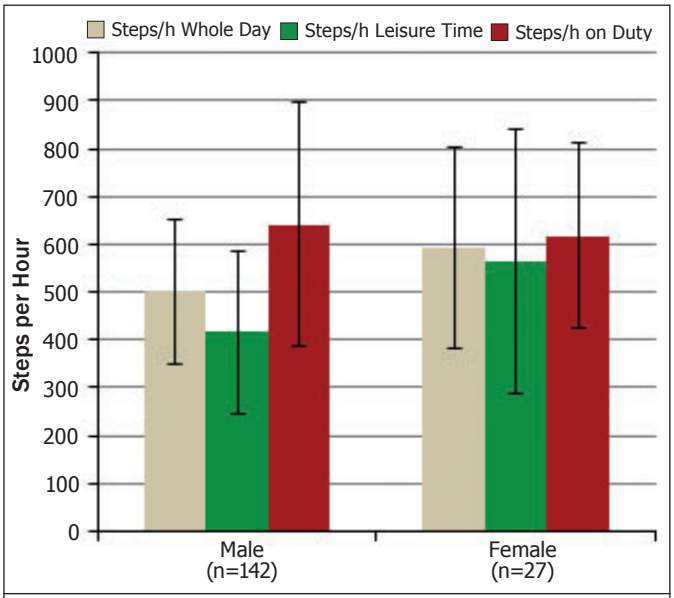

Figure 2. Influence of gender on physical activity levels. Plotted steps per hour (steps/h) is the mean (±SE) of the detected steps of participants by gender over each daily measuring period category. Note: N=169 total participants.

Correlation and Regression Analysis of the Determinants-Predictors of Activity

In the following sections we describe the results of the correlation and regression analysis of the influence of known risk factors of internal and orthopaedic diseases on physical activity. We investigated the effect of the risk factors on step count per day as well as on step count per hour in mean, leisure time and on duty. In order of appearance, we identified waist circumference, BMI, age, and gender to be the main predictors of physical activity.

Step Count Per Hour (Mean)

The statistic model was significant at F=4.645 (P=.001), and the model equation correlated to R=0.321 with the criterion variable (R^2=0.103; R^2adjusted=0.081; f^2=0.115; power=0.99). The variance in the mean step count per hour was predicted to a significant extent by the variable waist circumference (β=-0.511; b=-6.374; SE=2.059; P=.002; r=-0.283; sr^2=0.06). Waist circumference accounted for 10.3% of the variance in the mean step count per hour.

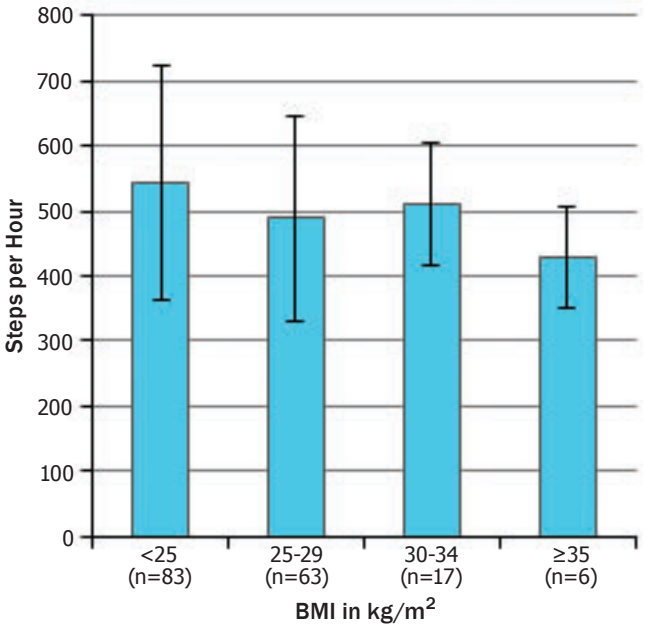

Figure 3. Influence of BMI on physical activity levels. Plotted steps per hour (steps/h) is the mean (±SE) of the detected steps of participants by BMI score grouping over each daily measuring period category. Note: N=169 total participants.

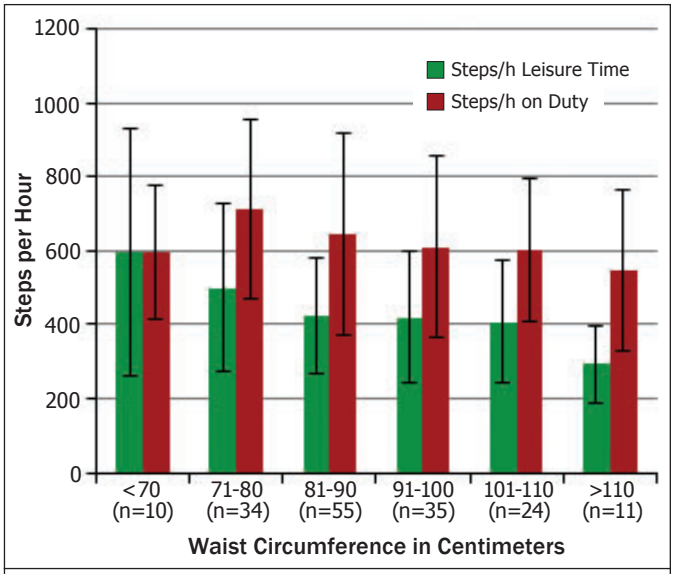

Figure 4. Influence of waist circumference on physical activity levels. Plotted steps per hour (steps/h) is the mean (±SE) of the detected steps of participants by BMI score grouping over each daily measuring period category. Note: N=169 total participants.

Step Count per Hour (During Duty Hours)

The statistic model was significant at F=3.051 (P=.019), and the model equation correlated to R=0.265 with the criterion variable (R^2=0.07; R^2adjusted=0.047; f^2=0.075; power=0.944). The variance in the step count per hour during work time was predicted to a significant extent by the variable age (β=-0.215; b=-6.351; SE=2.517; P=.013; r=-0.153). Age accounted for 7% of the variance in the step count per hour during duty hours.

Step Count per Hour (During Leisure Time)

The statistic model was significant at F=3.431 (P=.01), and the model equation correlated to R=0.279 with the criterion variable (R^2=0.078; R^2adjusted=0.055; f^2=0.085; power=0.96). The variance in the step count per hour during leisure time was predicted to a significant extent by the variable waist circumference (β=-0.469; b=-6.972; SE=2.487; P=.006; r=-0.284; sr^2=0.033). Waist circumference accounted for 7.8% of the variance in the step count per hour during leisure time.

Step Count per Day (Mean)

The statistic model was significant at F=2.653 (P=.007), and the model equation correlated to R=0.362 with the criterion variable (R^2=0.131; R^2adjusted=0.082; f^2=0.151; power=0.999). The variance in the mean step count was predicted to a significant extent by the variables waist circumference (group) (β=-0.417; b=-6020.038; SE=1827.427; P=.001; r=-0.298; sr^2=0.06) and BMI (group) (β=0.242; b =5609.392; SE=2687.715; P=.038; r=-0.128; sr^2=0.024). Waist circumference (group) and BMI (group) accounted for 13.1% (41.7%: 24.2%) of the variance in the mean step count.

Step Count per Day (During Leisure Time)

The statistic model was significant at F=4.298 (P<.001), and the model equation correlated to R=0.443 with the criterion variable (R^2=0.197; R^2adjusted=0.151; f^2=0.245; power=0.99). The variance in the step count during leisure time was predicted to a significant extent by the variables waist circumference (group) (β=-0.352; b =-4196.461; SE=1451.402; P=.004; r=-0.296; sr^2=0.009), BMI (group) (β=0.221; b=4221.637; SE=2134.67; P=.05; r=-0.127; sr^2=0.02), and gender (β=0.271; b=11369.217; SE=3394.708; P=.001; r=0.326; sr^2=0.057). Waist circumference (group), BMI (group), and gender accounted for 19.7% (35.2%: 22.1%: 27.1%: 19.7%) of the variance in the step count during leisure time.

Comment

This study shows that some individual determinants correlate with physical activity. Analogous to the study conducted by Woolf et al, it has been shown that a large waist circumference correlates negatively with physical activity.[5] Our study has also shown that the leisure time PAL was particularly dependent on the waist circumference.

With regard to age, subjects under 25 years of age and over 50 years of age in particular showed a comparably high level of physical activity. The subjects in the age groups in between were less active, particularly during their leisure time. Subjects who had a history of injury to the locomotor system or suffered from a musculoskeletal disorder were less active than those who had only internal disorders or were healthy. Physical activity is thus limited by musculoskeletal disorders, which was specifically demonstrated for spondyloarthropathy.[18] As a consequence of these factors, attention should be paid to the fact that the BMI and waist circumference increase in relation to the level of physical inactivity, particularly during leisure time, and constitute risk factors for the development of orthopedic and internal disorders. For example, a high body weight is a significant risk factor for the incidence of gonarthrosis.[19,20]

Regarding the influence of gender on physical activity, our survey is unlike the findings of Cheah et al[10] in that we found women are more active than men, particularly during their leisure time. This also correlated with our finding that the female subjects had smaller waist circumferences and lower BMIs than the male subjects. All recruited women had fixed-term employment contracts. Irrespective of gender, it was revealed that people with fixed-term employment contracts were more likely to have normal values (BMI and waist circumference) than employees with contracts of indefinite duration.[11]

Other working group studies have shown that social status is an especially important predictor and that a low status correlates with poor health behavior.[21] In our study, employment contracts of indefinite duration are associated with higher earnings and status within the cohort. Age is a key factor here. Some permanent employees had a lower status than some temporary employees who held executive positions. In an earlier study, we showed that noncommissioned officers, who are comparable to intermediate service employees, had a significantly unhealthier lifestyle than officers.[11] The current study has also shown that officers are less physically active during duty hours than other comparison groups, but they compensate for this deficiency by increased leisure activity. Beenackers et al observed a greater health awareness in higher social classes.[22] Our study has confirmed that in addition to affiliation to a specific job position group; age, waist circumference, BMI, and gender in particular constitute predictors of physical activity.

This study has some limitations. Environmental factors, which also affect physical activity, such as the area in which the subjects live, public transport, and the route they take to work or shopping facilities, have not been analyzed.[23] The fact that the subjects were recruited from a single occupational group (Soldiers), the limited number of participants, and the resulting imbalance in their age and gender structure must also be acknowledged as limitations.

In summary, the present study identified waist circumference, BMI, age, and gender as essential predictors of physical activity. A large waist circumference, a high BMI, and the male gender correlate with low PALs, particularly during leisure time. The subjects under 25 years of age and between 50 and 60 years of age were more active than subjects between those age groups. Subjects with musculoskeletal disorders were less active than healthy subjects or those with internal disorders. Health promotion should focus on raising the physical activity level, particularly during leisure time, with the aim of exerting a positive influence on the associated risk factors.

Table 3. *P*-values of the comparison of activity levels in relation to waist circumference for leisure time period and on duty period.*

Leisure Time					
Waist Circumference	71-80 cm	81-90 cm	91-100 cm	101-110 cm	>110 cm
<70 cm	.0023	<.0001	<.0001	<.0001	<.0001
71-80 cm		.0018	.002	.0052	.001
81-90 cm			.0836	.0994	.0246
91-100 cm				.0871	.0328
101-110 cm					.0295
On Duty					
Waist Circumference	71-80 cm	81-90 cm	91-100 cm	101-110 cm	>110 cm
<70 cm	.0195	.0579	.0878	.094	.065
71-80 cm		.0189	.0076	.0088	.0048
81-90 cm			.051	.0487	.0223
91-100 cm				.0916	.045
101-110 cm					.0521

*Note: Leisure time: $F=3.604$; $e^2=650258.13$; $P=.004$
On duty: $F=1.24$; $e^2=370349.64$; $P=.293$

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GEHS Neurophysiological Classification System for Patients with Carpal Tunnel Syndrome

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Abstract

Background: 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. Following a thorough history and physical examination, electrophysiological examination including both nerve conduction studies (NCS) and electromyography (EMG) testing may be performed and currently serve as the reference standard for the diagnosis of CTS. The EMG and NCS exams should identify the peripheral nerve, specific location in the nerve pathway, involvement of sensory and/or motor axons, and the presence of myelinopathy and/or axonopathy neuropathic process.

Neurophysiological Classification Systems for Patients with CTS: Clinical electrophysiologists now have 2 neurophysiological classification systems for patients with CTS from which to choose when preparing their electrophysiological testing reports. The Bland (2000) and GEHS (2012) neurophysiological classification systems for patients with CTS are discussed.

Case Studies: Two case studies of patients with electrophysiological evidence of CTS are presented. Application and comparison of categorizations by the Bland and GEHS neurophysiological classification systems are incorporated into the presentation and discussion of these case studies.

Summary and Clinical Relevance: This article describes 2 neurophysiological classification systems for patients with CTS. The Bland system documents the distribution of patients with CTS on a scale based upon nerve conduction study findings, but it does not include any EMG findings in its grading scale. The GEHS neurophysiological classification system includes findings for both the NCS and EMG components of the electrophysiological examination. The GEHS classification system provides electrophysiological evidence of myelinopathy and/or axonopathy for patients with CTS. Additional research comparing the psychometric properties and prognostic utility of the Bland and GEHS neurophysiologic classifications is warranted.

