

# THE UNITED STATES ARMY MEDICAL DEPARTMENT JOURNAL

## THE FOUNDATION OF A SYSTEM FOR HEALTH: ARMY MEDICINE'S PERFORMANCE TRIAD

*October - December 2013*

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# Perspectives

## COMMANDER'S INTRODUCTION

MG Steve Jones

Instilling fitness and resilience in our Soldiers, Families, and Army Civilians is as important today as it was during the long winter at Valley Forge. These qualities are critical as the Army continues to fight our nation's longest war with an all-volunteer force. The Ready and Resilient Campaign seeks to institute a cultural change in the Army by directly linking personal resilience to readiness, and emphasizing the responsibility of each individual to build and maintain resilience. Taking a deliberate approach to strengthening physical, psychological, and emotional resilience will increase unit readiness and the ability of Soldiers, Families and Civilians to deal with the significant challenges of the Army Profession.

The Army Medical Department's Performance Triad supports the Ready and Resilient Campaign and is a key component of our transition from a healthcare system to a System for Health. Patients spend an average of 100 minutes each year in our healthcare system. Their decisions during the other 525,500 minutes of the year, the Lifespace, have a great impact on their health and their lives. Sound decisions concerning the basics of Activity, Nutrition, and Sleep are key to optimizing health, performance and resilience. The Performance Triad will lead to sound decisions, more healthy behaviors, and more optimal performance.

We know that individual resilience can be built, maintained, and strengthened with an appropriate training regimen. By taking a systematic approach we can better include activities into our schedule, follow a healthy diet that supports our training, and ensure we get the rest we need. A thoughtful plan will make our training more effective, help prevent injuries and overtraining. Start by setting challenging but realistic goals. Include both short and long term goals that are specific and

measurable. Pick a physical activity that you enjoy and make it a regular part of your daily schedule. There's no single best way to train, the best activity for you is one you will consistently stick with. Remember that it is just as important to train your mind and include mind-body activities as well. Meditation not only reduces stress but can also increase your ability to concentrate. Yoga increases flexibility while reducing stress. Other mental training activities can improve your cognitive function.

Diet has a major influence on overall physical and psychological fitness. Quality nutrition means eating the right foods in the right quantities to improve performance and maintain a healthy weight. Plan your meals in advance and follow your plan. Sleep, the final element of the Performance Triad, is as important as the other two. Training overloads the body and a recovery period allows the adaptation which increases physical and psychological fitness. Proper recovery includes cooling down, refueling, rehydrating, and sleep. And once again, make a point to include adequate time in your schedule.

Soldier athletes following a more advanced training program can achieve even greater goals. Their training plan should incorporate a strategy to improve endurance, speed, strength, power, flexibility, and the technical/mental skills required in their job. They should specifically tailor their training to accomplish their goals, and incorporate advanced techniques including training cycles and periodization. Rest may include active recovery activities such as walking, light biking, or swimming. With more intense and higher volume training, it's even more important to follow a careful plan to avoid overtraining and overuse injuries. Finally, keep a training log—it helps you stay motivated, track your progress, and accomplish your goals.

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### EDITOR'S PERSPECTIVE

In her introduction to the contents of this issue, The Surgeon General outlines the genesis and concept of the Performance Triad foundation to the System of Health initiative for Army Medicine. Dr Bradley Nindl of the US Army Public Health Command organized and led the effort to collect articles for this issue which present a sample of the professional skill and knowledge resources of Army medicine which are dedicated to realizing this

transition. Each pillar of the Performance Triad is represented by articles describing completed studies and ongoing research to allow implementation of policies and doctrine from a perspective of solid, science-based knowledge.

Military service demands a strong, fit body. Obviously, strength and fitness cannot be achieved nor maintained without exercise. However, as Dr Nindl and his coauthors discuss in their article, both physical training and

## PERSPECTIVES

sports are essential, but are also the main cause of musculoskeletal injuries among military service members. Such injuries often render the service member medically not ready to deploy, or cause evacuation from theaters of operation. Their article presents a scholarly, well-researched, carefully developed plan for achieving the necessary levels of fitness and strength among Soldiers while significantly reducing the number of musculoskeletal injuries incurred during training and individual fitness activities. This article should be the starting point for anyone charged with the development and implementation of physical training plans, programs, and doctrine for military service members.

In their article, Dr Patricia Deuster and Dr Marni Silverman look at another benefit of physical fitness beyond its necessity in the strength and endurance required to perform physically-demanding tasks. They explore resilience as an indispensable characteristic for military service, sometimes being the difference between life and death. Using their extensive research, they carefully develop the position that physical fitness is essential for a person to grow and maintain the resilience necessary to deal with the stresses and uncertainties of constantly changing demands. Further, their article presents the demonstrated relationship of resilience and good health in general, adding yet another contribution of physical fitness to the goals of the Performance Triad.

The combat experiences of the past decade have emphasized the utmost importance of physical conditioning for the mission-specific tasks faced in the environment of nonlinear warfare. Combat units throughout the Army are looking at ways to tailor physical training to specifically address the demands presented by those tasks in order to improve immediate and long-term combat effectiveness. Tyson Grier and his team of coauthors looked at such new programs to determine if more intense and focused physical training had an effect on injury rates or physical fitness beyond that experienced by units with standard Army fitness training programs. They conducted detailed research in the literature, and collected and analyzed extensive amounts of data from battalions in training to discover any definitive trends and/or relationships among focused training, regular training, fitness levels, and injuries incurred by those involved in physical training. Their comprehensive analysis demonstrates various relationships depending on various physiological parameters of individuals involved, and provides a wealth of data on which planners can base their programs and policies for physical fitness training and standards.

Those involved in the transformation of raw recruits into combat Soldiers have many challenges, whether

researching, designing, implementing, or conducting the training. This is particularly true for the physical fitness requirements and programs in that they are charged with the training and physical development of people presenting a cross-section of physical, fitness, capabilities, motivations, and dedication. They must do this while minimizing injury, but meeting the time limitations of the training schedule. Therefore, those who design the training regimen must have an understanding of the demands of the physical activity mandated by the training. To do that, those demands must be measured and quantified. In their study, Dr Jan Redmond and her team evaluated 3 measurement instruments used with Soldiers in the basic combat training environment to determine the agreement among them. Each instrument had its respective use limitations, overhead requirements, and other considerations which must be factored into any decisions concerning use in the training environment. Their article clearly describes the carefully designed and conducted study, the data analysis, and the results, conclusions, and recommendations which should be of great assistance for future training planners and evaluators.

Accurate measurement of physical activity during training is valuable for many purposes, including to verify the level of standardization at different training sites. Kathleen Simpson and her team used the information concerning measurement instruments discussed in the above paragraph to design and conduct a study measuring the amount of physical activity involved in basic combat training at 2 different training locations. Their excellent article clearly describes the careful, extensive data collection and the detailed statistical analyses of the various data groups. The conclusions based on their solid research demonstrate that the physical activity in the training conducted at the 2 study sites closely match each other, indicating a good level of standardization in implementation of the prescribed training regimen.

The prosperity of this nation, and to a lesser degree a large part of the world, since World War II has changed the perspective of nutrition from one of insufficiency to that of abundance. However, that seemingly positive trend is not without its negative aspects. The prosperity has also given us the ability to exhaustively and seemingly endlessly evaluate the nutritive properties of the many substances classified as food, and publicize those findings to the population. Even with the availability of that information, most food choices are not made from a nutritive aspect, but rather from convenience, advertising hype, habit, and other lifestyle factors. This trend has long been reflected in an inexorable increase in obesity and other unhealthy, nutrition-related manifestations such as cardio and digestive conditions. Since the

military is a snapshot, albeit a generally healthier one, of the population as a whole, the nutrition choices and habits of military members are of concern to health professionals. Since nutrition and good health—and therefore military readiness—are absolutely interdependent, nutrition is another of the designated foundation pillars of good health in The Surgeon General's Performance Triad. This issue of the AMEDD Journal contains 3 articles presenting studies by Army health professionals addressing different aspects of nutrition within the Army, and which undoubtedly reflect the situation throughout all the US military services. Dr Dianna Purvis and her coauthors lead off with their article describing Soldier dietary behaviors and the relationship of healthy eating behaviors and demographic, lifestyle, and psychosocial factors. They collected a considerable amount of data from a relatively large study population, and methodically reduced, parsed, and analyzed that data, and correlated the results with extensive literature research reflected in the references cited throughout the article. The results of their efforts should be of great interest for everyone involved in organizational nutrition planning and management, whether civilian or military.