Median mononeuropathy at or distal to the wrist, or carpal tunnel syndrome, is the most common peripheral nerve compression disorder in the upper extremity.[1-4] 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.[5-7] Carpal tunnel syndrome is defined by the American Academy of Orthopaedic Surgeons as a symptomatic compression neuropathy of the median nerve at the level of the wrist, characterized physiologically by evidence of increased pressure within the carpal tunnel and decreased function of the nerve at that level.[8]

A thorough history and physical examination are considered essential screening tools for detecting signs and symptoms of peripheral neuropathy.[9-12] Nerve conduction measurement is often performed on the median nerve to determine whether certain entrapment neuropathies are present, and nerve conduction studies are considered the gold standard or has criterion-related validation when assessing the electrophysiological status of the peripheral nerve.[3,9-15] The electrophysiological examination including both nerve conduction and electromyography studies should identify the peripheral nerve, specific location in the nerve pathway, involvement of sensory and/or motor axons, and the presence of myelinopathy and/or axonopathy neuropathic process.[10-12]

Neurophysiological Classification Systems for Patients With CTS

Different ways of expressing the severity of carpal tunnel syndrome are found in the existing literature and in clinical records. In 2000, Bland[16] documented the distribution of patients with CTS on a scale based upon nerve conduction study findings. Bland created this CTS classification system largely independent of the exact

normal values used in any given electrodiagnostic laboratory. This classification scale demonstrates a highly significant linear relationship between the neurophysiological grading and a numerical score derived from the clinical history.[16,17] Bland's neurophysiological grading scale for patients with CTS is shown in Table 1.

Nerve conduction studies (NCS) and electromyography (EMG) testing will provide electrophysiological evidence of pathological conditions of the median nerve to include demyelination (myelinopathy) and axon loss (axonopathy).[9-12] The Bland classification system for patients with carpal tunnel syndrome is based on nerve conduction findings but does not include any reference to the EMG portion of the electrophysiological evaluation.[16]

A new neurophysiological classification system for patients with CTS was introduced in 2012.[18] The GEHS (Greathouse, Ernst, Halle, and Shaffer) neurophysiological classification system for patients with CTS includes findings for both the NCS and EMG components of the electrophysiological examination. The GEHS classification system provides electrophysiological evidence of myelinopathy and/or axonopathy for patients with CTS. The GEHS neurophysiological classification system for patients with CTS is shown in Table 2.

The GEHS neurophysiological classification system for patients with CTS is comprised of data from both the NCS and EMG components of the electrophysiological examination.[18] Furthermore, this new system provides information including specific abnormal findings of sensory and/or motor axons and myelinopathy and/or axonopathy. The GEHS neurophysiological classification system for patients with CTS is presently being used by clinical electrophysiologists and has been cited in numerous research manuscripts.[19-23]

Table 1. Bland's Neurophysiological Grading Scale for Patients with carpal tunnel syndrome.[17]

Grade		Nerve Conduction Findings
0	Normal	Normal motor and sensory conduction studies
1	Very mild	CTS demonstrable only with most sensitive tests
2	Mild	Sensory nerve conduction velocity slow on finger/wrist measurement Normal terminal motor latency
3	Moderate	Sensory potential preserved Motor slowing; DML to ABP <6.5 ms
4	Severe	Sensory potentials absent Motor potential preserved; DML to APB <6.5 ms
5	Very Severe	Sensory potentials absent DML to APB >6.5 ms
6	Ext Severe	Sensory and motor potentials effectively unrecordable Surface motor potential from ABP <0.2 mV amplitude

DSL indicates distal sensory latency; DML, distal motor latency; APB, abductor pollicis brevis; and Ext, extremely.

Table 2. GEHS Neurophysiological Classification System for Patients with carpal tunnel syndrome.[19]

Grade	Nerve Conduction and EMG Findings
Very Mild	Abnormal comparison study; eg, prolonged comparison study between D4 median/ulnar DSLs Normal EMG of the APB
Mild (sensory only)	Prolonged palmar and/or D2 DSLs Normal DML to APB Normal EMG of the APB
Mild (sensory and motor)	Prolonged palmar and/or D2 DSLs Prolonged DML to APB <5.0 ms Normal EMG of the APB
Moderate	Prolonged or absent DSLs Prolonged DML to APB <6.0 ms Normal EMG of the APB
Moderate/Severe	Prolonged or absent DSLs Prolonged DML to APB >6.0 ms EMG – presence of abnormal spontaneous electrical activity in the APB; no decrease in interference pattern or abnormal MUP duration and amplitude of the APB
Severe	Prolonged or absent DSLs Prolonged DML to APB >7.0 ms EMG – presence of abnormal spontaneous electrical activity in the APB; decreased interference pattern of APB, may have abnormal duration and amplitude of motor unit potentials in the APB

DSL indicates distal sensory latency; DML, distal motor latency; EMG, electromyography APB, abductor pollicis brevis; APB, abductor pollicis brevis; and D2, digit 2 (index finger).

The purpose of developing and implementing the new GEHS neurophysiological classification system for patients with CTS is to provide health care providers an enhanced system of electrophysiological evaluation and grading scale so that they may evaluate and treat their patients with CTS with the most complete electrophysiological data that includes both NCS and EMG testing. This article describes the GEHS neurophysiological classification system for patients with CTS and presents 2 case studies of patients with electrophysiological evidence of CTS. The Bland and GEHS neurophysiological classification system for patients with CTS is incorporated into the presentation and discussion of these case studies.

Case 1

A 49-year-old right-hand dominant woman was referred by an orthopaedic surgeon for electrophysiological evaluation of suspected bilateral CTS. She is employed as a unit coordinator at a local school district. In January 2013, the patient noted numbness and tingling (N/T) in the palmar surface of both hands. She has no past medical history of bilateral upper extremity problems and

denies recent trauma to the neck or both upper extremities (BUE). In the right upper extremity (RUE) she has N/T in the palmar surfaces of all digits (D1-D5), but otherwise denies N/T in the RUE proximal to the wrist. She denies pain or weakness in the RUE. The left upper extremity (LUE) symptoms are identical to the RUE but less severe in the left hand. No proximal N/T, pain, or weakness in the LUE. She has chronic neck pain but denies radicular symptoms in BUE. The patient denies history of headaches, or visual or cranial nerve problems. She was evaluated and treated by a chiropractic provider without relief of symptoms. She wears bilateral wrist splints with some relief of symptoms from this intervention. The patient is being treated for anxiety but otherwise, the review of systems is noncontributory for cardiovascular, pulmonary, gastrointestinal, genitourinary, or endocrine problems. She denies diabetes, heavy metal exposure, thyroid disease, renal disease, or alcohol abuse, and has no family history of neuromuscular disease.

The patient was evaluated in May 2014. On physical examination, the patient displayed mild decreased motion of active cervical mobility in all planes with mild neck pain or right side bend and rotation. The Spurling's test to the right produced neck pain, but no neck pain was produced on the left maneuver. Neither the left nor right Spurling's test produced radicular pain in BUE. She had normal active mobility of bilateral shoulder, elbow, forearm, wrist, and hand motions. There was normal (5/5) motor strength testing of bilateral shoulder, elbow, forearm, wrist, and hand motions and there was no atrophy or clonus noted in BUE. The biceps, triceps, and brachioradialis muscle stretch reflexes were present and equal in BUE. The Hoffman reflex was absent in both hands. There was a decreased sensation to light touch and pain (pin prick) in the palmar surfaces of the right thenar eminence and right D2. Otherwise, sensory testing was normal for light touch and pain in BUE, including all peripheral nerves and dermatomes (C4-T1). The Tinel's and Phalen's tests were negative for bilateral median nerve involvement at the wrists. There were normal radial pulses bilaterally for thoracic outlet syndrome in the scalene, costoclavicular, and pectoralis minor/clavipectoral fasica humeral maneuvers.

Results of the nerve conduction and electromyography studies are provided in Tables 3 and 4, respectively. Clinically noteworthy NCS abnormal findings are indicated by the shaded cells in Table 3. Electromyography of selected muscles in BUE (C5-T1 innervation) and bilateral cervical paravertebral muscles were normal (Table 4).

In conclusion of case study 1: this was an abnormal NCS study of BUE and a normal EMG study of BUE and the bilateral low cervical paravertebral muscles. There was electrophysiologic evidence on this exam of a mild, bilateral (right = left) median mononeuropathy at or distal to the wrist; demyelinating neuropathic process; affecting both motor and sensory fibers; EMG of the left and right abductor pollicis brevis (APB) was normal. There was no electrophysiologic evidence on this exam of (1) bilateral median mononeuropathy in the forearms; (2) bilateral ulnar or superficial radial mononeuropathy; or (3) bilateral C5-T1 radiculopathy in BUE and the bilateral cervical paravertebral muscles.

Based on the case study 1 results, the GEHS neurophysiological classification system category was a mild (sensory and motor fiber involvement) bilateral (left and right median nerves) CTS with prolonged palmar and D2 distal sensory latencies (DSLs) and a prolonged distal motor latency (DML) to APB of less than 5.0 milliseconds. EMG of the bilateral APBs was normal. In contrast, the Bland neurophysiological classification system would grade these findings as a bilateral moderate CTS with sensory potential preserved and motor slowing, DML to APB less than 6.5 milliseconds. The Bland system does not include EMG evaluation of the APBs. Both CTS classification systems identified bilateral median motor and sensory involvement with a demyelinating neuropathic process, but only the GEHS classification system demonstrated electrophysiological evidence of the absence of motor fiber axonopathy.

Case 2

A 53-year-old right-hand dominant woman was referred by her primary care provider for electrophysiological evaluation of suspected CTS. The patient is a bus driver. In 2000, the patient was evaluated with NCS and diagnosed with CTS, resulting with treatment of bilateral wrist splints. She had decreased pain and N/T in both hands after using the wrist splints. In the summer of 2014, she noted increased pain and N/T in both hands. After the onset of these new symptoms, she used her wrist splints, but the splints only exacerbated her symptoms. The hand pain and N/T increased with driving and at night. She reported right shoulder pain but otherwise no pain in the RUE other than the hand pain. She denied N/T or weakness in the BUE proximal to the wrist. She had N/T in the palmar surfaces of both hands D1-D5, right more than left. She denied neck pain or radicular pain in BUE. She had low back pain and some occasional N/T in the dorsum and toes of both feet. Otherwise, she denied pain, N/T, or weakness in BLE. The patient is being treated for congestive heart failure and is not on blood anticoagulants. Otherwise, the review of systems was noncontributory for cardiovascular, pulmonary, gastrointestinal, genitourinary, or endocrine

Table 3. Case 1: Nerve Conduction Study Results. Note: clinically noteworthy values are indicated by shaded cells.

Anti Sensory Summary											
Site	**NR**	**Peak (ms)**	**Normal Peak (ms)**	**P-T Amplitude (μV)**	**Normal P-T Amplitude (μV)**	**Site 1**	**Site 2**	**ΔP (ms)**	**Distance (cm)**	**Velocity (m/s)**	**Normal Velocity (m/s)**
Left Superficial Radial Anti Sensory (Base 1st Digit)											
D1		2.3	<2.7	21.4		D1	Base 1st Digit	2.3	10.0	43	
Right Superficial Radial Anti Sensory (Base 1st Digit)											
D1		2.5	<2.7	28.4		D1	Base 1st Digit	2.5	10.0	40	
Ortho Sensory Summary											
Site	**NR**	**Peak (ms)**	**Normal Peak (ms)**	**P-T Amplitude (μV)**	**Normal P-T Amplitude (μV)**	**Site 1**	**Site 2**	**ΔP (ms)**	**Distance (cm)**	**Velocity (m/s)**	**Normal Velocity (m/s)**
Left Median Ortho Sensory (Wrist)											
Palm		2.8	<2.2	46.3	>15	Palm	Wrist	2.8	8.0	29	
D2		4.0	<3.6	21.9	>15	D2	Wrist	4.0	14.0	35	
Right Median Ortho Sensory (Wrist)											
Palm		2.8	<2.2	26.8	>15	Palm	Wrist	2.8	8.0	29	
D2		4.3	<3.6	13.8	>15	D2	Wrist	4.3	14.0	33	
Left Ulnar Ortho Sensory (Wrist)											
Palm		1.7	<2.2	60.8	>10	Palm	Wrist	1.7	8.0	47	
D5		2.9	<3.5	23.8	>10	D5	Wrist	2.9	14.0	48	
Right Ulnar Ortho Sensory (Wrist)											
Palm		1.8	<2.2	48.2	>10	Palm	Wrist	1.8	8.0	44	
D5		2.9	<3.5	27.0	>10	D5	Wrist	2.9	14.0	48	
Motor Summary											
Site	**NR**	**Onset (ms)**	**Normal Onset (ms)**	**O-P Amplitude (mV)**	**Normal O-P Amplitude (mV)**	**Site 1**	**Site 2**	**ΔO (ms)**	**Distance (cm)**	**Velocity (m/s)**	**Normal Velocity (m/s)**
Left Median Motor (Abd Poll Brev)											
Wrist		4.8	<4.2	4.8	>5	Elbow	Wrist	3.6	23.0	64	>50
Elbow		8.4		6.7							
Right Median Motor (Abd Poll Brev)											
Wrist		4.9	<4.2	3.1	>5	Elbow	Wrist	4.4	25.0	57	>50
Elbow		9.3		3.3							
Left Ulnar Motor (Abd Dig Minimi)											
Wrist		2.9	<3.6	7.2	>5	B Elbow	Wrist	3.2	20.0	63	>50
B Elbow		6.1		5.1		A Elbow	B Elbow	1.6	12.0	75	>50
A Elbow		7.7		5.5							
Right Ulnar Motor (Abd Dig Minimi)											
Wrist		2.8	<3.6	8.6	>5	B Elbow	Wrist	3.3	21.0	64	>50
B Elbow		6.1		8.5		A Elbow	B Elbow	1.6	12.0	75	>50
A Elbow		7.7		8.2							

NR indicates no response; P-T, peak to trough; and O-P, onset to peak.

problems. She denied diabetes, heavy metal exposure, thyroid disease, renal disease, or alcohol abuse. Her maternal aunt has multiple sclerosis, but otherwise there is no family history of neuromuscular disease.