Since many, perhaps most, military recruits are not well versed in good dietary behaviors when they enter the service, one of the efforts made by the Army to improve nutritional behaviors is called the Soldier Fueling Initiative. It provides nutrition education and improved dining facility menus to Soldiers at basic combat training and advanced individual training locations in an effort to instill good dietary habits in trainees as an inherent part of their military lifestyle. However, no program or policy will be successfully implemented without positive, effective leadership, especially in the early phases of the military experience. Dr Theresa Jackson and her research team conducted a study to examine the influence and effectiveness of troop leaders at 2 training locations with regard to eating behavior of their Soldiers. Their study examined the activities and attitudes of Soldiers within the framework of the Soldier Fueling Initiative, and how it was or was not supported by their leadership during training. Their findings clearly indicate the relationship of Soldier nutrition practices and the leadership they experienced in this area. This article is important to those designing and planning training for troop leaders working in these environments, as well as for Soldiers training under the Soldier Fueling Initiative.

Laura Lutz and her coauthors examined the actual (self-reported) eating behaviors of Soldiers in basic combat training to quantify any changes in dietary quality between their start and completion of that training cycle.

Their investigation focused on the types and quantities of food consumed during training, and demographic data and tobacco use were factored into the data analysis as well. The study was carefully designed with a solid background of research, and the data collection was detailed. The results of their analysis, clearly presented in the article, indicate that the efforts of initiatives to improve the dietary habits of Soldiers from the beginning of their Army experience are showing measureable success.

The fact that adequate sleep, the third pillar of the Performance Triad, is essential to good health has been widely recognized for many years, not only by scientists and medical professionals, but by most people, usually based on personal experience. Unfortunately, similar to both healthy activity and good nutrition, adequate sleep loses against the time demands of our multitasked lifestyle of unlimited entertainment, universal contact, and 24 hour availability. Lack of sleep begins early as teenagers cannot prioritize their activities, and continues into the working life with too many commitments (and/or jobs) and the demands of parenthood. Cynthia Lentino and her coauthors looked at sleep habits in the military population to examine the relationship of sleep quality to physical performance, nutritional habits, measures of obesity, and lifestyle behaviors, among other things. Their excellent, thoroughly referenced article clearly presents the details of their data collection, its analysis, and the conclusions developed from that analysis. The results of their study reinforce the findings of other research in this area, and unquestionably demonstrate that the 3 elements of the Performance Triad are highly interdependent in both positive and negative relationships.

Dr Nancy Wesensten and Dr Thomas Balkin conducted an extensive, thorough literature review for research which could be used to address the adverse effect of insufficient sleep on military readiness. Their primary goal was to identify data and research findings for use in developing an optimally effective sleep health education program which could be taught to military personnel and their families, since good sleep habits are just as important in garrison as in a deployed environment. Just as importantly, such a program must be understood and supported by military leadership at all levels, so that the sleep of combat troops would be a major consideration in maintaining the combat effectiveness of the fighting force. Their article is a logically organized, easily understood presentation of their research findings, which further undergird The Surgeon General's concept of the Performance Triad as the foundation in the development and maintenance of a fighting force at the highest level of readiness and combat capability.

# A System for Health: Essential Element of National Security

LTG Patricia D. Horoho  
The Surgeon General of the United States Army

Army Medicine is transitioning from a healthcare system to a System for Health. This means shifting the focus to prevention of disease, injury, and disability. More importantly, it means advocating a culture shift to Soldiers and beneficiaries by encouraging them to develop a mindset that drives them to optimize their own health. The Performance Triad is the enabler of our transition to a System for Health, as well as the framework for helping to change the mindsets of those for whom we are professionally and personally responsible. If we can improve the health literacy of the Army community, our Army family will make better decisions about Activity, Nutrition, and Sleep, which form the 3 pillars of the Triad. The depth of science and professional knowledge represented by the articles in this issue is essential to the evidence-based foundation we are using to encourage and assist Army beneficiaries to choose good health.

The successful transition to a System for Health is vitally important. Not only is it important to the survival of Army medicine as an affordable, viable entity, but also—I am convinced—to the security of our nation. We spend more than any other nation on healthcare, yet we are becoming less and less healthy. Obesity is increasing and tobacco use and substance abuse are on the rise among both children and adults, chronic diseases lead our nation in causes of death, and the cost of our healthcare system is simply not sustainable.

The declining health status of our Soldiers, their Families and our nation as a whole are common concerns

shared across and beyond Army Medicine. Additionally, we face the challenges of the drawdown, sequestration, budget cuts, and furloughs. These challenges fill our inboxes, consume our days, and negatively affect morale and our sense of value to the organization. Together, health issues and financial pressures present a significant threat to our security and to our Army's most basic mission: to fight and win our nation's wars. However, we cannot—I repeat, cannot—allow the challenges we face to drive us to despair. We are part of an organization that has faced equal and greater challenges over the past 238 years. We have seized the opportunities that those challenges presented, and we emerged stronger and more resilient. Today is no different.

Everyone in Army Medicine has an active role in changing not only the way Army Medicine is organized and operates, but how we interact with our beneficiaries, and how we influence health. Whether in leadership positions at the headquarters, the regional medical commands, the major subordinate commands, or closer to the point of health care delivery in our medical treatment facilities or line units, each of us has a critical part in shaping the future of Army Medicine. What we do and how we do it will be our legacy. I believe that legacy will be the transformation of health care, not only across the Army, but across the nation.

**ARMY STRONG!**



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**Serving To Heal...Honored To Serve**

# Strategies for Optimizing Military Physical Readiness and Preventing Musculoskeletal Injuries in the 21st Century

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## ABSTRACT

With downsizing of the military services and significant budget cuts, it will be more important than ever to optimize the health and performance of individual service members. Musculoskeletal injuries (MSIs) represent a major threat to the health and fitness of Soldiers and other service members that degrade our nation's ability to project military power. This affects both financial (such as the economic burden from medical, healthcare, and disability costs) and human manpower resources (Soldiers medically unable to optimally perform their duties and to deploy). For example, in 2012, MSIs represented the leading cause of medical care visits across the military services resulting in almost 2,200,000 medical encounters. They also result in more disability discharges than any other health condition. Nonbattle injuries (NBIs) have caused more medical evacuations (34%) from recent theaters of operation than any other cause including combat injuries. Physical training and sports are the main cause of these NBIs. The majority (56%) of these injuries are the direct result of physical training. Higher levels of physical fitness protect against such injuries; however, more physical training to improve fitness also causes higher injury rates. Thus, military physical training programs must balance the need for fitness with the risks of injuries. The Army has launched several initiatives that may potentially improve military physical readiness and reduce injuries. These include the US Army Training and Doctrine Command's Baseline Soldier Physical Readiness Requirements and Gender Neutral Physical Performance Standards studies, as well as the reimplementation of the Master Fitness Trainer program and the Army Medical Command's Soldier Medical Readiness and Performance Triad Campaigns. It is imperative for military leaders to understand that military physical readiness can be enhanced at the same time that MSIs are prevented. A strategic paradigm shift in the military's approach to physical readiness policies is needed to avoid further degradation of warfighting capability in an era of austerity. We believe this can be best accomplished through leveraging scientific, evidence-based best practices by Army senior leadership which supports, prioritizes, and implements innovative, synchronized, and integrated human performance optimization/injury prevention policy changes.

The United States military is being transformed as deployments in Iraq and Afghanistan come to an end and the Department of Defense (DoD) cuts budgets and personnel. The Chairman of the Joint Chiefs of Staff, General Martin Dempsey, has stated that strategies and capabilities are key factors in cutting \$450 billion from DoD's budget over the next 10 years.<sup>1</sup> Further, on January 26, 2012, the strategic guidance from the Pentagon, presented from then Secretary of Defense, Leon Panetta and GEN Martin Dempsey, included the recommendation for Army personnel strength reductions from 570,000 to 490,000 over the next 5 years.<sup>2</sup> Second-order effects from this decline in troop strength superimposed upon the persistent and significant percentage of Soldiers considered medically not ready (MNR) to deploy could potentially have significant consequences if the manned force structure is not able to meet military operational requirements for protecting our nation's

vital and important interests. As a consequence of these austere changes/decrements in resources, protection of force health and performance optimization of Soldiers and other service members will be more important than ever.