The patient was evaluated in March 2015. On physical examination, the patient had normal active cervical motion in all planes without neck or BUE pain. Both the left and right Spurling maneuvers were normal without pain in the neck or BUE. She had normal active mobility of bilateral shoulder, elbow, forearm, wrist, and hand motions. There was 3+/5 motor strength of the bilateral APB and opponens pollicis, but otherwise there was normal (5/5) motor strength testing of bilateral shoulder,

Table 4. Case 1: Electromyography Results.

Side	Muscle	Nerve	Root	Ins Act	Fibs	Psw	Amp	Dur	Poly	Recrt	Int Pat	Comment
Right	1stDorInt	Ulnar	C8-T1	Nml	Nml	Nml	Nml	Nml	0	Nml	Nml	
Right	Abd Poll Brev	Median	C8-T1	Nml	Nml	Nml	Nml	Nml	0	Nml	Nml	
Right	PronatorTeres	Median	C6-7	Nml	Nml	Nml	Nml	Nml	0	Nml	Nml	
Right	ExtCarRadLong	Radial	C6-7	Nml	Nml	Nml	Nml	Nml	0	Nml	Nml	
Right	Biceps	Musculocut	C5-6	Nml	Nml	Nml	Nml	Nml	0	Nml	Nml	
Right	Triceps	Radial	C6-7-8	Nml	Nml	Nml	Nml	Nml	0	Nml	Nml	
Right	Deltoid	Axillary	C5-6	Nml	Nml	Nml	Nml	Nml	0	Nml	Nml	
Right	Cervical Parasp Low	Rami	C7-8	Nml	Nml	Nml						
Left	1stDorInt	Ulnar	C8-T1	Nml	Nml	Nml	Nml	Nml	0	Nml	Nml	
Left	Abd Poll Brev	Median	C8-T1	Nml	Nml	Nml	Nml	Nml	0	Nml	Nml	
Left	PronatorTeres	Median	C6-7	Nml	Nml	Nml	Nml	Nml	0	Nml	Nml	
Left	ExtCarRadLong	Radial	C6-7	Nml	Nml	Nml	Nml	Nml	0	Nml	Nml	
Left	Biceps	Musculocut	C5-6	Nml	Nml	Nml	Nml	Nml	0	Nml	Nml	
Left	Triceps	Radial	C6-7-8	Nml	Nml	Nml	Nml	Nml	0	Nml	Nml	
Left	Deltoid	Axillary	C5-6	Nml	Nml	Nml	Nml	Nml	0	Nml	Nml	
Left	Cervical Parasp Low	Rami	C7-8	Nml	Nml	Nml						

Abbreviations
Nml: normal
Ins Act: insertional activity
Fibs: fibrillation potentials
Psw: positive sharp waves
Amp: amplitude
Dur: duration
Poly: polyphasic
Recrt: recruitment
Int Pat: interference pattern

elbow, forearm, wrist, and hand motions, and there was no atrophy or clonus noted in BUE. The biceps, triceps, and brachioradialis muscle stretch reflexes were present and equal in BUE. The Hoffman reflex was absent in both hands. There was a decreased sensation to light touch (LT) and pain (pin prick) in the palmar surface of the right thenar eminence and right D1, and increased sensation to LT and PP in the palmar surface of the left D1. Otherwise, sensory testing was normal for LT and pain in BUE to include all peripheral nerves and dermatomes (C4-T1). The Tinel's and Phalen's tests were negative for bilateral median nerve involvement at the wrists. There were normal radial pulses bilaterally for thoracic outlet syndrome in the scalene, costoclavicular, and pectoralis minor/clavipectoral fasica humeral maneuvers.

Results of the nerve conduction study are presented in Table 5. Electromyography of selected muscles in BUE (C5-T1 innervation) is presented in Table 6. Clinically noteworthy NCS and EMG abnormal findings are indicated by the shaded cells in Tables 5 and 6. There was abnormal spontaneous electrical activity including increased insertional activity and the presence of fibrillation potentials and positive waves in both the right and left APBs. In the right APB, there was a 50% decreased interference pattern on maximum voluntary contraction but normal configuration (shape, duration and amplitude) of the motor unit potentials (MUPs). There was normal MUP configuration and interference pattern in the left APB. Otherwise, EMG testing of selected muscles in BUE was normal.

In conclusion of case study 2: this was an abnormal NCS and EMG study of BUE. There was electrophysiological evidence on this exam of a severe, bilateral (right more than left) median mononeuropathy at or distal to the wrist; demyelinating and axonal loss neuropathic process affecting both motor and sensory fibers. Chronic denervation was present in both the left and right APB. There was no electrophysiological evidence on this exam of: (1) bilateral median mononeuropathy in the forearms; (2) bilateral ulnar or superficial radial mononeuropathy; (3) bilateral brachial plexopathy; or (4) bilateral C5-T1 radiculopathy in BUE.

Based on the case study 2 results, the GEHS neurophysiological classification system was a severe (sensory and motor fiber involvement), bilateral (right more than left median nerves) CTS with absent palmar and D2 DSLs on the right; prolonged palmar and D2 DSLs on the left; and prolonged DMLs to the right APB (8.9 milliseconds) and left APB (9.1 milliseconds). There was electrophysiological evidence of chronic denervation in both the left and right APB, with decreased interference pattern in the right APB. In contrast, the Bland neurophysiological classification system would grade these findings as a bilateral, very severe CTS with sensory potentials absent and motor slowing; DML to APB more than 6.5milliseconds. The Bland system does not include EMG evaluation of the bilateral APBs. Both CTS classification systems identified bilateral median motor and sensory involvement with a demyelinating neuropathic process, but only the GEHS classification system demonstrated

Table 5. Case 2: Nerve Conduction Study Results. Note: clinically noteworthy values are indicated by shaded cells.

Anti Sensory Summary											
Site	**NR**	**Peak (ms)**	**Normal Peak (ms)**	**P-T Amplitude (μV)**	**Normal P-T Amplitude (μV)**	**Site 1**	**Site 2**	**ΔP (ms)**	**Distance (cm)**	**Velocity (m/s)**	**Normal Velocity (m/s)**
Left Superficial Radial Anti Sensory (Base 1st Digit)											
D1		2.3	<2.7	38.8		D1	Base 1st Digit	2.3	10.0	43	
Right Superficial Radial Anti Sensory (Base 1st Digit)											
D1		2.3	<2.7	33.1		D1	Base 1st Digit	2.5	10.0	43	
Ortho Sensory Summary											
Site	**NR**	**Peak (ms)**	**Normal Peak (ms)**	**P-T Amplitude (μV)**	**Normal P-T Amplitude (μV)**	**Site 1**	**Site 2**	**ΔP (ms)**	**Distance (cm)**	**Velocity (m/s)**	**Normal Velocity (m/s)**
Left Median Ortho Sensory (Wrist)											
Palm		4.2	<2.2	15.7	>15	Palm	Wrist	4.2	8.0	19	
D2		5.1	<3.6	16.3	>15	D2	Wrist	5.1	14.0	27	
Right Median Ortho Sensory (Wrist)											
Palm	NR		<2.2		>15	Palm	Wrist		8.0		
D2	NR		<3.6		>15	D2	Wrist		14.0		
Left Ulnar Ortho Sensory (Wrist)											
Palm		1.9	<2.2	36.6	>10	Palm	Wrist	1.9	8.0	42	
D5		3.3	<3.5	15.5	>10	D5	Wrist	3.3	14.0	42	
Right Ulnar Ortho Sensory (Wrist)											
Palm		1.9	<2.2	30.1	>10	Palm	Wrist	1.9	8.0	42	
D5		3.3	<3.5	17.3	>10	D5	Wrist	3.3	14.0	42	
Motor Summary											
Site	**NR**	**Onset (ms)**	**Normal Onset (ms)**	**O-P Amplitude (mV)**	**Normal O-P Amplitude (mV)**	**Site 1**	**Site 2**	**ΔO (ms)**	**Distance (cm)**	**Velocity (m/s)**	**Normal Velocity (m/s)**
Left Median Motor (Abd Poll Brev)											
Wrist		9.1	<4.2	4.6	>5	Elbow	Wrist	4.8	25.0	52	>50
Elbow		13.9		4.8							
Right Median Motor (Abd Poll Brev)											
Wrist		8.9	<4.2	2.0	>5	Elbow	Wrist	4.8	26.0	54	>50
Elbow		13.7		1.5							
Left Ulnar Motor (Abd Dig Minimi)											
Wrist		3.4	<3.6	5.7	>5	B Elbow	Wrist	3.6	22.0	61	>50
B Elbow		7.0		7.4		A Elbow	B Elbow	1.6	11.0	69	>50
A Elbow		8.6		6.6							
Right Ulnar Motor (Abd Dig Minimi)											
Wrist		3.2	<3.6	10.9	>5	B Elbow	Wrist	3.6	20.0	56	>50
B Elbow		6.8		9.8		A Elbow	B Elbow	1.6	11.0	69	>50
A Elbow		8.4		7.6							

NR indicates no response; P-T, peak to trough; and O-P, onset to peak.

electrophysiological evidence of motor fiber axonopathy in the bilateral APBs by EMG examination.

Comment

The advantage of having this additional information regarding EMG changes (axonopathy) for patients with CTS, is that it provides the health care team and the patient with information that may be useful in determining next treatment steps as well as long-term prognosis. In the case of a patient with EMG changes, the combined effects of compression and ischemia are evident with the loss of a subset of axons and the denervation of a segment of the innervated muscle fibers. The EMG examination specifically provides information regarding motor fiber

Table 6. Case 2: Electromyography Results. Note: clinically noteworthy values are indicated by shaded cells.

Side	Muscle	Nerve	Root	Ins Act	Fibs	Psw	Amp	Dur	Poly	Recrt	Int Pat	Comment
Right	1stDorInt	Ulnar	C8-T1	Nml	Nml	Nml	Nml	Nml	0	Nml	Nml	
Right	PronatorTeres	Median	C6-7	Nml	Nml	Nml	Nml	Nml	0	Nml	Nml	
Right	Abd Poll Brev	Radial	C8-T1	Incr	3+	3+	Nml	Nml	0	Reduced	50%	fib amp<100
Right	Biceps	Musculocut	C5-6	Nml	Nml	Nml	Nml	Nml	0	Nml	Nml	
Right	Triceps	Radial	C6-7-8	Nml	Nml	Nml	Nml	Nml	0	Nml	Nml	
Right	Deltoid	Axillary	C5-6	Nml	Nml	Nml	Nml	Nml	0	Nml	Nml	
Left	1stDorInt	Ulnar	C8-T1	Nml	Nml	Nml	Nml	Nml	0	Nml	Nml	
Left	Abd Poll Brev	Median	C8-T1	Incr	2+	2+	Nml	Nml	0	Nml	Nml	fib amp<100
Left	PronatorTeres	Median	C6-7	Nml	Nml	Nml	Nml	Nml	0	Nml	Nml	
Left	Biceps	Musculocut	C5-6	Nml	Nml	Nml	Nml	Nml	0	Nml	Nml	
Left	Triceps	Radial	C6-7-8	Nml	Nml	Nml	Nml	Nml	0	Nml	Nml	
Left	Deltoid	Axillary	C5-6	Nml	Nml	Nml	Nml	Nml	0	Nml	Nml	

Abbreviations
Nml: normal
Ins Act: insertional activity
Fibs: fibrillation potentials
Psw: positive sharp waves
Amp: amplitude
Dur: duration
Poly: polyphasic
Recrt: recruitment
Int Pat: interference pattern
Incr: increased
fib amp: fibrillation potential amplitude

denervation as confirmed by the presence of increased insertional activity and abnormal resting potentials (eg, positive sharp wave, fibrillations potentials). Additionally, EMG examination provides the healthcare team with information regarding the presence, morphology, and recruitment pattern of motor units that is critical for determining the extent of motor fiber involvement and if reinnervation (polyphasic or large motor potentials) is truly occurring. Collectively, the EMG examination affords critical motor fiber neurophysiologic information that allows the healthcare team, in concert with the patient, to carefully consider interventions.[9-12,24,26]

Although the Bland and GEHS classification schemes provide a framework for reporting and categorizing carpal tunnel syndrome based on neurophysiologic findings, further research regarding the predictive and prognostic value of the classification schemes is needed. Currently research is limited to previous work by Bland et al who surveyed 1,268 patients who had undergone carpal tunnel decompression. Multiregression identified preoperative nerve conduction study findings, greater age, lower symptom scores, longer disease duration, and male gender as significant ($P<.05$) predictors of poor surgical outcome. Nerve conduction studies had the strongest effect of predictors, with patients with middle-grade nerve conduction abnormalities having better results than those with normal results or severe abnormalities.[17] These findings are promising, but additional longitudinal studies examining the predictive and prognostic value of the Bland and GEHS classification schemes regarding various interventions (duty limitations, splinting, mobilization, injection, and surgical release) are recommended. Future trials should also go beyond subjective reporting and include various outcomes measures (surgical findings, self-report, strength, sensation, serial NCS/EMG findings, physical performance testing, and healthcare utilization) and rigorous statistical analysis to determine the prognostic utility and cost/benefit of the classification schemes.

Summary and Clinical Relevance

Clinical electrophysiologists now have 2 neurophysiological classification systems for patients with CTS from which to choose when preparing their electrophysiological testing reports. The Bland classification system was formulated based on nerve conduction study findings only. It was created largely independent of the exact normal values used in any given electrodiagnostic laboratory, and does not include any EMG findings in the grading scale. The GEHS neurophysiological classification system includes findings for both the NCS and EMG components of the electrophysiological examination in its grading scale. The GEHS classification system provides electrophysiological evidence of myelinopathy and/or axonopathy for patients with CTS. Future research comparing the psychometric properties and prognostic utility of the Bland and GEHS neurophysiologic classifications is warranted.