Musculoskeletal injuries (MSIs) are the cause of a large percentage of service members deemed to be MNR and placed on limited duty.<sup>3</sup> These MSIs are a major threat to the health and fitness of our Soldiers and other service members placing our nation's war-fighting capability at risk.<sup>3,4</sup> The costs imposed by this threat are both financial (such as the economic burden from medical, healthcare and disability costs) and human. The injuries exacerbate human manpower losses as Soldiers are medically unable to perform their duties for deployment.<sup>3,5-8</sup> The majority of the injuries encountered in military populations are training-related, overuse injuries.<sup>8,9</sup>

## STRATEGIES FOR OPTIMIZING MILITARY PHYSICAL READINESS AND PREVENTING MUSCULOSKELETAL INJURIES IN THE 21ST CENTURY

Controlling MSIs among military personnel and continuing to reduce injury rates depend on institutionalizing existing best practices for injury prevention and physical training, plus prioritizing relevant research in the future. Accomplishing this requires establishing stronger linkages across commands, operational personnel, researchers, medical providers, public health, and safety officials.<sup>10</sup> With the emphasis of the *2010 Quadrennial Defense Review Report*<sup>11</sup> on the health and fitness of the total force, and the *2007 Joint Force Health Protection Concept of Operations*<sup>12</sup> encompassing a healthy, enhanced, and protected force, now is the time to critically review military physical readiness practices—both human performance optimization (HPO) and injury prevention (IP)—with the Army and other services. The promotion and sustainment of military physical readiness requires an energized sense of urgency from senior military leadership responsible for the implementation of policies and strategies that promote and sustain military physical readiness. Such actions will contribute to force readiness and align the DoD and the Military Healthcare System with a fundamental premise that the Soldier is the center of our Warfighter capability. The human service member is the prime resource and key enabler of all Warfighting systems.<sup>12(ES-2)</sup>

This article proposes that the military approach to military physical readiness requires a new strategic paradigm that recognizes that physical training, physical fitness, and injury prevention are interrelated and can be optimized simultaneously. For the purposes of this article, the term military physical readiness is an umbrella term referring to both HPO and IP efforts. This article describes (1) the scope and impact of the MSI problem on readiness; (2) the implications for the associations among physical training, fitness, and injuries for readiness; (3) an assessment of current Army Physical Readiness Training Doctrine; (4) an overview of injury risk mitigation strategies and efforts; (5) current HPO/IP efforts in the Army targeting military physical readiness; (6) recommendations as to the implementation of organizational, communication, scientific, and operational changes through strategic planning; and (7) alternative scenarios for HPO/IP.

### SCOPE AND IMPACT OF THE MUSCULOSKELETAL INJURY PROBLEM ON MILITARY READINESS

Former Army Surgeon General LTG Eric Schoemaker identified that the Army's deployment readiness was at just 85% for active duty and only 70% for Guard and Reserve forces.<sup>13</sup> BG Brian Lein, former command surgeon at US Forces Command, warned that it would be difficult for the Army to maintain unit manning levels in the future if nondeployable status remained at the current level:

If we don't get our arms around the nondeployable population, and the biggest population is the MNR population, we're going to have a significant problem manning our units to get them to go downrange.... The Soldier is the center of our formations, so if the Soldier is not ready to go, then the unit is not ready to go.<sup>13</sup>

Across the military services, injuries represent the biggest medical threat to readiness.<sup>8,14,15</sup> In 2012, MSIs resulted in over 2.2 million medical encounters annually across the military.<sup>16</sup> These injuries affect more than 600,000 individual service members each year.<sup>17</sup> In comparison, the second leading cause of medical encounters, mental disorders, results in approximately 2.1 million encounters annually, affecting approximately 250,000 service members.<sup>17</sup> The biggest share of the injury problem (over 40%) belongs to the Army.<sup>8</sup> Across the services, overuse injuries can be estimated to cause more than 55% of all injury encounters by active duty service members.<sup>8</sup>

Published research demonstrates that the physical training-related injury risk is the highest for basic combat training in the Army and Marine Corps.<sup>9</sup> The incidence during US Army basic combat training ranges from 19% to 40% for men and 40% to 67% for women.<sup>18,19(pp6-7)</sup> For advanced individual training with training cycles from 9 to 16 weeks duration, the literature reports training-related injury incidences ranging from 24% to 40% for men and 30% to 60% for women.<sup>19(pp6-7)</sup> For operational units including infantry, armor, and military police, injury incidence has been reported to range from 5% to 13% per month (equivalent to annualized rates of 60 to 150 injuries per 100 soldiers per month) depending on the type of unit.<sup>19(pp6-7)</sup> Soldiers report that physical training and sports activities caused the largest proportion of these injuries. Army research shows that physical training and sports cause 53% to 63% for ordnance Soldiers in advanced individual training, 40% for armor Soldiers, 38% for garrison Soldiers, 42% for senior officers at the US Army War College, 58% for light infantry Soldiers, 53% for military police, and 34% for wheeled vehicle mechanics.<sup>19(pp6-7)</sup>

Downstream effects from the MSI epidemic in the military profoundly impact hospitalizations and outpatient visits, lost/limited duty time, and disabilities. Acute MSIs and chronic musculoskeletal conditions arising from injuries are consistently the leading cause of hospitalizations and outpatient visits in the military. Of the over 20 million ambulatory visits to military medical treatment facilities reported in 2012, over 4 million (20%) were acute injuries and other injury-related musculoskeletal/connective conditions.<sup>16</sup>



It has been estimated that across all the services more than 25 million limited duty days annually result from injuries, an equivalent of 68,000 service members a year on limited duty.<sup>3,18(p11)</sup> If limited duty is prescribed in proportion to the percent of injuries reported by the services, the Army owns the largest share (slightly over 40%) of those limited duty days or about 10 million limited duty days (about 27,000 man-years on limited duty each year). The healthcare costs alone ascribed to those 68,000 DoD service members are over \$700 million a year. The cost of salaries of Soldiers who cannot deploy is just over \$3 billion annually. The costs to the Army for medical care and salaries of Soldiers on limited duty can be conservatively estimated to be about \$1.5 billion per year. The time lost to commanders and organizations is incalculable.

The long-term effects in terms of disability discharges are just as sobering. Disabilities from MSIs have increased over time disproportionately to medical treatment rates.<sup>6,20</sup> From 1982 to 2002, the disability discharge rates specifically for MSIs increased from less than 15 for both men and women to 140 per 10,000 for females (a 9-fold increase) and to 81 per 10,000 for males (a 5-fold increase).<sup>18(pp6-7)</sup> These disproportionate disability discharge rates between men and women imply that MSI risk mitigation strategies are essential for optimal performance among military women. Such injury risk mitigation strategies will be particularly critical as more women enter combat-centric occupations resulting from the elimination of the 1994 direct combat definition and assignment rule on January 9, 2013. In addition to the manpower losses incurred by the Army and other services due to disabilities, the Department of Veterans Affairs (VA) costs for compensation have historically been high.<sup>6</sup> The VA reported in 2001 that the annual compensation paid to disabled service members totaled over \$21 billion, with over \$5.5 billion to service members with musculoskeletal disabilities.<sup>18(p10)</sup> Although it is understood that soldiering is a physically demanding occupation,<sup>21-26</sup> the Army as an enterprise organization should not accept these high injury incidence rates and medical costs associated with them, especially since the risk factors for these injuries are largely understood and many methods for reducing injuries are available.