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Q Fever

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Abstract

Q fever is a significant infectious disease threat to US military personnel deployed in the Middle East. Its environmental stability, aerosol transmission, and animal reservoir make it a considerable risk for deployed troops due to its potential for weaponization and risk of natural infection. It presents as a flu-like illness that responds promptly to antimicrobial therapy. Q fever should be suspected in patients presenting with a compatible febrile illness in an endemic area and especially if the individual has been exposed to livestock. Diagnosis is confirmed with serologic blood tests, but empiric therapy should be initiated when Q fever is considered. If left untreated, patients with acute Q fever can develop severe complications as well as chronic disease manifesting several months after the initial infection.

Q fever is a zoonotic infection caused by the obligate intracellular gram negative bacteria *Coxiella burnetti*.[1] First identified in Queensland, Australia, in 1933 and dubbed "Query Fever," it often presents as a self-limited flu-like illness that occasionally causes more severe disease or a chronic form of illness. Q fever has been reported worldwide with recent studies suggesting a high prevalence in Iraq and Iran.[1-4] Estimates from recent studies in the United States suggest that Q fever is significantly more prominent than previously thought, and that US military personnel are at increased risk.[2-6] *C burnetti* infects many animal species, though cattle, sheep, and goats are thought to be the primary reservoirs.[1-7] Human infection usually occurs through inhalation of dust or aerosols from infected animals; however sexual contact, unpasteurized milk, transplacental transmission, and tick bites, though rare, are also known modes of transmission.[1-4,7]

Clinical Presentation

Q fever can present in acute and chronic forms. In acute Q fever, symptoms generally begin 2-3 weeks after infection. Patients present with a constellation of flu-like symptoms that include fever, headache, malaise, myalgias, and gastrointestinal symptoms.[3,7] Severe infection is uncommon but can present as pneumonia, meningitis, and granulomatous hepatitis with inoculum size being proportional to severity.[3,7] The mortality rate varies but is generally estimated to be about 2%.[1-7] Sixty percent of patients infected with *C burnetti* will develop the acute form of infection, however, 1% to 5% of those patients will eventually develop chronic Q fever.[2,3,5-7] Pregnant patients, immunosuppressed patients and those with valvulopathies and prosthetic heart valves are at highest risk of developing chronic Q fever.[3,7] The most common form of chronic Q fever is endocarditis, though vascular, bone, and testicular infections, have been reported.[3] Patients typically develop chronic Q fever 3 months after initial infection.

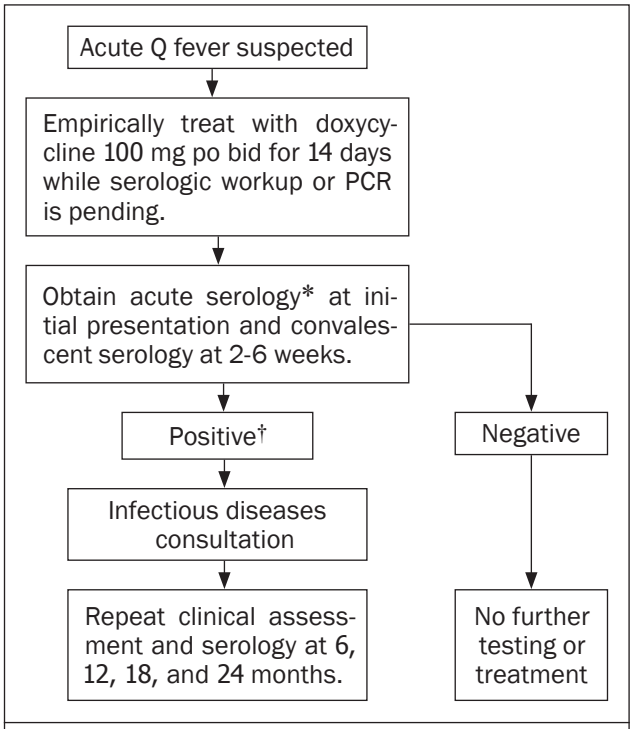
Diagnosis

Q fever is an inherently difficult infection to diagnose. It requires a high level of suspicion and is often a clinical diagnosis with serologic confirmation. In the deployed environment, Q fever infection should be suspected in patients with a flu-like febrile illness with recent exposure to livestock.[7] However, absence of animal exposure should not exclude the diagnosis as a recent study suggested only one third of cases of Q fever had a known exposure.[4-6] Additional clues to infection include prolonged fever, thrombocytopenia, and hepatitis.[3,7] A clinical diagnosis should be confirmed with serology.[3] Providers should collect serum samples at initial presentation and subsequently after 4 to 6 weeks.[3] Of note, empiric therapy of suspected Q fever should not be withheld waiting for laboratory results. Presently, the USAF School of Aerospace Medicine (USAFSAM) is the only Department of Defense (DoD) laboratory approved to perform Q fever serologic testing; ideally all specimens should be sent to USAFSAM to minimize laboratory variation.[3] Serologies can also be performed at the Centers for Disease Control and Prevention (CDC). Commercial laboratories should be avoided as results are often unreliable. Interpretation of these serologies requires understanding of the antigenic phases of *C burnetii* and is beyond the scope of this review.[3] A rapid PCR test is available at some DoD laboratories and may aid in diagnosis. The sensitivity for the rapid PCR test is highest in the first week of infection.[3]

Additional studies should include a complete blood count with differential, a basic metabolic panel, liver-associated enzymes test, erythrocyte sedimentation rate,

and C-reactive protein.[3] Patients with acute fever should have follow-up to ensure resolution of the acute infection. This is best done under the guidance of an infectious diseases physician.[3]

Chronic Q fever should be suspected in patients with a history of acute Q fever and symptoms of chronic infection (fevers, elevated inflammatory markers, heart murmur).[3] Chronic Q fever diagnosis requires the presence of elevated antibody titers, clinical symptoms, and an identifiable source of infection (such as vegetation on a heart valve suggestive of endocarditis).[3] Consideration of chronic Q fever should prompt consultation of an infectious diseases specialist.[3] The Armed Forces Infectious Disease Society and the CDC have provided thorough guidelines, illustrated in the Figure, providing further instruction and guidance on the diagnosis and management of Q fever.[3,7]



Q fever management algorithm. Adapted from Armed Forces Infectious Diseases Society guidelines.[3]

*Serology should be performed at the same reference lab to minimize interlaboratory variability.

†Report confirmed cases to public health/preventive medicine office.

Treatment

Patients with suspected acute Q fever should receive empiric doxycycline 100 mg every 12 hours for 14 days.[3] Pregnant patients should be treated with trimethoprim/sulfamethoxazole (160 mg/800 mg) DS twice daily until delivery.[3,7] Patients treated within the first 3 days of illness typically improve within 72 hours.[7] Treatment for chronic Q fever should consist of doxycycline 100 mg every 12 hours and hydroxychloroquine 200 mg every 8 hours for 18 months and should be coordinated closely with an infectious disease specialist.[3] An effective vaccine for Q fever has been developed in Australia, but is not available in the United States and requires serologic testing prior to administration due to severe inoculation-site reactions related to previous exposures.[7] Prevention efforts should focus on minimizing exposure to livestock and ticks.

Importance in a Deployed Setting

C burnetii is exceptionally infectious (with only a single organism being able to cause infection), easily aerosolized, and can remain stable in the environment for months, making it an attractive agent for bioterrorism, currently category B.[1,3,7] Prior to the Biological Weapons Convention which banned use of biological agents in war, it was studied in offensive weapon programs for this purpose.[1] Additionally, Q fever is endemic to numerous countries where US troops are located, and more than 150 cases among active duty service members deployed in Iraq have been confirmed.[3,4] The risk for natural infection in the deployed setting is presumably due to the primary reservoirs of the disease (cattle, sheep, and goats) being the most common livestock in much of the Middle East.[2]

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Mobile Phone Health Applications for the Federal Sector

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Abstract

Purpose: As the US healthcare system moves toward a mobile care model, mobile phones will play a significant role in the future of healthcare delivery. Today, 90% of American adults own a mobile phone and 64% own a smartphone, yet many healthcare organizations are only beginning to explore the opportunities in which mobile phones can improve and streamline care.

Method: After searching Google Scholar, the Association for Computing Machinery Database, and PubMed for articles related to mobile phone health applications and cell phone text message health, we selected articles and studies related to the application of mobile phones in healthcare. From our initial review, we identified the potential application areas and continued to refine our search, identifying a total of 55 articles for additional review and analysis.

Findings: From the literature, we identified 3 main themes for mobile phone implementation in improving healthcare: primary, preventive, and population health. We recommend federal health leaders pursue the value and potential in these areas; not only because 90% of Americans already own mobile phones, but also because mobile phone integration can provide substantial access and potential cost savings.

Conclusion: From the positive findings of multiple studies in primary, preventive, and population health, we propose a 5-year federal implementation plan to integrate mobile phone capabilities into federal healthcare delivery. Our proposal has the potential to improve access, reduce costs, and increase patient satisfaction, therefore changing the way the federal sector delivers healthcare by 2021.

Although 90% of American adults now own a mobile phone and 64% own some form of smartphone,[1,2] the opportunities for using them in healthcare delivery have remained largely unexplored. Mobile phones are portable, accessible, and ideal for transmitting individualized information; thus, they have the potential to provide means to streamline healthcare at relatively small cost outlays.[3] For now, however, applying mobile phone use toward improving healthcare remains mainly confined to that found in academic studies; despite the evidence indicating the prospective value of employing mobile technology in healthcare, we found no indication that federal healthcare leaders have exercised the capacity on a scale of any magnitude. We recognize the substantial potential for using mobile phones in the areas of primary, preventive, and population health, and a need for federal healthcare to improve its use of this technology to stay competitive in the areas of access, costs, and satisfaction. To seize that potential and answer that need, we propose a 5-year federal implementation plan to integrate mobile phone capabilities into federal healthcare delivery.

Methods

We began our analysis with a comprehensive review of the literature. Using Google Scholar, the Association for Computing Machinery Database, and PubMed, we queried the extant recent literature (2009 to the present) using the following criteria: mobile phone health applications and cell phone text message health. From the result of our query, we included articles and studies specifically relating to the application of mobile phones in healthcare. We excluded those articles that did not have a focus on the use of mobile phones toward improving healthcare such as articles concerning the medical side effects of prolonged cell phone use.

From our review and analysis of the initial set of articles, a pattern emerged. We identified 3 predominant themes in mobile application use in healthcare: primary, preventive, and population health applications. These themes motivated us to further refine our literature search to include search query terms such as mobile phones primary care and cell phone preventive health. Synthesizing our search results, we identified a final sample of 55 articles for subsequent analysis. Our review of the studies formed our recommendation.

Findings

Primary Care

Primary care can be defined as the "continual basic and routine care" that is provided as the first point of care for the patient.[4] The first of our major themes in using

mobile phone technology in healthcare delivery is found in primary care. Both the civilian and federal sectors face a primary care shortage, and the lack of access creates overcrowded emergency rooms and rising costs.[4] In the United States, primary care access is one of healthcare's biggest challenges,[5] and recent studies show that various mobile phone applications can help to improve that access.

First, messaging capabilities between primary care managers and patients can reduce the number of routine visits that do not require face-to-face interaction, such as for prescription renewals. Military treatment facility administrators have started to explore secure messaging in primary care delivery. Secure messaging provides a method to communicate health information electronically while protecting the health information from unauthorized viewing. Available on mobile phones, a goal of secure messaging is to ease communication between primary care managers and patients, allowing patients to ask routine questions without an appointment. Implemented correctly, the secure messaging system can improve access for those who need a physical visit, recapturing care that the military might otherwise send to the civilian sector.

Second, studies show that using text messaging for appointment reminders significantly reduces missed appointments, resulting in up to 40% improved attendance rates.[6,7] These attendance rates receive great attention and are highly visible in the federal system, because of the negative effect that missed appointments have on access and costs. Most efforts to improve missed appointment rates in the military are based on enforcing punitive measures, but these recent studies suggest that a proactive text messaging approach can be very effective and a viable alternative.[6,7] Although the US Army has started to use text messages as appointment reminders, the method has been employed only on a limited scale.[8]

Finally, mobile phones have the potential to improve access by enabling providers and disease managers to effectively monitor chronic conditions. Most relevant studies focus on diabetes, hypertension, and asthma management.[9] Many studies show that text messaging and phone interventions have positively influenced patient behaviors and outcomes, such as by significantly improving blood sugar measures in diabetes patients who received continual text messages to monitor and control their levels.[9] These encouraging text messages spur patients to be involved with their own care, which can help keep them from further complications. Therefore, effective disease management via mobile phones provides a viable option to preserve valuable primary care appointment availability through inspiring a high level of patient engagement in personal health maintenance.

Preventive Health

The second major field for mobile phone use in healthcare is prevention, including smoking cessation, fitness, and immunization reminders, among others. Researchers often focus on smoking cessation, in part because smoking is so prevalent—it is the leading cause of premature deaths in the United States and responsible for 1 in 5 deaths nationwide[10]—and because mobile phone intervention results are so dramatic, increasing cessation rates by up to 70%.[11] Most experiments include interactive text messages that send smokers positive reminders about the benefits of quitting, and replies to messages when the smokers need extra encouragement. These studies have been among those indicating the most effective mobile phone use interventions; the majority of findings show significantly increased cessation rates both in the short- and long-term.[11,12] However, there is limited published literature about mobile phone use as a smoking cessation tool, and that lack of literature may be a contributing factor to Whittaker and colleagues' lack of a significant finding of mobile phones providing a long-term effect on smoking cessation.[11]

Another potential preventive health application is the use of location services to send notifications when a mobile phone is at a specific place. Researchers are beginning to explore this technology as a possibility for just-in-time interventions.[13] People could program their phone with "trigger" locations, like workplace smoking area and favorite fast food restaurant. A visit to these locations would generate a reminder to avoid unhealthy behaviors, intervening in moments of weakened willpower.

The main goal for any preventive health intervention is to change poor behaviors while encouraging good behaviors, so incentives have a large role in mobile phone integration with preventive care. Most mobile phone prevention studies to date focus on intrinsic rewards like self-efficacy—one's ability to plan and proceed toward a goal.[14,15] However, there may be an opportunity to study prevention with other reward systems, especially in the social networking setting. Ultimately, prevention, with or without mobile phones, is about positively influencing patient behaviors to take more individual responsibility for healthcare.

Population Health

Mobile phones have several applications in population health. Healthcare leaders could adopt the model of other data-gathering industries and collect individual health information via mobile phones, analyzing

the data to determine current and localized trends in population health. There are already applications testing this capability, gathering and filtering through large amounts of user-input data to determine where outbreaks happen.[16] For example, Chunara and colleagues[16] outline their own Outbreaks Near Me, an application for Android and iPhone smartphones, with which users can provide real-time disease outbreak reports. They further describe other applications for disease and disaster reporting as well as the ability to integrate the reporting with internet-based outbreak monitoring systems, such as HealthMap.org (http://www.healthmap.org/en/).

These types of applications are especially helpful with cold and flu viruses; people may choose not to visit their primary care managers when they have a virus that only requires symptom management, so the primary care facility may not have an accurate picture of the virus' prevalence without self-reporting. Once trends materialize, mobile phones can be used to disseminate population health messages back to the people. Patients can receive messages that warn of a high flu incidence in their area and provide helpful reminders such as to wash their hands or get vaccinated. This infrastructure would be particularly helpful for population protection; if public health officials suspected a serious epidemic, mass messaging could disseminate that information to many people simultaneously.

Although the Army has started to explore mobile phone integration into traumatic brain injury management,[8] many federal administrators have not been quick to adopt mobile phone technology, perhaps due to the associated challenges. We propose the implementation of a 5-year plan that depends on the federal sector's ability to mitigate the difficulties of privacy and reimbursement. Integrated into our proposal, federal health leaders will have to implement security measures to protect patient information as well as decide how to best capture virtual workload and collect reimbursement from insurers. Without good reimbursement methods, detailed cost-savings of mobile phone use is almost impossible. We provide greater detail of our proposal in the next section.

Comment

After researching effective methods for incorporating mobile phones into health delivery, we propose a 3-phase, 5-year plan for the federal sector to improve access, costs, and patient satisfaction by 2021, allowing federal health to compete in today's health environment.

The first phase will require one year and focuses on perfecting the new secure messaging systems in military health. For example, the Air Force is currently introducing its secure messaging system, MiCare, which advertises a 72-hour response time from a primary care managers.[17] It is critical that Air Force leadership focuses on this response time and adjusts provider schedules accordingly; if this response window is broken early and often in MiCare's debut, patients will view secure messaging as a burden instead of an improvement to their health delivery, making them very hesitant to participate in future efforts. Secure messaging is a pilot program for the federal sector, and military treatment facility leaders should take great care to ensure a smooth implementation.

The second phase in our proposal, lasting approximately 2 years, includes implementing high-visibility programs of interactive appointment and smoking cessation reminders. First, federal health will focus on interactive appointment messages, giving patients the option to reply and immediately reschedule. This is a relatively simple way to improve access and gain patient support for future mobile phone integration. Second, the federal sector will implement an interactive messaging system to assist with smoking cessation in its health and wellness centers. Encouraging smokers to quit is important for both individual health and rising healthcare costs, and this effort will again garner further support for future mobile health applications. Gaining the patients' trust and confidence during this phase will be crucial for the third phase.

The final and most advanced stage, which we also project to have a 2-year duration, includes integrating mobile phones into the federal health sector's disease management and population health programs. This phase depends on the success of patient engagement in the first 2 phases; if disseminating information via mobile phones receives the appropriate public support response, federal health providers can next start collecting information from the patients. Patients can input disease management measures into applications or text messages, which can give the provider better oversight and identify complications before they become severe. Potentially, the disease management information could be integrated into currently available internet-based outbreak monitoring platforms. Similarly, public health officials can pull information from the general population to analyze localized illness trends.

Limitations and Additional Research

As with other approaches that focus on the archival analysis, the sampling procedure is a limitation.[18] Despite our confidences that we chose appropriate and sufficient search criteria for this study, the potential search criteria options are vast. It is possible, perhaps likely, that had we included additional search terms, our search would

have revealed additional articles that would inform this study. Likewise, had we searched in additional databases, we may have unearthed other literature. Future researchers may benefit their analyses by broadening their scope and database selections.

Through this research, we exposed several areas for further inquiry. Although there are numerous studies on appointment reminders, most that we found are limited to one-way messaging: caregivers to patients. Future studies should consider investigating interactive messaging with rescheduling capability, as well as its effect on access. We found that the literature on cost-savings for mobile phones in healthcare is also lacking. Exploring reimbursement models for provider messaging and the effect on costs would contribute insights into reducing costs in healthcare mobile phone use that would be of interest to both researchers and practitioners.

An additional limitation for this study is the sheer pace of innovation; because technology changes at a rapid pace, arguably, some of our suggested applications for mobile phone use may be obsolete and supplanted by newer technology by 2021. Future researchers should note that because of the pace of technology innovation and development, the 5-year plan we propose is suitable for longitudinal study.

Conclusion

The federal health system should employ the 5-year integration plan now to fully use mobile phones in the areas of primary, preventive, and population health. Employing these programs quickly and accurately can help the federal healthcare sector stay competitive in today's environment by improving access, controlling purchased-care costs, and increasing patient satisfaction, all of which will change the way that federal administrators deliver healthcare as we head into the 2020s.

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A Primary Care Telehealth Experience in a US Army Correctional Facility in Germany

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ABSTRACT

Objective: To assess the feasibility of using telehealth (TH) equipment and infrastructure within the US Army's European Theater to evaluate and treat inmates with general medical complaints, and perform physicals and medical safety checks in a US Army Correctional Facility (CORFAC).

Methods and Materials: Synchronous TH encounters were performed using Polycom RealPresence software on providers' computers with high definition cameras on monitors at distant sites and PolyCom HDX9000 Practitioner Cart along with AMD Global Telemedicine devices at the originating site within the CORFAC. These devices included an AMD-2500 General Exam Camera, AMD Fiber optic Otoscope, and AMD Telephonic Stethoscope. Patient consent for TH was obtained, and they were seen in the Medical Dispensary with Army Medics presenting the patients to the providers via TH.

Results: From May 22, 2014, to January 12, 2015, a physician assistant, nurse practitioner, and 4 physicians completed 177 synchronous TH encounters primarily at a CORFAC in Mannheim, Germany. Of these 177 encounters, 114 were Special Housing Unit (SHU) safety checks and 63 encounters were for physicals, medication management, and a variety of medical complaints including acute infections, abdominal pain, and musculoskeletal and dermatological complaints.

Conclusion: Synchronous TH was an effective option for the delivery of high quality routine medical care for minor illnesses, injuries, and other nonurgent conditions, as well as for general physicals and SHU checks in a correctional facility. Acceptance by providers and clinic staff was found to be high. Inmates were generally satisfied with their TH encounters. However, some inmates reported a preference to see providers in-person, highlighting one of the challenges with acceptance of telehealth programs.

Care of prisoners or inmates of correctional facilities poses unique challenges. These include considerations of security threats, challenge of transportation under secure conditions, a varying and highly transient population, and often the remote locations of correctional facilities must all be taken into account when developing a strategy for medical care of this population.

In Europe, the US Army Correctional Facility (CORFAC) was previously located at Mannheim, Germany, 45 geographical miles from the nearest military medical treatment facility (MTF). It moved in 2015 and is now located in Sembach, Germany. The location is 30 to 60 minutes from provider locations at various clinics. The CORFAC census generally ranges from 13-15 inmates who are young (aged 18-40 years) and generally healthy. The inmates in this CORFAC are confined for less than 120 days. Longer confinements are transported to a stateside correctional facility. This mission requires medical support but due to the size would not be efficient use of a full time privileged medical provider. Additionally, the requirement for a provider to commute to and from the CORFAC daily put an unacceptable burden on the productivity of that provider's assigned clinic. Therefore, a solution was proposed in the form of establishing a telehealth protocol.

Telehealth, the practice of interviewing and examining a patient from a remote location using the assistance of trained technicians and high quality video and sound equipment, has been studied for many years in various settings, including prison facilities.[1-5] While TH has been found to have significant potential for increasing productivity, the benefits from a business standpoint have been inconsistent.[6] One concept that seems to be clear is that despite initial resistance from providers and patients, the effectiveness, and satisfaction (for both providers and patients) tends to increase with time and exposure to TH medicine.[1,7,8]

The Department of Defense and Landstuhl Regional Medical Center (LRMC) have invested in the expansion and development of a TH program which has potential for significant benefit in Europe, as downsizing results in communities that are not large enough to justify a dedicated provider.

This article reviews the implementation of a TH program specifically for the European CORFAC. The support of this type of unit can be accomplished by any TH trained provider from any location where video conferencing equipment was available. Any provider connected to the Europe Regional Medical Command (ERMC) intranet can perform medical video teleconferencing from their office desktop. The goal of project was to assess the feasibility of medical visits via TH while meeting the medical mission needs of the CORFAC. The result envisioned was high quality care while decreasing the time and costs spent in provider transportation to and from his/her assigned location.

Materials and Methods

Program Organization

Implementation of this TH effort required a rethinking of the delivery of medical care at the CORFAC by the dispensary technician staff, the primary care providers, and ultimately the patients themselves. Initially, potential barriers identified included possible resistance from medical personnel, lack of staff technical expertise, and difficulties coordinating services. In March 2014, the Landstuhl TH Program Office (THPO) and the CORFAC Dispensary Team began meeting to work through barriers and technical and clinical issues. A standard operating procedure was written with guidelines outlining tasks and roles. Inquiries were made to the American Correctional Association regarding the feasibility and legality of TH in prison systems. Many institutions in the United States were using some form of TH, even if only simple telephonic connections. A 2004 survey of institutions in all 50 states revealed that slightly over half of state correctional institutions and 39% of federal institutions use some type of TH or telemedicine applications.[1] Armed with some existing experience delivering specialty care via synchronous TH in Europe, THPO began training providers and dispensary medical technicians in the use of TH equipment. Per Army Telehealth Policy Memo 08-053,* written informed consent is required prior to participating in synchronous TH. This is obtained from inmates during CORFAC initial processing. Only one inmate chose not to consent to being seen for his medical issues via TH. Telehealth Clinic was performed Monday through Friday, except Wednesdays when a provider was present at the CORFAC. Inmates would register for sick call the night prior and at an agreed upon time the next morning, the TH Clinic would commence in which both patient and the provider would meet in the Virtual Exam Room. The medics assisted providers with physical exam elements during the TH encounter. Special Housing Unit checks were also performed via TH during weekdays.

Correctional Facility Telehealth Patient Encounters.

Reason For Encounter	Number of Encounters
Confinement physical	8
Periodic Health Assessment	8
Medication visit	8
Abdominal pain	6*
Transfer physical	5
Musculoskeletal pain/ injury (other)	5
Intake medical screening	3
Back pain	2
Rash	2
Onychomycosis	2
URI (cold symptoms)	2
Knee pain	1
Lower extremity contusion	1
Toe pain	1
Ankle injury	1
Wrist injury	1
Dry scalp	1
Pharyngitis	1
Chest pain	1
Difficulty sleeping	1
ER F/U syncope	1
Generalized weakness	1
Diarrhea	1
Total sick call encounters	63
Special Housing Unit (solitary confinement) checks	114
Total TH encounters	177

*One abdominal pain patient transferred to emergency department for evaluation.

The Special Housing Unit (SHU) is a location within the correctional facility where inmates are in cells in what is normally called solitary confinement. Special Housing Unit checks are a daily medical safety check which must be performed by a credentialed medical provider assessing both the inmate's cell condition and the general health of the inmate. Special Housing Unit checks consist of a brief presentation by the guard staff as to the condition of the cell and a brief interview with the inmate regarding any overnight health issues or concerns. A review of American Correctional Association Guidelines revealed that solitary confinement checks via TH met the duty of the facility to provide face-to-face credentialed provider daily medical safety checks.[2] A small group of internists at LRMC were trained to perform these checks via TH on weekends.

Sick call presenting complaints were mostly minor involving medication issues, acute illnesses, and injuries as shown in the Table. Physical exams were performed via TH using mostly the TH general exam camera, stethoscope, and otoscope. Emergency procedures were in place for the occasion that an inmate presents to the TH sick call with a problem requiring evaluation at the Emergency Department.

Telehealth Equipment at CORFAC Originating Site

In 2009, the Europe Regional Medical Command THPO purchased PolyCom HDX9000 Practitioner Carts (Polycom, Inc, San Jose, CA) along with telehealth devices such as the AMD-2500 General Exam Camera, AMD

*Internal military document not readily accessible by the general public.

Fiberoptic Otoscope, and AMD Telephonic Stethoscope (AMD Global Telemedicine, Chelmsford MA) (Figures 1, 2). By 2010, nearly all Army clinics in Europe had robust TH capabilities. Although not originally slated for the equipment, these items were installed at the CORFAC from a clinic in Germany which was not using them at the time. Smaller, desktop PolyCom HDX4000 units were installed in all behavioral health clinics including the CORFAC in 2010. The PolyCom HDX9000 Practitioner Cart and the telehealth general exam camera, otoscope and stethoscope provided sufficient quality tools to perform comprehensive assessments of patients at the CORFAC for most primary care/sick call complaints presented by this patient group.