#### IMPLICATIONS FOR THE ASSOCIATION OF PHYSICAL TRAINING, FITNESS, AND INJURIES FOR READINESS

The rigor of physical training, particularly preparing for physically demanding military occupations, places great demands on the musculoskeletal system. The many beneficial outcomes of effective physical training are well documented.<sup>18,27-30(pp6-7)</sup> Conversely, adverse outcomes

also occur from physical training, the most common of which are MSIs. For example, many of the injury-related musculoskeletal conditions are due to the cumulative effects of repetitive microtrauma forces: overreaching/training, overuse, overexertion, and repetitive movements experienced during both occupational duties and physical training.<sup>7</sup> Overuse injuries are an indicator that a unit is overtraining. As a consequence, one can expect that units with increasing overuse injury rates can also expect decreases in physical fitness. Thus, injury rates can be reduced and physical fitness enhanced by judicious modifications of training that can be calculated to optimize fitness and minimize injury risks. Of the almost 750,000 MSIs reported in 2006 in military medical surveillance data on active duty, nondeployed service members, 82% were classified as overuse.<sup>18(p16)</sup> As stated previously, typically 30% to 50% of these injuries are specifically attributable to physical training and sports activities.<sup>18(pp6-7)</sup>

The physical training MSI epidemic in the military training/garrison environment, arguably under-recognized by military leaders and policy makers, has been well documented in the scientific literature. Senior leaders should understand that the major cause of the more than 30,000 medical evacuations between 2001–2006 from Operations Iraqi Freedom and Enduring Freedom were not battle injuries but rather nonbattle injuries (NBIs) from participation in sports and physical training activities. Hauret et al reported that medical evacuations for NBIs (36%) were twofold greater than for battle related injuries (18%).<sup>4</sup> The major causes for these nonbattle related medical evacuations were from physical training and sports (about 20% of the total). Further, Cohen et al reported that medical evacuations from Iraqi Freedom and Enduring Freedom were greater for musculoskeletal related injuries (24%) than combat injuries (14%).<sup>31</sup> Hence, effective physical training injury mitigation strategies are needed to keep more people “in the fight” and to decrease the number needed to be sent “to the fight” to replace those injured.

Numerous extrinsic and intrinsic risk factors for MSIs have been identified. Extrinsic risk factors include high running mileage, age of running shoes, and seasonal variations, such as higher overall rates in summer.<sup>18(p23)</sup> Intrinsic risk factors include female gender, low aerobic fitness, low levels of physical activity prior to military entrance, cigarette smoking prior to military entrance, past ankle sprains, low muscular endurance, and older age.<sup>18(p18)</sup>

The most important modifiable risk factor for training-related injuries is the physical training program itself.

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Without physical training, these type of injuries do not occur. The scientific literature documents that greater volumes of training, especially weight-bearing physical training such as running or marching, are associated with higher risks of injuries.<sup>19,32-34</sup> Among the intrinsic risk factors for training-related injuries, low levels of physical fitness, in particular low levels of aerobic fitness or slow run times, have been consistently shown to be associated with higher risks of such injuries.<sup>18,19,35-37</sup> Ironically, this means that the Army and other services must expose service members to the risk of injury resulting from physical training in order to develop mission essential physical fitness and accrue the benefits of higher levels of fitness.

Interestingly, it has been shown that there are thresholds of physical training above which injury risks increase but physical fitness plateaus or decreases.<sup>19,34,38</sup> Increased injury risks and decreased physical performance are 2 of the cardinal signs of overtraining. If the thresholds of training indicative of overtraining can be identified, scientists and commanders should be able to design programs that simultaneously minimize injury rates for units and enhance physical fitness of Soldiers and other service members.

With the exception of considering aerobic fitness levels in assigning basic trainees into groups for ability group runs,<sup>39</sup> no systemic Army-wide policy exists for using known intrinsic risk factors to stratify Soldiers based upon injury risk potential and tailor their physical readiness training accordingly. More research is needed to identify modifiable risk factors for injury and the effectiveness of prevention strategies employing that knowledge.

### ASSESSMENT OF CURRENT ARMY PHYSICAL READINESS TRAINING DOCTRINE

The Army continually tries to improve its physical training curriculum by inserting new evidence-based physical training information into policy and doctrine in an effort to balance HPO/IP. In October 2012, the Army Training and Doctrine Command's (TRADOC) Army Physical Fitness School published an authoritative doctrine in the form of *Field Manual 7-22, Army Physical Readiness Training*.<sup>39</sup> Beginning in the early 2000s, the US Army Physical Fitness School initiated efforts to redesign Army physical training. In consultation with subject matter experts from the Army Institute of Public Health at the US Army Public Health Command (USAPHC) and the US Army Research Institute of Environmental Medicine, a program was designed to improve Warfighter's physical capability for military operations and reduce musculoskeletal injuries. This was

achieved by examining the standard list of warrior tasks and determining: (1) physical requirements of military tasks; (2) fitness components involved; and (3) training activities most likely to improve performance of military tasks. Injury prevention features included reduced running mileage, exercise variety (cross-training), and gradual, progressive training.<sup>40</sup> This program was subsequently validated in field and laboratory studies<sup>41-43</sup> which demonstrated that the overall adjusted injury risk was 1.5 to 1.8 times higher in groups of Soldiers performing traditional military physical training compared to groups participating in the new physical readiness training (PRT). Scores on the Army Physical Fitness Test (APFT) and physical performance metrics were similar or higher in groups using the PRT programs.<sup>40,44</sup> The Army adopted the new PRT as official doctrine as a result of these studies.

Despite the advantages and benefits of the current evidence-based Army PRT, several areas of concern and limitations with the current doctrine must be acknowledged. First, the PRT program was only assessed over a relatively short time period (approximately 8 weeks). Kraemer et al have shown that the incorporation of resistance training provides superior gains in strength, power, muscle hypertrophy, and military task performance over a 6-month training period when compared to conventional military field training.<sup>45</sup> Recently, Grier et al have shown that more weekly resistance training imparts a protective effect for injuries in infantry Soldiers.<sup>46</sup> Fortunately, TRADOC is examining ways to encourage and monitor other test components of physical fitness rather than relying solely on aerobic fitness and muscle endurance.

Although there are a number of short-term studies available in the literature, a paucity of research has considered physical performance adaptations over the "life-cycle spectrum" of the Warfighter, particularly among operational units. Important considerations for physical training optimization among our Soldiers, in terms of incorporating resistance training, must be acknowledged. For relatively untrained Soldiers, improvements in strength at the onset of training are primarily due to neural factors (eg, increased agonist activation, improved motor unit coordination, and synchronization). Therefore, previously untrained Soldiers/recruits should participate first in relatively low-load, low-volume resistance exercise protocols to induce substantial improvements in strength and minimize the likelihood of injury due to relatively modest loads and volume. Following 2 to 3 months of training, the initial period of rapid neural adaptations has elapsed and most additional strength gains are due to muscular factors (ie, hypertrophy). After the

initial few months of resistance training, heavier loads and greater volumes of lifting appear to be required for further performance enhancement.<sup>19</sup> It would be difficult to identify the optimal physical training programs without additional validation studies.

Second, the majority of field validations utilized the APFT as the performance outcome measure. Debate is ongoing among military physical training subject matter experts with regard to the appropriateness of the APFT to assess the capability of a Warfighter to perform occupational and/or combat duties.<sup>47</sup> However, no other established and accepted metrics of “combat or functional performance” is yet available. In 2012, the Army evaluated 2 different tests for consideration as doctrine: (1) an APRT consisting of a 60-yard shuttle run, 1-minute rower, standing long jump, 1-minute push-up, and 2-mile run to replace the APFT; and (2) an Army Combat Readiness Test.

Currently, a Baseline Soldier Physical Readiness Requirements study is being conducted by the TRADOC Initial Military Training Center with support from leading subject matter experts from the USAPHC, the US Army Research Institute of Environmental Medicine, the US Military Academy, the Consortium for Health and Military Performance (CHAMP) at the Uniformed Services University of the Health Sciences (USUHS), and the TRADOC Physical Readiness Division. The intent of this study is to systematically quantify, evaluate, and summarize the physical demands of warrior tasks and battle drills to determine, validate, and implement appropriate physical testing that would be used to assess a Soldier’s ability to successfully execute warrior tasks and battle drills. This study is projected to result in implementation of a new physical readiness testing paradigm in May 2015. It is clear that continued efforts are required to identify and establish the most valid metrics for military physical performance assessment. These TRADOC efforts indicate a paradigm change for physical training and testing.