Figure 1. (A) PolyCom HDX9000 Practitioner Cart at originating/patient location; (B) provider laptop with PolyCom RealPresence software at healthcare provider location.

Telehealth Equipment at Distant Site

Technicians from the LRMC Video Network Center (VNC) installed PolyCom RealPresence software on providers' laptops at Kleber Army Health Clinic and LRMC. Additionally, high definition web cameras were installed on monitors on the provider desks or in a video teleconference (VTC) room.

LRMC Video Network Center

The LRMC VNC manages the VTC servers for both nonmedical and medical conferencing using PolyCom CMA Gatekeeper. At the initiation of every medical VTC encounter, the VNC technicians would assign the encounter a unique identification number to secure the connection for patient privacy. The VNC also checked the audio and video quality of each encounter and were available anytime there were connection problems. Rarely were there any audio/video issues and there were no technical issues that prompted cessation of TH services. Bandwidth within the ERMC Network was sufficiently high to ensure good audio/video quality with near negligible network delay.

Electronic Medical Record Data and Peer Review

Encounters and provider notes were documented in the patient's outpatient military electronic medical record (AHLTA). Physician peer review was performed and no standard of care issues were identified.

Data

Patient encounter data for physicals and sick call visits were culled from a variety of sources, including a password-protected ERMC TH cart reservation calendar for which all TH Encounters in ERMC are documented, and daily printed AHLTA clinic lists from the CORFAC dispensary. Special Housing Unit checks were all documented on a CORFAC blotter report and each individual solitary confinement check is documented on an electronic Standard Form 600 signed by the provider assigned that day.

Results

Providers participating in the care of inmates via TH consisted of a physician assistant, nurse practitioner, family practitioner, and a group of 3 internists who saw inmates on the weekend for SHU checks. These

Figure 2. AMD Global Telemedicine instruments which are on the Practitioner Cart for use in assessing the patient.

providers completed 177 synchronous TH encounters, primarily at the Mannheim and Sembach CORFACs. Patients were seen weekly from May 22, 2014, to January 12, 2015. Of these 177 TH encounters, 114 were SHU safety checks and 63 were for physicals, medication visits, and a variety of other typical acute care complaints. During this time, only one patient required transfer to a higher level of care during a TH encounter. The inmate complained of severe epigastric pain which necessitated transfer to the LRMC Emergency Department for evaluation due to the limitation of ancillary services of lab and x-ray at the US Army Correctional Facility-Europe.

Primary Care Encounters

The routine physical and sick call types of encounters comprised 63 of the encounters as shown in the Table. About one-third (24) of those encounters were for physicals and medication visits. All newly incarcerated inmates require an initial medical screening to assess any urgent needs, followed by a confinement physical within 48 hours of arrival. Intake medical screenings and physicals were accomplished using synchronous TH equipment. The remainder of the encounters addressed a variety of complaints which were easily assessed using TH.

Special Housing Unit Checks

The SHU encounters consisted of a brief presentation by the CORFAC medic or guard staff relaying the appearance and condition of the inmate's cell and any overnight events affecting the inmate's health. The encounters were brief and did not require use of telehealth examination devices. The encounters were very easily accomplished via TH. A SHU check could turn into a medical encounter if the inmate had a medical complaint, but this did not occur during the pilot study.

Provider, Staff and Inmate Satisfaction

Although not formally surveyed, there was a generally good acceptance by the providers involved in the program and appreciation for the high quality of the network connections and TH medical devices used. The clear advantage for providers was being able to manage minor sick-call type complaints and physicals via TH from their own offices, saving many hours a day of driving. There was general acceptance of the idea of using TH, and a provider's confidence was further bolstered knowing that every Wednesday a provider would be "in-house" to see inmates and perform follow-ups. There was also recognition that contingency plans and access to local emergency service was also available if required. Providers noted satisfaction with the capabilities of the TH equipment to include general exam camera, and fiber optic otoscope. Some difficulty was noted with the telephonic stethoscope. It seemed to perform well for heart sounds when the distant provider wore headphones. For breath sounds however, it seemed less useful, possibly due to cord or connection interference noise. The idea of seeing patients from a distance via TH is new to many medical care providers and although acceptance is not immediate, providers recognize that high quality encounters can be achieved and acceptance improves over time.

Inmates were generally satisfied with their TH experience. Many inmates did express a preference to see a provider in person. Solitary confinement checks and many of the initial intake medical screenings of the inmates are performed while the patients are handcuffed. Despite some reported dissatisfaction, nearly all inmates freely consented to the encounters and many came back multiple times for TH services, even though they could have waited to be seen in person on Wednesdays. Generally, medical visits via TH seemed to meet inmate expectations for high quality health care.

Comment

The Landstuhl THPO and CORFAC partnership started in March 2014 and has developed into an enduring line of service which continues to assist in the performance of daily sick call, physicals, and solitary confinement checks using synchronous TH. There is somewhat of a learning curve in both performing TH encounters as a provider and receiving care via TH as a patient. It is the view of the authors that not all types of care can be successfully accomplished via TH. This particular group of inmates in this smaller correctional facility represented a generally young, healthy, and male cohort confined for short periods. However, in a larger institution with a more diverse inmate population, carefully considered screening criteria should be incorporated into developing TH programs. That is particularly important for screening to determine which patients may require a carefully nuanced or specialized physical exam or may have more urgent or emergent conditions that require treatment. Telehealth encounters may be used as a screening tool; an information-gathering encounter to assess whether a patient may need a face-to-face encounter or higher level of care facility. Telehealth may also be used for medical education classes such as diabetes education.

Conclusions

Synchronous TH was shown to be a feasible and effective option for the delivery of high quality, routine medical care for minor illnesses, injuries, and other nonurgent and nonemergent conditions, as well as for general physicals and checks in a population aged 18 to 30 years. Synchronous TH provided a platform for

safe and effective health care delivery to this population over a 7- month period. Overall, the TH encounters appeared to be accepted by providers and clinic staff. A conservative estimate is that 660 hours of unproductive provider time traveling to and from the facility was saved. Inmates were generally satisfied with their TH encounters. Some inmates did report a preference to see providers in person. This highlights one of the challenges with TH programs and their acceptance by both providers and patients. The authors believe that acceptance should improve over time as with most new technological advances.

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Erratum

In the book review article "A New Monograph From the Borden Institute" on pages 99-100 of the October-December 2015 issue of the *AMEDD Journal*, the title of the book reviewed was incorrectly stated as:

Long-Term Health Consequences of Exposures to Burn Pits in Iraq and Afghanistan

The correct title is:

Airborne Hazards Related to Deployment

Repair of a Gingival Fenestration Using an Acellular Dermal Matrix Allograft

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ABSTRACT

A case report illustrating the successful treatment of a gingival fenestration with an acellular dermal matrix (ADM) allograft. After 2½ months of healing, the ADM was completely integrated into the soft tissues of the mandibular anterior gingiva with complete resolution of the gingival fenestration, resulting in excellent gingival esthetics.

Marginal tissue recession is of 2 types; one due to periodontitis and the other primarily related to mechanical factors like tooth brushing. Recession from periodontitis can involve all tooth surfaces, while recession from mechanical factors typically involves only one surface. Periodontitis is associated with plaque and calculus whereas facial recession is associated with high levels of personal oral hygiene and professional care. Predisposing factors to gingival recession include frenal pull, underlying bone dehiscence, subgingival restorations, tooth malposition, orthodontic appliances, and thin gingival biotype.[1-5]

While a wide array of various gingival defects may be diagnosed in patients, only those anomalies that also present with associated symptoms, esthetic concerns, or the potential for exacerbated sequelae may require treatment.

Two commonly discussed localized gingival defects include the gingival dehiscence and fenestration. The more common of the two, the gingival dehiscence, is described as an isolated area in which the root is denuded of bone.[6] The defect combines 3 characteristic qualities including gingival recession, bone loss through the margin of the bone, and root exposure (Figure 1).[7]

In contrast, the gingival fenestration is a rarer phenomenon.[1,7,8] The word fenestration is derived from the Latin word fenestra, meaning window, which describes how the defect clinically presents.[7] A fenestration may be distinguished by the loss of overlying alveolar bone and gingiva, which results in an exposed root surface, but the marginal bone and gingiva remain intact (Figure 2).[7]

Gingival fenestration defects are of uncertain etiology.[1,2,7] Some authors have suggested the etiology of gingival fenestration as subgingival calculus and the use of

Figure 1. Gingival dehiscence.

Figure 2. Gingival fenestration.

Gutka (a mixture of powdered tobacco, areca nut [fruit of *Arecacatechu*] and slaked lime [aqueous calcium hydroxide]).[1] Other reports of gingival fenestrations have listed etiologies as extreme buccal inclination of root tips with thin or nonexistent cortical plates combined with chronic periapical inflammation.[9,10] Additionally, two of the authors (LGB and EBF) have clinically attributed gingival fenestrations to possible trauma leading to

bony sequestration (Figure 2) and to past use of smokeless tobacco with subsequent healing over previously exposed root calculus.

Localized gingival defects are routinely corrected with autogenous grafts from either the palatal mucosa or buccal gingiva. However, many patients may not desire a palatal graft due to the additional morbidity of the procedure, or due to a history of significant postsurgical bleeding from the palatal donor site.[4,11]

The surgical correction of gingival defects have evolved from the early use of pedicle grafts originally described by Grupe and Warren in 1956.[12] Presently, with the advent of the autogenous subepithelial connective tissue graft (SCTG), as described by Langer and Langer with modification by others, predictable root cover has increased to more than 90%.[13-17]

An alternative to the autogenous graft is the acellular dermal matrix (ADM*) allograft. The material is human dermis which has been decellularized and treated to prevent disease transmission, leaving only a scaffold of Type I collagen.[18] The benefit of ADM is the elimination of the morbidity associated with graft removal from an oral site. Several authors have reported on the success of ADM allograft .[4,18-21]

Repair of gingival fenestrations has been reported in the literature.[1,22-25] Previous case reports all used the SCTG for repair of the defects. This article reports a case of repair of a gingival fenestration using an ADM allograft.

Case Report

A male, 28-year-old Soldier was referred to the Department of Periodontics for evaluation of his mandibular anterior gingiva associated with tooth #24, a mandibular central incisor (Figure 3). The patient reported a history of daily smokeless tobacco use in the area of the mandibular anterior but reported complete cessation of this product approximately 2 years prior.

Subsequent to the cessation of smokeless tobacco use, the patient noticed an irregularity of his gingiva, which upon clinical examination was determined to be a gingival fenestration (Figure 3).

A review of the medical history revealed that the patient was taking no medications and no contraindications to treatment were noted. All surgical options were presented and discussed. The patient selected ADM as the material for the procedure.

*Perio Derm: Dentsply International, Inc; York, PA.

Figure 3. Presurgery: gingival fenestration, tooth #24.


Figure 4. Site preparation.

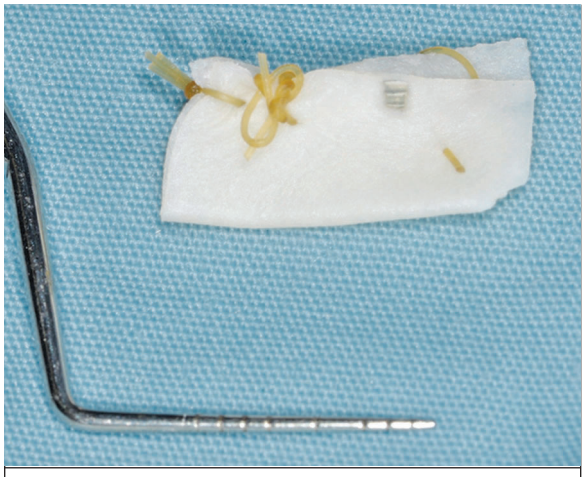
Figure 5. Hydrated ADM allograft.

Following a presurgical rinse with 0.12% chlorhexidine and administration of local anesthesia (2% lidocaine with 1:100,000 epinephrine), the gingival fenestration was excised to expose new connective tissue margins

Figure 6. Initial ADM placement.

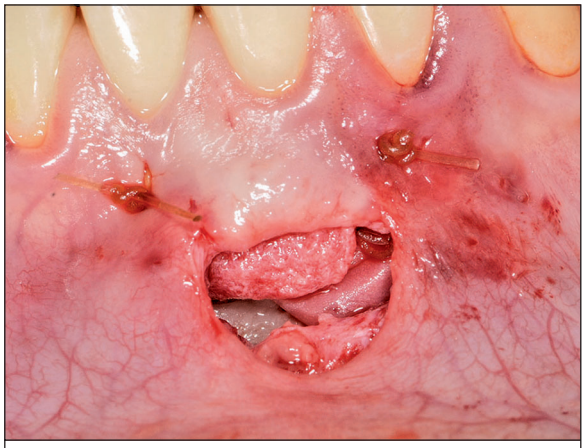

Figure 7. ADM secured with Chromic Sutures.

(Figure 4). The labial tissue was elevated to create a "pouch." The tissue preparation was intentionally designed to avoid the marginal gingiva, thereby decreasing the chance of postsurgical recession. Following the removal of calculus with ultrasonic instrumentation, root planing was completed with hand instruments.

The ADM was hydrated according to the manufacturer's instructions (Figure 5), and placed under the elevated labial tissue as shown in Figure 6. The allograft was secured with 5.0 Chromic Sutures* (Figure 7). The labial tissue was then closed over the ADM using 5.0 Vicryl Sutures* (Figure 8). Hemostasis was obtained with direct pressure for 2 minutes. Home instruction included daily chlorhexidine oral rinsing every 12 hours as well as the administration of pain medications: acetaminophen (500 mg) with codeine (30 mg) (1 to 2 tabs every 4 to 6 hours as needed for severe pain and naproxen (500 mg) (1 tab every 12 hours as needed for moderate pain).

The patient was followed at one, 2, 4, and 10 weeks (2½ months) when a final follow up revealed good healing of the soft tissues with complete integration of the ADM allograft (Figure 9).

*Ethicon US, LLC; Neenah, WI.

Figure 8. Labial tissue sutured with Vicryl Suture.

Figure 9. Photo taken at 2½ month postsurgical visit (complete correction of fenestration).

Comment

Although gingival fenestration is a relatively rare occurrence, as this case report demonstrates, one of the etiologies of this condition can be resolution of a smokeless tobacco lesion over previously exposed calculus. The predictable repair of this clinical entity has been earlier demonstrated with the autogenous subgingival connective tissue graft.[1,22-25]

This report demonstrates the success of surgical treatment utilizing ADM. The advantage of this technique is the elimination of the need for autogenous donor tissue. Additionally, the surgical design in this case did not incorporate the free gingival margin, thus reducing the risk of postsurgical recession or dehiscence formation.

Summary

This case illustrates the successful treatment of a gingival fenestration with an ADM allograft. After 2½ months of healing, the allograft was completely integrated into the soft tissues of the mandibular anterior

gingiva with complete resolution of the gingival fenestration. ADM allograft is easy to use and resulted in excellent gingival esthetics.

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Reasons for Non-third Molar Extractions in a Military Population

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The mission of the US Army Dental Command is to provide responsive and reliable oral health services and influence health to improve readiness and advance wellness in support of the force, their military families, and all those entrusted to our care. That mission is directly supportive of the Dental Command's vision of strengthening the health of our nation by improving the oral health of our Army.[1]

Based on the fact that dental care is an essential and required component for readiness and is a cost-free benefit, one could assume that the number of non-third molar extracted teeth in the active-duty military population is low. That perception may be why the reasons for non-third molar extractions in a high-tempo Army population have not been extensively studied. The objective of this study was to examine the relationship between the frequency of non-third molar tooth extraction and the factors that contributed to extraction in a military population.

The reasons for and pattern of tooth loss in nonmilitary populations are well-documented.[2-18] The main reasons for permanent tooth loss varies among different countries. Dental caries predominates as the most common reason for tooth extraction in most countries.[2-7,12-14,17,18] In Germany and Canada, however, periodontal disease has been cited as the primary reason for tooth extraction.[10,11] In Italy and Singapore, caries and periodontal disease appear to affect the extraction rate equally.[8,9] The damage caused by dental caries is the main reason for tooth loss in younger populations, but periodontal disease is the primary factor for tooth loss in older populations.[2,3,6-13]

Methods

This retrospective study was reviewed by the Tripler Army Medical Center Regional Institutional Review Board (IRB) and was determined to be no greater than minimal risk. This project used existing data/records and collected information that was recorded in charts from January 1, 2000 to January 1, 2014. Individually identifying data elements were not recorded. The researcher did not keep a linking list of any sort. The IRB granted a waiver of consent process after it made the following determinations: the research involved no more than minimal risk to the subjects; the waiver did not adversely affect the rights and welfare of the subjects; the research could not be practicably carried out without the waiver; and, whenever appropriate, the subjects were provided with additional pertinent information after their participation. No personal identifiers were used and records were locked in the records room.

Power analysis determined that a sample size of 400 records was sufficient to detect significant differences between the different reasons for extraction. Inclusion criteria for records required that at least one non-third molar tooth was extracted. Four hundred dental records were selected (using online random number generators) from over 12,000 available records. To ensure that no records were duplicated, a stratified randomization scheme was used; 40 records were selected from each of the 10 color jackets used to sort records in the clinic. This process continued until the sample size of 400 non-third molar extraction cases was reached. Color jackets indicated differences in the second to last number of the patients' social security number. At no time was personally identifiable information recorded and social security numbers were not recorded. Data (without any identifiers) were recorded directly on an Excel spreadsheet. Patient records were not removed from the dental clinic. Research records were maintained on a secured (common access card) computer in the dental clinic; access to research records was restricted to authorized research personnel only.

The records were reviewed with the Corporate Dental Application and Digital Enterprise Viewing and Acquisition Application databases for information relating to the location of the tooth extracted, previous treatment performed, reason for extraction, gender and age of the patient. With a sample size of 400 subjects, the study was able to estimate the reasons for non-third molar extraction with 95% confidence at $\alpha=0.05$. The study had 80% power to detect a difference of 14% between rates for older and younger patients. Rates and reasons

for extraction and location of tooth extracted were estimated at 95% confidence intervals. Rates were estimated separately for number of patients and for the total number of extractions. A 2-sided Fisher's exact test was used to compare reasons for extraction by age category, gender, caries risk and tooth location. A significance level of 0.05 was used for all analyses.

Results

Chart selection was random but stratified so that an equal distribution of charts was reviewed using the next to last digit scheme. For patients who had multiple reasons for extractions, all of the reasons were recorded. Therefore, the totals for some categories exceeded 100%. The reasons for extraction of non-third molar teeth, categorized by gender, age, inclusion or exclusion in the High Caries Risk (HCR) program,* and tooth location are presented in Tables 1, 2, 3, and 4, respectively. Based on the collected data, caries was the primary reason for extraction of 73% of non-third molar teeth followed by failed endodontic treatment (21%) and extraction of teeth which were originally planned for prosthodontic treatment (14%). Loss of teeth due to trauma was also 14%, while loss due to periodontal disease was 10%, followed by extractions for orthodontic reasons (3%) and extractions due to hyperocclusion (2%). A diagnosis was not recorded in 80 of the 400 records. Because of this, the sample size was adjusted to 320 records for all subsequent analyses.

Table 1. Reasons for extraction by gender. Percentages may sum to greater than 100% because an extracted tooth may match more than one category. Note: study sample=320.

Reason for Extraction	Total (% sample)	Gender		*P* value
		Male N=268 [84% sample] n (%N)	Female N=52 [16% sample] n (%N)	
Caries	233 (73%)	197 (74%)	36 (69%)	.610
Failed Endo	66 (21%)	54 (20%)	12 (23%)	.708
Preprosthetic	14 (14%)	34 (13%)	10 (19%)	.269
Trauma	45 (14%)	37 (14%)	8 (15%)	.827
Periodontal	31 (10%)	24 (9%)	7 (13%)	.310
Orthodontics	11 (3%)	10 (4%)	1 (2%)	1.000
Hyperocclusion	7 (2%)	6 (2%)	1 (2%)	1.000
No Diagnosis	80 (20%)			

Table 2. Reasons for extraction by age group. Percentages may sum to greater than 100% because an extracted tooth may match more than one category. Note: study sample=320.

Reason for Extraction	Age Group			*P* value
	19-29 Years N=128 [45% sample] n (%N)	30-39 Years N=131 [41% sample] n (%N)	40-60 Years N=61 [19% sample] n (%N)	
Caries	103 (80%)	96 (73%)	34 (57%)	.003
Failed Endo	25 (20%)	30 (23%)	10 (17%)	.583
Preprosthetic	17 (13%)	19 (15%)	7 (12%)	.865
Trauma	15 (12%)	17 (13%)	12 (20%)	.289
Periodontal	5 (4%)	11 (8%)	15 (25%)	<.001
Orthodontics	3 (2%)	6 (5%)	2 (3%)	.614
Hyperocclusion	4 (3%)	2 (2%)	1 (2%)	.648

The distribution of caries as the reason for extraction among gender reveals no statistical difference (69% female, 74% male). When comparing the reasons for extraction based on age groups, caries remain the leading cause at 80% for the group aged 19-29 years, 73% for the group aged 30-39 years, and 57% for the group aged 40-60 years. Extraction due to caries across all age groups was significant (P=.003). Ninety-seven percent of the extractions due to caries were performed on patients who were identified as HCR according to the American Dental Association Caries Risk Criteria, shown on the following page. Posterior teeth were extracted more frequently than anterior teeth. Based on tooth location, significant differences were found for teeth extracted due to caries and for trauma. Posterior teeth were more likely to be extracted due to caries than anterior teeth, and anterior teeth were more likely to be extracted if trauma was involved.

Table 3. Reasons for extraction, displayed by qualification for High Caries Risk (HCR) category (yes or no). Percentages may sum to greater than 100% because an extracted tooth may match more than one category. Note: study sample=320.

Reason for Extraction	Category		*P* value
	HCR No N=143 [45% sample] n (%N)	HCR Yes N=177 [55% sample] n (%N)	
Caries	62 (43%)	171 (97%)	<.001
Failed Endo	45 (31%)	21 (12%)	
Preprosthetic	33 (23%)	11 (6%)	
Trauma	37 (26%)	8 (5%)	
Periodontal	25 (17%)	6 (3%)	
Orthodontics	11 (8%)	0 (0%)	
Hyperocclusion	7 (5%)	0 (0%)	.003

The second most common reason for non-third molar tooth extraction was failed endodontic treatment. Based on gender, 23% of female Soldiers and 20% of male Soldiers required extraction due to failed endodontic

*The High Caries Risk Program is designed to improve overall oral health by customizing dental treatment for the individual Soldier to meet his or her needs. It seeks to create a partnership between the Soldier and the dental professional and help break the decay-repair-decay cycle. The program helps the Soldier identify risk factors and receive nutritional counseling, oral hygiene instructions, intensive treatment to help prevent future decay, and treatment for any cavities. The program follows Soldiers as they are assigned to various locations throughout their Army careers.

Table 4. Reasons for extraction by tooth location. Percentages may sum to greater than 100% because an extracted tooth may match more than one category. Note: study sample=320.

Reason for Extraction	Tooth Location		*P* value
	Anterior N=23 [7% sample] n (%N)	Posterior N=297 [93% sample] n (%N)	
Caries	2 (26%)	227 (76%)	<.001
Failed Endo	5 (22%)	61 (21%)	.796
Preprosthetic	2 (9%)	42 (14%)	.753
Trauma	11 (48%)	34 (11%)	<.001
Periodontal	3 (13%)	28 (9%)	.477
Orthodontics	2 (19%)	9 (3%)	.183
Hyperocclusion	0 (0%)	7 (2%)	1.000

treatment which was not appropriate for retreatment. All age groups showed similar percentages for the number of teeth extracted due to failed endodontic treatment with age groups 19-29 years (20%), 30-39 years (23%), and 40-60 years (17%). Thirty-one percent of the patients who were treated with extraction due to failed endodontic treatment were not in the HCR category, while 12% of those patients were in HCR category. This difference was significant ($P<.001$).

The next most common reason for extractions in the military population was divided equally between extractions on teeth which were originally planned for prosthodontic treatment and trauma. For the preprosthodontic and trauma categories, there was no difference based on gender or age group.

Based on HCR, 23% of preprosthodontic treatment extractions were performed on patients who did not qualify for HCR, while 6% of the extractions were performed on patients who qualify for the HCR program with a statistical significance of $P<.001$ (Table 3).

Analysis of the number of teeth extracted due to trauma revealed no apparent difference based on gender or age group. Twenty-six percent of patients treated with extraction due to trauma did not qualify for the HCR program, while 5% did qualify ($P<.001$). Also, 48% of the teeth extracted due to trauma were anterior teeth, while 11% were posterior teeth ($P<.001$) as shown in Table 4.

Caries Risk Criteria

Low Risk Criteria

No incipient or cavitated primary or secondary carious lesions during current exam and no factors that may increase caries risk.*

Moderate Risk Criteria (any of the following)

One or two incipient or cavitated primary or secondary carious lesions during current exam.

No incipient or cavitated primary or secondary carious lesions during current exam but presence of at least one factor that may increase caries risk.*

High Risk Criteria (any of the following)

Three or more incipient or cavitated primary or secondary carious lesions diagnosed during current exam.

Presence of multiple factors that may increase caries risk.

Xerostomia (medication, radiation, or disease induced).

Suboptimal fluoride exposure (inadequate/no systemic fluoride, inadequate topical fluoride exposure).

Poor oral hygiene.

Irregular dental visits.

Incipient lesions are noncavitated localized or generalized white spots and/or interproximal radiolucencies.

*Risk Factors: factors that increase the risk of developing caries include, but are not limited to:

Deep pits and fissures.
Exposed root surfaces.
Frequent sugar intake (>5 times per day).
Active orthodontic treatment.
Developmental or acquired enamel defects.
Inadequate salivary flow, as determined from PMH or unstimulated salivary flow testing (<0.2 mL/min).
Many multisurface restorations.
Eating disorders.
Restoration overhangs and open margins.
Chemotherapy or radiation therapy.
Physical disability that impedes oral hygiene.

Source: American Dental Association

Periodontal disease was the reason for extraction of 31 of 320 teeth (10%). There was no statistical difference based on gender or tooth location. The majority of the patients who had extractions due to periodontal disease (17%) did not qualify for the HCR program, while 3% did qualify. Also, patients in the 40-60 year age group had 25% tooth loss due to periodontal disease versus 4% of patients in group aged 19-29 years and 8% in 30-39 year age group. This difference was significant ($P < .001$).