### INJURY RISK MITIGATION STRATEGIES AND EFFORTS

In a 2003 policy memorandum, Secretary of Defense Donald Rumsfeld challenged the DoD to reduce the incidence of preventable accidents. The memo stated:

World-class organizations do not tolerate preventable accidents. Our accident rates have increased recently, and we need to turn this situation around. I challenge all of you to reduce the number of mishaps and accident rates by at least 50% in the next two years. These goals are achievable and will directly increase our operational readiness. We owe no less to the men and women who defend our nation.<sup>48</sup>

In response to that memorandum, the Defense Safety Oversight Council (DSOC), chaired by the Under Secretary of Defense for Personnel and Readiness, was formed to provide governance on DoD-wide efforts to reduce preventable injuries. The Military Training Task Force (MTTF), comprised of civilian and military injury experts from Johns Hopkins Center for Injury Research and Policy and the Army Center for Health Promotion and Preventive Medicine (now the USAPHC), was chartered to support this accident and injury prevention directive with a focus on interventions that relate to all aspects of military training.<sup>49</sup> The Joint services Physical Training Injury Prevention Working Group (JSPTIPWG) was created under the MTTF in September 2004 to evaluate military physical training injury prevention programs, policies, and research for recommendations to reduce physical training-related injuries.<sup>49</sup> An expedited systematic review process was used by the working group to: (1) establish the evidence base for making recommendations to prevent physical training-related injuries; (2) prioritize the recommendations for prevention programs and policies; and (3) prioritize further research and evaluation efforts that could likely reduce physical training-related injuries.<sup>49</sup>

Of the 40 promising injury prevention strategies systematically reviewed, only 6 intervention strategies to reduce physical training-related injuries had the requisite evidence-based scientific support to recommend for implementation across the military. These interventions in order of priority were: (1) prevent overtraining (ie, excessive running mileage); (2) perform multiaxial, neuromuscular, proprioceptive, and agility training; (3) wear mouthguards during high-risk activities; (4) wear semi-rigid ankle braces for high risk activities; (5) consume nutrients to restore energy balance within one hour following high-intensity activity; and (6) wear synthetic-blend socks to prevent blisters.<sup>49</sup> It is important to note that not all of these evidence-based interventions have been implemented as doctrine. Of equal interest, 23 intervention strategies with some theoretical basis for efficacy were identified as lacking sufficient evidence to recommend at that time.<sup>49</sup> The JSPTIPWG recommended that upon determination by systematic reviews that scientific information is scant and gaps exist in knowledge about prevention, more research is needed before the implementation of policies and programs.<sup>50</sup> The efforts of the DSOC and the MTTF work group indicated that the DoD and the services are no longer willing to accept injuries as a given cost of conducting training and operations.

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### CURRENT HPO/IP EFFORTS IN THE ARMY TARGETING MILITARY PHYSICAL READINESS

The Army published *Technical Bulletin MED 592, Prevention and Control of Musculoskeletal Injuries Associated with Physical Training*<sup>19</sup> in May 2010. It is an important comprehensive document that translates state-of-the-art guidance into principles that military and civilian healthcare providers and allied medical personnel can understand and implement. Such evidence-based preventive principles can protect Army personnel from musculoskeletal injuries associated with physical training. The document serves as an authoritative source on HPO/IP and helps military care providers and leaders:

- ▶ understand physiologic and pathophysiologic responses to exercise,
- ▶ know risk factors associated with training-related musculoskeletal injuries,
- ▶ understand interventions with varying levels of evidence for effectiveness in preventing training-related injuries,
- ▶ recognize the presentation and acute treatment of Soldiers with training-related MSIs,
- ▶ evaluate and appropriately treat Soldiers with acute training-related MSIs, and
- ▶ advise commanders on planning, implementing, and evaluating any proposed comprehensive program designed to reduce physical training-related MSIs.

A common trend among Warfighters is extreme conditioning programs (ECPs) (for example, CrossFit (CrossFit Inc, Washington, DC), Insanity (Beachbody LLC, Santa Monica, CA), Gym Jones (Gym Jones LLC, Salt Lake City, UT), and others) characterized by high-volume, intense training workouts. These well-marketed and popularized conditioning programs continue to generate interest and support among military and civilian fitness communities. Acceptance of ECPs is reinforced by anecdotal reports of marked gains in physical performance. However, physicians and other primary care and rehabilitation providers have identified a potential emerging problem of disproportionate MSI risk, particularly for novice participants. Muscle strains, torn ligaments, stress fractures, and mild to severe cases of potentially life-threatening exertional rhabdomyolysis have been anecdotally reported in increasing numbers as the popularity of ECPs has grown.<sup>51</sup> Unfortunately, the short- and long-term physiological, functional, and readiness outcomes or safety of ECPs have not been carefully studied. Only one study to date has reported fitness outcomes in the peer-reviewed literature using a CrossFit-based program. Smith et al reported increases in maximal aerobic fitness and body composition after

10 weeks of training. However, limitations for this study were that a control group was not included in the study and injury data were not reported.<sup>52</sup>

On September 13 and 14, 2010, a workshop on ECPs, composed of the CHAMP, other members of the DoD, and representatives of the American College of Sports Medicine, was convened at the USUHS in Bethesda, Maryland, to begin a critical dialog on this important issue.<sup>53</sup> From this workshop, the consensus was that further research was needed to confirm or negate the purported increase in injury risk from participating in ECPs and clarify other modifiable contributing factors.<sup>53</sup>

Former US Army Surgeon General LTG Eric Schoomaker initiated an ongoing effort germane to HPO/IP in the military. LTG Schoomaker identified Soldier Medical Readiness as his number one priority.<sup>54</sup> The US Army Medical Command (MEDCOM) has partnered with the Headquarters, Department of the Army (HQDA); US Army Forces Command (FORSCOM); TRADOC; Installation Management Command; US Army Reserve Command; US Army Special Operations Command; Director, Army National Guard; US Army Human Resource Command; HQDA G-1; and HQDA G3/5/7 to execute a coordinated campaign to increase medical readiness in the Army. Through execution of this campaign, MEDCOM expects support to: (1) deploy healthy, resilient, and fit Warfighters; (2) increase the medical readiness of the Army; and (3) effectively manage the medically not ready (MNR) population to return the maximum number of Warfighters possible to deployable status. These goals will be accomplished through 3 primary lines of effort:

- 1.0 MNR Soldier Identification
- 2.0 MNR Management Programs
- 3.0 Evidence-Based Health Promotion, HPO/IP Programs

Line of Effort (LOE) 3.0 of the *Soldier Medical Readiness Campaign Plan*<sup>54</sup> (SMR-CP) embodies the key task to coordinate, synchronize, and integrate health promotion, injury prevention, and human performance optimization programs across the Army with key objectives to improve physical fitness and reduce injury rates. Figure 1 lists the SMR-CP LOE 3.0 strategic objectives, objective statements, quantifiable measures, target goals, and initiatives. The main objectives of this LOE are to: (1) provide evidence-based health promotion services to enable healthy lifestyle choices and eliminate preventable health issues that contribute to MNR Soldiers; (2) implement, support, and evaluate promising injury prevention and performance optimization best practices/programs;