Comment

Many advances have been made in the etiology of dental caries and the importance of prevention. Awareness of the risks of high sugar diets and the importance of regular dental exams and daily brushing is well known.[19-21] However, the data collected from the current study indicate that the main reason for non-third molar extraction in our military patient population is still caries. In fact, 73% of non-third molar extractions in our study were due to caries. This supports other research findings that identified caries as the primary reason for tooth extraction in many other populations.[2-7,12-14,17,18] Caries was identified as the primary reason for emergency visits for deployed military members as well.[22,23] In their study, Richards et al[14] identified caries as the reason for 59% of the 558 tooth extractions in 417 visits. The distribution of extractions among age groups in the current study revealed that of the 233 extractions due to caries, 80% were in the 19-29 year age group, 73% were in the 30-39 year group and 57% in the 40-60 year group. This finding was statistically significant ($P = .003$). This distribution could be explained by the fact that most Army recruits are in the 19-29 year age group. The majority of these Soldiers had not received dental treatment prior to enlistment in the Army, so some teeth were inevitably deemed nonrestorable during their dental examination.

The Soldiers in the group aged 30-39 years had the same dental problems observed in the younger age group. One observation is that the average age of enlistment has increased over the past decade, perhaps reflecting the continuous operational nature of the military mission. Another important factor is multiple deployments lasting between 12 and 18 months (or longer) over the last 14 years with the increased deployment tempo from military operations. It was often difficult for some Soldiers to be seen at a dental clinic for routine care during deployment. The probability of a Soldier with an asymptomatic carious lesion receiving dental treatment during deployment was small as emergency care was often the only type of care available.

The extraction rate due to caries dropped in the 40-60 year age group. At this point in their military careers, Soldiers have been seen multiple times for annual exams and have most likely eliminated the active component of caries.

Soldiers are dentally categorized based on their risk of developing a significant dental problem over the next year. This type of categorization is common across the uniformed services. In 2006, the Department of Defense (DoD) published the latest policy letter on oral health and readiness.[24] Health Affairs Policy 06-011 set the guidelines for the updated Individual Medical Readiness requirements outlined in *DoD Instruction 6025.19*.[25] Military departments perform annual dental readiness assessments to determine a service member's Dental Readiness Classification (DRC):

- Service members designated Class 1 (DRC 1) are those with a current dental examination who do not require dental treatment or reevaluation. As such, from a dental health standpoint, those personnel are deployable worldwide.
- Dental Class 2 (DRC 2) service members have a current dental examination and require nonurgent dental treatment or reevaluation for oral conditions that are unlikely to result in dental emergencies within 12 months. They are deployable worldwide.
- Dental Class 3 (DRC 3) service members require urgent or emergent dental treatment. They normally are not considered to be deployable worldwide.
- Dental Class 4 (DRC 4) are service members whose dental readiness classification is undetermined by virtue of being overdue for their annual dental examination.

Despite the efforts to ensure dental readiness in the Army, DRC 2 patients may progress to DRC 3 if no restorative intervention occurs in a reasonable amount of time. Another possible reason for the high percentage of Soldiers suffering from extensive caries is lifestyle. Many Soldiers resort to high caffeine, high sugar energy drinks to stay alert. This could help explain why caries remain a concern in the 40-60 year age group.

The second most common reason for non-third molar extraction, regardless of gender or age group, was failed endodontic treatment. The lack of a well-sealed restoration can lead to bacterial leakage into the root canal system, necessitating retreatment or extraction. The most common reasons for endodontic failure are missed canals, incompletely treated canals, and fractured roots.[26] From the data, it was difficult to accurately discern between true failed endodontic therapy and failed endodontic therapy due to a faulty restoration. The two are often inextricably linked. The success rate for root canal therapy is often cited as greater than 80%.[26] It is

not uncommon that the lack of a quality restoration to cover the cusps of endodontically treated posterior teeth will lead to fracture of the tooth/restoration and subsequent exposure of the obturation material to oral fluids. Sorensen and Martinoff [27] determined that among 1,273 endodontically treated teeth, those treated with coronal coverage restorations (onlays, partial, or complete metal crowns; and metal ceramic crowns) survived much longer than endodontically treated teeth with no coronal coverage restorations. Coronal coverage did not significantly improve the success of endodontically treated anterior teeth. This finding supports the placement of crowns on posterior teeth that cover sufficient coronal tooth structure to prevent fracture when occlusal forces attempt to separate the cusp tips. Zadic et al[28] found that 57% of extracted teeth in their sample population did not have a permanent coronal restoration.

Based on data from the current study, it appears that 31% of the extractions due to endodontic failure were performed on patients who did not qualify for HCR program, while 12% were performed on patients who did qualify ($P<.001$). This supports the idea that the clinical failure of most endodontically treated posterior teeth is not an active caries issue, but rather a mechanical issue where immediate cuspal coverage is necessary to support teeth that have lost a considerable amount of supporting dentin. Vire[29] found that prosthetic failure of teeth restored with a crown occurred after an average of 87 months. Without a crown, the average prosthetic failure occurred at 50 months. Fourteen percent of the non-third molar extractions occurred prior to prosthodontic treatment. These teeth received endodontic treatment but fractured before receiving prosthodontic restoration. The data collected showed no association with gender, age, or tooth location. Most patients treated with tooth extraction prior to prosthodontic treatment did not qualify for the HCR program (23%), while 6% qualified for the program. Full cuspal coverage following endodontic treatment is a practice guideline for posterior teeth. However, some long wait times can be experienced before the patient is seen. We suspect that some of the extracted teeth were from patients waiting to be seen for cuspal coverage.

Trauma was the cause for extracting 14% of non-third molar teeth. There was no association between extraction due to trauma and gender and age. Based on tooth location, most teeth extracted due to trauma were anterior teeth in patients who did not qualify for the HCR program. Some reported reasons for trauma included falling due to seizures, vehicle accidents, sports-related trauma, or fights. Anterior teeth were involved in trauma much more than posterior teeth. This difference was statistically significant ($P<.001$).

The percentage of periodontally involved teeth that were treated by extraction ranged from 4% in the group aged 19-29 years to 25% in the 40-60 year group ($P<.001$). This is consistent with results of other research that indicate that periodontal disease is the main reason for extraction in older age groups.[10,11,30-33] Albandar et al[34] conducted a study to estimate the prevalence and extent of periodontal disease in the United States using data from the third National Health and Nutrition Examination Survey (http://www.cdc.gov/nchs/nhanes/nh3data.htm). In their study, they used the data from a sample size of 9,689 dentate persons aged 30 to 90 years who received a periodontal examination. The data collected included periodontal attachment loss, probing depth, and furcation involvement in 2 randomly selected quadrants per person. Based on the analysis of the results, Albandar et al reported that the overall number of teeth lost increased with age from 1.49 teeth in the group aged 30-34 years to 11.29 teeth in the group aged 85-90 years.[34]

Based on caries management by risk assessment,[35] the criteria for which is shown on page XX, patients who qualify for the HCR program were more likely to have extractions due to caries as shown in Table 3. Ninety-seven percent of the patients who were treated by extraction due to caries qualifed for the HCR program. On the other hand, caries was responsible for 43% of extractions among those not qualified for HCR ($P<.001$). These results emphasize the importance of the HCR program in the prevention of tooth extraction due to caries. The findings from the extractions categorized by HCR are interesting in that every factor (reasons for extraction) was statistically significant. Unfortunately, the statistical tests can only show that there was a difference but cannot explain why those differences occurred. Some reasons are intuitive—patients with teeth extracted due to caries were much more likely to be enrolled in the HCR program. There were significant differences for all other reasons for extraction, based on whether the patient was enrolled in HCR, but it is difficult to speculate why these differences occurred. Patients were much more likely to have teeth extracted for failed endodontics, preprosthetic reasons, trauma, periodontal issues, orthodontics, and hyperocclusion if they were not enrolled in the HCR program. More than half of the study population was enrolled in the HCR program, but patients in the HCR category were less likely to have teeth extracted for reasons other than caries.

An incidental finding was that 80 extractions were performed without recording the reason for the extraction. Because the treatment was tooth extraction, it was necessary to record a diagnosis, communicate treatment options with the patient, and also have the patient sign and

authorize consent to show that the patient understood and agreed with the provider about the treatment plan. From a legal standpoint, the dental record is a medicolegal document that should be comprehensive, easy to use, clear, legible, and retrievable. The dental record should contain a record of diagnoses and findings, record of treatment, and prescriptions including all diagnostic aids, recommendations, and patient responses. The lack of a recorded diagnosis is a serious breach of proper record keeping. It is difficult to believe that 20% of the providers did not have a diagnosis prior to extracting the teeth. It is reasonable to assume that the error was administrative, caused by inadequate attention to the details of accurate record keeping. However, such does not diminish the seriousness of the error.

Based on collected data, caries was the major cause of non-third molar extraction in this military population. Even though Soldiers are entitled to dental care at no monetary cost and must make mandatory annual dental visits, dental caries remains the primary reason for non-third molar tooth extraction. This trend could be related to the fact that many Soldiers are from lower socioeconomic families. It has been established that low socioeconomic status is a risk factor for caries.[36-38] Many Soldiers enter the military with little dental information and are unaware of the causes of dental caries and the importance of prevention. Many Soldiers have never seen a dental care provider prior to joining the military and subsequently never received oral hygiene instruction. Explaining the importance of oral hygiene and demonstrating the proper brushing and flossing technique to Soldiers are important steps toward improved oral health. Additionally, when diagnosed with caries, some Soldiers lack the motivation to follow up with the necessary appointments in order to receive treatment. If enough time lapses, Soldiers may wait until the only treatment option is extraction. Further study is needed to address the high caries rate in active duty military populations and to investigate why so many providers apparently do not enter a diagnosis for tooth extractions.

Conclusions

The results of this retrospective study of a high-tempo Army unit show that the primary reason non-third molar teeth were extracted was due to caries, followed by endodontically treated teeth failures, failures of teeth prior to definitive prosthodontic care, trauma and periodontal disease. Loss of teeth due to caries was not related to gender, but was significant for Soldiers aged less than 40 years, for location of the teeth (posterior more common than anterior), and highly significant for those persons enrolled in a High Caries Risk program. Loss of teeth due to periodontal disease accounts for approximately 10% of non-third molar tooth loss and is highly correlated with advancing age. Based on tooth location, posterior teeth are more likely to be extracted rather than anterior teeth due to caries, and anterior teeth are more likely to be extracted due to trauma.

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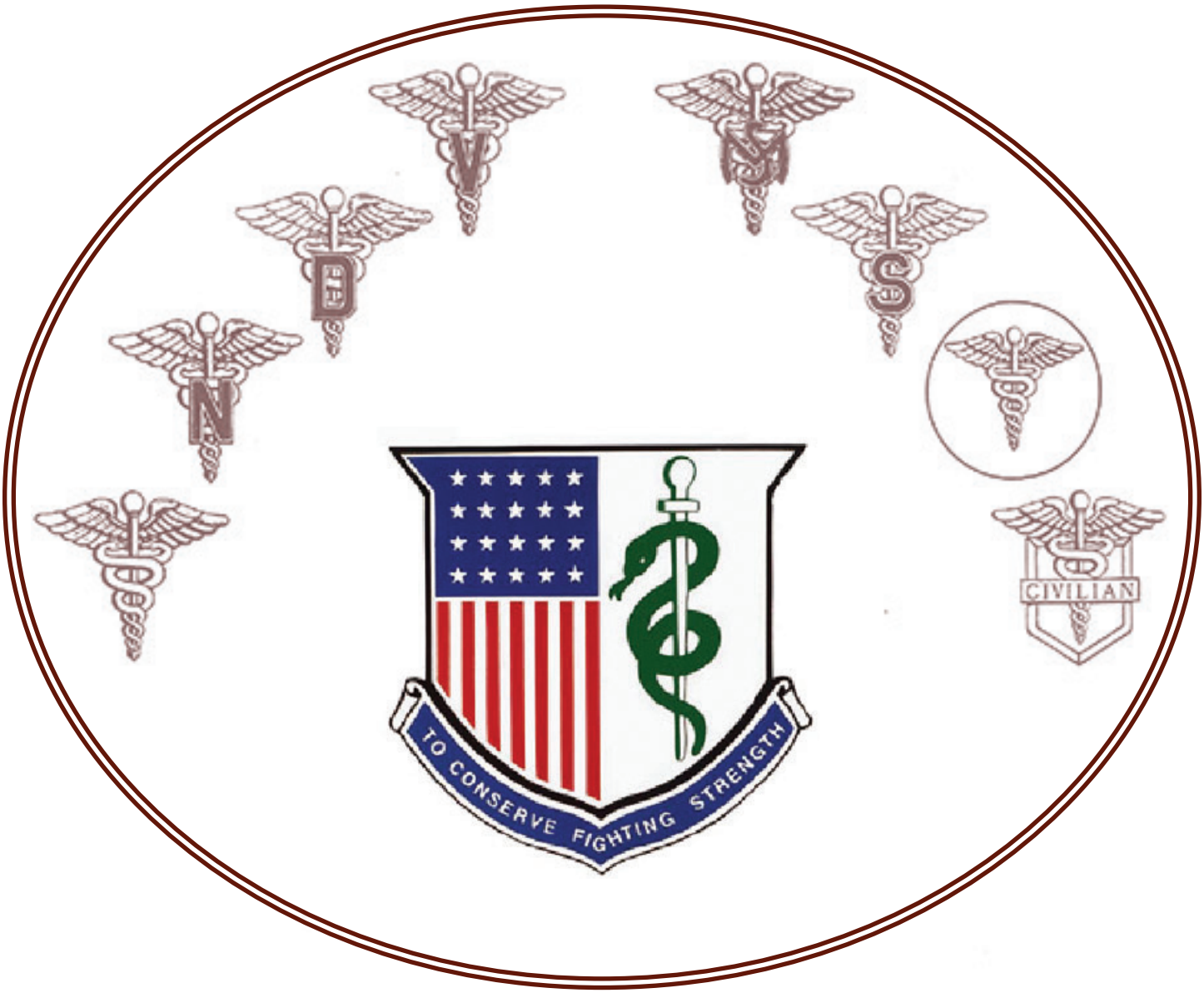

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