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<b>Strategic Objective: Synchronize Medical Readiness Related Research</b>
<p>Objective Statement: communicate commanders' and public health research needs; collaborate with Army partners on HPO/IP projects; and enhance communication of evidence-based lessons learned to commanders, policy makers, and the health promotion community; ultimately contributing to the reduction in MNR Soldiers.</p> <p>Measures: (1) number of scientific publications on MSI; (2) number of scientific presentations on MSI; (3) number of current agreements that leverage Army partners.</p> <p>Target: (1) &gt;50% manuscripts on MSI in peer-reviewed journals per fiscal year; (2) 5 talks/presentations per fiscal year specifically on MSI research; (3) one agreement with and Army partner to disseminate MSI research lessons learned not later than September 30, 2011.</p> <p>Initiatives: (1) complete research inventory; (2) complete list of suggested future HPO/IP research; (3) develop communication/coordination strategy</p>
<b>Strategic Objective: Improve Integration of Musculoskeletal Injuries Rehabilitation Programs</b>
<p>Objective Statement: synchronize, coordinate, and improve unit-based and MTF-based musculoskeletal injury rehabilitation programs to enable Soldier medical readiness.</p> <p>Measures: number of Soldier profile days due to musculoskeletal injury in FORSCOM units evaluated.</p> <p>Target: 15% decrease in profile days due to MSI in FORSCOM units evaluated.</p> <p>Initiatives: (1) unit-based medical management; (2) unit-based rehabilitation program; (3) musculoskeletal action plan; (4) aquatic rehabilitation pilot program; (5) aquatic warrior exercise program standardization.</p>
<b>Strategic Objective: Improve Soldier Injury Prevention/Human Performance</b>
<p>Objective Statement: coordinate and synchronize evidence-based HPO/IP policies and programs that support Army Force Generation in each of its phases in order to improve the medical readiness of the Army.</p> <p>Measures: (1) percentage that pass APFT in FORSCOM units evaluated; (2) percentage of Soldier injury rate in FORSCOM units evaluated; (3) recommendations for injury prevention provided to FORSCOM units evaluated.</p> <p>Target: (1) &gt;85% pass rate on current APFT in FORSCOM units evaluated; (2) 15% decrease in injury rate in FORSCOM units evaluated; (3) recommendations for injury prevention targets provided to FORSCOM units evaluated (25th ID, 4th ID).</p> <p>Initiatives: (1) conduct inventory of ongoing Army HPO/IP programs and initiatives; (2) conduct review of evidence-based support for HPO/IP initiatives and infantry division best practices and gaps; (3) implement, support, review and evaluate promising Army HPO/IP initiatives; (4) Initial Entry Training Soldier Athlete initiative; (5) 101st Eagle Tactical Athlete Program Research study; (6) 4th ID Iron Horse Performance Optimization US Army Medical Command/FORSCOM; (7) US Army Special Operations Command (USASOC) Tactical Human Optimization Rapid Rehabilitation Reconditioning initiative; (8) USASOC Ranger Athlete Warrior Program; (9) 25th ID Advanced Tactical Athlete Conditioning initiative; (10) implement policy, guidance, education, and training and incorporate them into HPO/IP initiatives.</p>
<p>Note: Detailed descriptions of HOP/IP initiatives are presented in Figure 3.</p>
<p>Figure 1. Soldier Medical Readiness Campaign Plan (SMR-CP) LOE 3.0: Evidence-Based Health Promotion, Injury Prevention, and Human Performance Optimization Programs Balanced Scorecard.<sup>54</sup></p>

(3) assess existing best practices and their evidence base and evaluate the feasibility of incorporating them into standardized best practices to improve management of injuries and optimize Soldier Medical Readiness; and (4) identify research programs within Army Medicine that contribute to HPO/IP, and communicate evidence-based lessons learned from these studies.

The Army MEDCOM is championing the initiatives of the Performance Triad Campaign conceived by The Surgeon General, LTG Patricia Horoho, which focuses

on sustaining and enhancing Soldier stamina by implementing educational programs, motivational strategies, and revised policies to optimize aspects of Soldier health—activity, nutrition, and sleep—among the force. Operational implementation of this strategic initiative with an institutional, proactive system for health (as opposed to a reactive healthcare system) should maintain, restore, and improve health by improving fitness and mitigating MSIs.<sup>55</sup> A specific area of emphasis related to physical readiness involves providing greater educational awareness for Army Physical Readiness Training

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Figure 2. Performance Triad Activity Concept of Operations. The presentation of this Concept of Operations was part of a Performance Triad decision brief to The US Army Surgeon General on October 16, 2012.

LOE 1: Education – Inculcating a paradigm shift with the manner in which the Army views health should must start with the training base with appropriate programs of instruction. Evidence-based activity-centric research conducted by the US Army Research Institute of Environmental Medicine and others and published in peer-reviewed journals will serve as the cornerstone for establishing valid and effective best practices. Growing subject matter expertise within the Army can also be facilitated by partnering with relevant nonprofit health organizations such as the American College of Sports Medicine and the National Strength and Conditioning Association. These organizations offer industry-accepted certifications for health and fitness practitioners. Information dissemination of evidence-based scientific information from credible sources, such as the USAPHC and the Human Performance Resource Center, will be critical in providing the military with accurate and timely information.

LOE 2: Programs – There are many existing and emerging programs both within and outside of the Army that can be leveraged to foster greater awareness for activity among Soldiers and their families, such as Army Wellness Centers and Comprehensive Soldier and Family Fitness. Training and embedding master fitness trainers and master resiliency trainers across the Army will provide subject matter experts to educate Soldiers in physical and mental activities, such as mindfulness. Programs outside the military, such as the American College of Sports Medicine’s Exercise Is Medicine, that promote activity as a vital sign could be useful for integrating physicians, as well as allied health and fitness professionals prescribing exercise programs. The Army Morale, Welfare, and Recreation program serves as a platform to reach military families with activity-centric programs and initiatives.

LOE 3: Policy – Enforcing physical readiness training and requiring Army Wellness Center orientations will ensure fitness and exercise principles are practiced and disseminated. Active engagement by Army senior leaders in modeling and support via policy directives, as well as physical and mental activity efforts will resonate among Soldiers. Policies for families, civilians, and other special populations (pregnant Soldiers, etc) will ensure the Army family is engaged with improving their activity. Physical readiness assessment changes underway in the military have the potential to change the way Soldiers train. Environmental/infrastructure policy changes can also change the manner in which activity is fostered. Integrating and synchronizing the Activity lines of effort for education, programs, and policies should all summate to change the mindset of the Army family so that stamina is maintained, restored and improved.

doctrine, functional fitness, ECPs, minimalist running shoes, dangers of prolonged sitting, preventing injuries, safe running, preparing to perform physical activity, and resistance training. The Activity LOE within the Performance Triad (Figure 2) could be particularly successful if implementation of the TRADOC MFT program is adopted. Embedding MFTs within operational units down to the lowest level feasible could serve the dual role of providing and sustaining legacy subject matter experts on HPO/IP practices, as well as role modeling “what right looks like” to promote the desired behavior modification. Figure 2 illustrates a concept of operations for activity using education, program, and policy lines of effort.

Figure 3 provides more detailed descriptions for the current HPO/IP initiatives listed under the SMR-CP strategic objective: improve soldier injury prevention/human performance. Although a number of innovative HPO/IP initiatives are currently ongoing, most of these initiatives are largely unknown beyond where they are being locally conducted; they are not part of a larger synchronized, integrated, and coordinated HPO/IP effort. An opportunity exists to use these examples and adopt lessons learned so we can move forward with a more global, unified, and focused approach. This could lead to published research findings providing militarily feasible, acceptable, and suitable HPO/IP interventions and performance outcome measures. Until such efforts have been fully validated as scientifically credible and shown to be effective, caution should be exercised before widespread implementation. The 2 MEDCOM initiatives, the Soldier Medical Readiness and the Performance Triad campaigns, demonstrate that the Army medical community intends to transform their paradigm from one of reactive health care to one of proactive promotion of health.

An analysis of the strengths, weaknesses, opportunities, and threats of current HPO/IP initiatives in the Army is provided in Figure 4. Clear strengths of the current state of military HPO/IP programs which could be exploited to facilitate further progress are indicated. However, to capitalize on current momentum, action by senior Army leaders is required to review HPO/IP policies and direct the development of strategic initiatives to improve upon weaknesses and neutralize growing threats.

**RECOMMENDATIONS FOR THE WAY AHEAD:  
IMPLEMENTING ORGANIZATIONAL,  
COMMUNICATION, SCIENTIFIC, AND OPERATIONAL  
CHANGE THROUGH STRATEGIC PLANNING**

A paradigm shift is beginning in the Army and DoD approaches to physical readiness policies, training, and doctrine. The Army initiatives described above testify

to this need. In January 2004, the Deputy Secretary of Defense directed the Joint Staff to “develop the next generation of...programs designed to optimize human performance and maximize fighting strength.”<sup>58</sup> Subsequently, a new joint human performance enhancement capabilities document addressed human-performance standards, metrics, capabilities, and gaps.<sup>58</sup> The joint human performance enhancement capabilities outlined in the *Joint Force Health Protection Concept of Operations*<sup>12</sup> include: (1) manage Warfighter fatigue; (2) optimize human-systems integration; (3) enhance Warfighter sensory, cognitive, and motor capabilities; (4) enhance Warfighter learning, communications, and decision making; (5) enhance physiological capability; (6) provide/maintain ability to operate across the full range of environments; and (7) provide a healthy and fit force.

In 2005, the DoD Office of Net Assessment published *Human Performance Optimization and Military Missions*.<sup>59</sup> This report spawned a request from the Assistant Secretary of Defense, Health Affairs (ASD/HA) to the military services to convene a conference that was held June 7-9, 2006. The goal of the conference was to initiate development of a strategic plan for HPO within the military. The conference was titled “Human Performance Optimization in DoD: Charting a Course for the Future.”<sup>60</sup>

The conference included subject matter experts from over 56 different DoD stakeholder groups: senior leaders (ADM Michael Mullen, Chairman of the Joint Chiefs of Staff was the keynote speaker),<sup>61</sup> Warfighters/operators, unit commanders, allied health professionals, scientists and researchers, and safety officers. Recommendations from the workshop were published in a report forwarded to ASD/HA and a special supplement issue of *Military Medicine*.<sup>62</sup> In response to this report, the ASD/HA convened a HPO Integrated Product Team to review the USUHS report, collect relevant data from the services, and make recommendations for a novel comprehensive HPO program. Among these was a directive to The Army Surgeon General to incorporate key HPO requirements into a Joint Medical Research Command (under the US Unified Medical Command) as a key focus area. The plan for a US Unified Medical Command was later rejected in December 2006 primarily due to resistance from Air Force senior leadership.<sup>63</sup> With current federal budgetary constraints and the potential to reduce redundancies, conserve resources, and implement interoperability and collaboration among the services, the concept of a unified medical command is again worth consideration.<sup>64,65</sup> Currently, it appears the establishment off a Defense Health Agency in October 2013 is an effort toward developing a set of strategies

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<p>Initiative Title: Ranger, Athlete, Warrior (RAW) Program  Proponent: 75th Ranger Regiment  Description/Comments: Uses Army physical therapist-led train-the-trainer course and is a conglomeration of several physical performance techniques focusing on body mechanics, strength, speed, agility, and military task performance. Includes a RAW physical performance assessment as a metric.</p>
<p>Initiative Title: Eagle Tactical Athlete Program  Proponent: 101st Airborne/Air Assault Division and the University of Pittsburgh  Description/Comments: Extramural funded (via the Army Medical Research and Material Command Telemedicine and Advanced Technology Research Center) research effort comprehensively evaluating aspects of HPO/IP: injury surveillance, task and demand analysis, predictors of injury and optimal performance, design and validation of interventions, program integration and implementation, and monitoring to determine effectiveness of program.<sup>56</sup></p>
<p>Initiative Title: Mountain Athlete Program  Proponent: 4th ID/FORSCOM  Description/Comments: HPO program team consists of an Army physical therapist, CrossFit certified trainers, and power lifting coaches who focus on muscular strength, muscular and cardiovascular endurance, speed, agility, and flexibility. The goal is to reduce nondeployable injury rates and increase unit readiness.</p>
<p>Initiative Title: Iron Horse Performance Optimization Program  Proponent: 4th ID/FORSCOM  Description/Comments: Uses an embedded musculoskeletal action team (MAT) in a Brigade Combat Team through a full Army Force Generation cycle focusing on optimizing performance, minimizing injuries, identifying/treating injuries early, reconditioning rehabilitated Soldiers.</p>
<p>Initiative Title: Soldier Athlete Initiative  Proponent: TRADOC/MEDCOM  Description/Comments: Uses an MAT concept at TRADOC initial entry sites to address injury incidence rates.</p>
<p>Initiative Title: Tactical Human Optimization Rapid Rehabilitation &amp; Reconditioning Program  Proponent: US Army Special Operations Command (USASOC)  Description/Comments: Program incorporates a team consisting of physical therapists, strength and conditioning coaches, and a dietician to reduce injury, improve functional performance, and optimize proper fueling. Each team sets program priorities and performance metrics.</p>
<p>Initiative Title: Advanced Tactical Athlete Conditioning  Proponent: MEDCOM/25th ID  Description/Comments: Provides tools (train-the-trainer) and information necessary to lead Soldiers through a tactical, battle-focused approach to PT. Includes high-intensity aquatic training, tactical agility physical training, combat core conditioning, interval speed training, and running form analysis. The USAPHC is conducting program evaluation.</p>
<p>Initiative Title: Military Power, Performance and Prevention  Proponent: MEDCOM/US Army Medical Department Center and School  Description/Comments: This program measures multiple performance metrics such as mobility, power, and balance and injury surveillance in 2/75th Ranger Battalion, 1st Special Forces, a Stryker brigade and a support brigade from the 2nd ID. The goal is to identify those performance metrics that are predictive of injury. A special and unique feature of the initiative is the use of technology as a leveraging tool for the assessment and data collection.</p>

Figure 3. Human performance optimization and injury prevention initiatives tracked by the Office of The Surgeon General.<sup>57</sup>



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<b>Strengths</b>
<ol style="list-style-type: none"> <li>1. Current doctrine provided in <i>Field Manual 7-22</i><sup>39</sup> to guidelines established by the American College of Sports Medicine and the National Strength and Conditioning Association and has been validated by peer-reviewed, published research.</li> <li>2. Numerous intrinsic injury risk factors have been identified via evidence-based and peer-reviewed research findings.</li> <li>3. Innovative research efforts and public health practices occur with the US Army Medical Command (Medical Research and Materiel Command and USAPHC) that prioritizes HPO/IP research, surveillance, and evaluation.</li> <li>4. Many examples of human performance optimization and injury prevention initiatives currently ongoing across the Army.</li> <li>5. Increasing senior leader awareness with regard to the impact of musculoskeletal injuries on military readiness and national security.</li> <li>6. Current and future science and technology advances hold great promise with regard to human performance optimization and injury prevention research.</li> </ol>
<b>Weaknesses</b>
<ol style="list-style-type: none"> <li>1. The incidence rate for musculoskeletal injuries remains unacceptably high.</li> <li>2. Lack of physical training/injury prevention subject matter experts organic to the military personnel system.</li> <li>3. The main proponent for physical readiness training (US Army Physical Fitness School) is not resourced adequately, particularly with personnel.</li> <li>4. Poor synchronization, integration, and communication of human performance optimization/injury prevention efforts across Army commands and operators, health practitioners, researchers, and leaders.</li> <li>5. Implementation of physical training doctrine is unevenly applied across the Army.</li> <li>6. Validated and accepted performance metrics do not exist with regard to human performance optimization/injury prevention.</li> <li>7. HPO/IP initiatives have not been systematically applied or researched across the Warfighter's entire life-cycle or within Army Reserve or National Guard units.</li> </ol>
<b>Opportunities</b>
<ol style="list-style-type: none"> <li>1. Soldier Medical Readiness Campaign.</li> <li>2. Performance Triad Campaign.</li> <li>3. Establishment of a Defense Health Agency.</li> <li>4. Master fitness trainers.</li> <li>5. Current and future science and technology advances hold great promise with regard to human performance optimization and injury prevention research.</li> <li>6. Increasing senior leader awareness with regard to the impact of musculoskeletal injuries on military readiness and national security.</li> <li>7. Military health and fitness outreach to society's youth.</li> <li>8. Revise manner in which HPO/IP is assessed. Establish metrics of performance and effectiveness.</li> </ol>
<b>Threats</b>
<ol style="list-style-type: none"> <li>1. Commercialized HPO/IP entities (CrossFit, etc) are becoming increasingly popular among Soldiers and have not been supported by evidence-based research.</li> <li>2. Shrinking budgets can negatively impact research and development budgets and HPO/IP resource allocation.</li> <li>3. Excessive and increasing external loads (load carriage).</li> <li>4. Increasing societal trends for declining activity levels and fitness. Increased obesity.</li> <li>5. Lack of Unified Joint Medical/Research Command.</li> </ol>
<p>Figure 4. Strengths, weaknesses, opportunities and threats analysis for current Army HPO/IP initiatives.</p>

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on governance to achieve certain efficiencies on “shared services” across the DoD.

The workshop categorized the major issues/challenges to achieving HPO as (1) organizational, (2) communication, (3) scientific, and (4) operational, based upon the type of strategic action required to resolve identified obstacles within DoD.<sup>60</sup> With regard to organizational issues, existing policies should be reviewed with guidance to ensure consistency of HPO approaches in response to new research and technological developments.<sup>60</sup> Another important related issue involves operational translation and dissemination of knowledge and

research results to commanders and Warfighters.<sup>60</sup> The workshop recommended the establishment of a joint center for HPO to translate knowledge and research into the DoD standard of Doctrine, Organization, Training, Material, Leadership, Personnel, and Facilities.<sup>60</sup> The Human Performance Resource Center at CHAMP is an online (<http://hprc-online.org/about-us/about-hprc>) clearinghouse and information repository that serves to translate and disseminate timely, accurate, scientifically based HPO information to commanders, Warfighters, medical personnel, and researchers, some key examples of which are shown in Figure 5.

Source	Comments
<i>Field Manual 7-22: Army Physical Readiness Training</i> <sup>39</sup> (October 2012)	Supersedes discontinued <i>Training Circular 3-22.20: Army Physical Readiness Training</i> (August 2010)
<i>Technical Bulletin Med 592: Prevention and Control of Musculoskeletal Injuries Associated with Physical Training</i> <sup>18</sup> (May 2011)	First medical technical bulletin dedicated to disseminating evidence-based guidance for controlling MSIs.
Consortium for Health and Military Performance and American College of Sports Medicine Consensus Paper on Extreme Conditioning Programs in Military Personnel <sup>53</sup>	This peer-reviewed scientific manuscript is the product of a joint workshop addressing extreme conditioning programs held September 13-14, 2010, at USUHS, Bethesda, MD.
<i>American Journal of Preventive Medicine</i> , January 2010, Volume 38 (Supplement 1)	This supplement contains 25 peer-reviewed articles from the Joint Services Physical Training Injury Prevention Working Group which include systematic reviews. <sup>3,4,7,8,10,49,50</sup>
<i>Military Medicine</i> (Supplement: Total Force Fitness for the 21st Century: A New Paradigm), August 2010, Volume 175(8) <sup>60</sup>	This supplement contains 15 peer-reviewed articles from the 2006 joint service workshop “Human Performance Optimization in DoD: Charting a Course for the Future” hosted by USUHS, Bethesda, MD.
Warfighter Nutrition: Current Opportunities and Advanced Technologies Report From a Department of Defense Workshop <sup>55</sup>	This peer-reviewed article is the product of a joint DoD conference which concluded that nutritional optimization represents an integral and proactive approach to prevent illness, injury, and performance degradation throughout all phases of military service.
Physiological Employment Standards III: Physiological Challenges and Consequences Encountered During International Military Deployments <sup>23</sup>	This peer-reviewed article was the result of an Invited Keynote Presentation at the 1st Australian Conference on Physiological and Physical Employment Standards, 28 November 28, 2012 in Canberra, Australia. It provides a comprehensive overview of the physiological effects of deployment with a particular focus on physical fitness and injuries.
Human Performance Resource Center: A DoD initiative under the Force Health Protection and Readiness Program ( <a href="http://hprc-online.org/about-us/about-hprc">http://hprc-online.org/about-us/about-hprc</a> )	A website sponsored by the CHAMP at USUHS that translates and disseminates accurate, scientifically-based HPO information to commanders, Warfighters, medical personnel, and researchers.

Figure 5. Key authoritative military physical readiness sources for Army senior leaders.

Communication remains a large barrier to the achievement of HPO. A common concern is that commanders and clinicians in the field are typically unaware of current HPO information and research efforts. Operators at the highest levels often do not have adequate visibility of research results and existing biomedical solutions. There are also concerns about valid and reliable information from military research reaching the Warfighter, but rather the Warfighter gathers his information from unsubstantial commercial venues.<sup>60</sup> Consequently, opportunities for military scientists to regularly interact with operators about evidence and development of scientific findings should be encouraged. Future communication efforts should focus on coordination within and across services. Ideally, organizations that conduct HPO research need to be teamed with representatives from acquisition, medical personnel, and operational units from the field to discuss current research, to identify opportunities for cooperation, and to determine future HPO needs.<sup>60</sup>

The scientific issues raised by the workshop centered on the need to develop operationally relevant and standardized metrics to meet joint military requirements.<sup>53</sup> The development of these metrics was considered the single most important issue for research and application of HPO.<sup>60</sup> Accepted, reliable, and valid metrics that relate to combat effectiveness for all of the above capabilities are limited and remain an area for which joint consensus is needed, particularly for measures of performance and measures of effectiveness. Ideally, research efforts should consider the Warfighter through his/her entire life cycle as an integrated program of preparation, training, and monitoring from accession to retirement/separation.<sup>60</sup>

From an operational perspective, collaboration between operators and medical researchers is essential for developing and fielding feasible, acceptable, and suitable HPO approaches.<sup>60</sup> Options for maintaining functional fitness, performance nutrition, cognitive and psychological readiness throughout predeployment, deployment/engagement, and postdeployment/ redeployment timelines are desired and critically needed.<sup>60</sup> The HPO programming should preserve human capital by addressing service member weaknesses, injury and disease prevention, physical readiness training, maximizing sleep quality, and other factors affecting performance.<sup>60</sup>

The vision moving forward is to have HPO conceived as a joint, interagency, combined and coalition effort that creates an interdisciplinary center for investigating HPO in operational settings as well as establishing translational research and education agendas that address barriers and approaches to optimal performance. Developing

effective communication networks that cross research, medical and operational boundaries is critical to the success of this effort.<sup>60</sup> The recommended course of action is to provide HPO functionality by establishing a unified Joint Medical Research Program with a core HPO function. The specific objectives of such an option would be to: (1) advocate for HPO within DoD; (2) coordinate and integrate DoD extramural and intramural HPO medical research; (3) align HPO initiatives to DoD priorities; (4) collaborate with line HPO research functions to ensure synergy toward common endpoints; (5) establish HPO standards, (6) establish a clearinghouse function; (7) continue to leverage the Health Affairs HPO IPT as a community of interest; (8) recommend HPO policy and doctrine to Assistant Secretary of the Army (Health Affairs).<sup>60</sup> A concerted and integrated strategic HPO effort will serve to: (1) enhance the mental and physical resilience of the Warfighter; (2) reduce injury and illness or facilitate more rapid recovery if injury does occur; (3) provide seamless information and knowledge transfer from the laboratory to line; (4) improve the human weapon system's ability to accomplish the mission; and (5) allow the United States to remain at the leading/cutting edge in this area.<sup>60</sup> With the sanctioning of CHAMP and their educational arm, the Human Performance Resource Center at the USUHS as a Defense Center of Excellence (Figure 5), and the establishment of the Health Affairs Human Performance Optimization Health Sciences Advisory Committee, many of the recommendations are being realized.

### ALTERNATIVE SCENARIOS FOR HPO/IP

On February 19, 2013, the Strategy Innovation Office of USAPHC conducted an alternative exercise considering possible future scenarios with over 20 subject matter experts from the USAPHC Epidemiology and Disease Surveillance and the Health Promotion and Wellness Portfolios, and CHAMP. The purpose of this exercise was to brainstorm and develop narratives for different future HPO/IP scenarios based upon alternative political, economic, organizational, operational, environmental, scientific, technological, and social assumptions. Figure 6 depicts 2 key variables that would potentially influence future HPO/IP scenarios: (1) the use of scientific, evidence-based best practices; and (2) the extent to which senior leadership supports, prioritizes, and implements scientific innovative, synchronized, and integrated HPO/IP policy changes. Of the 4 possible alternative scenarios represented in Figure 6, two were chosen to script narratives for the best case, most desired scenario (Resilient, Dominant Warfighter) and the worst case (Injured, Nondeployable Warfighter), projected to occur unless appropriate strategies are implemented. These scenarios are discussed below.

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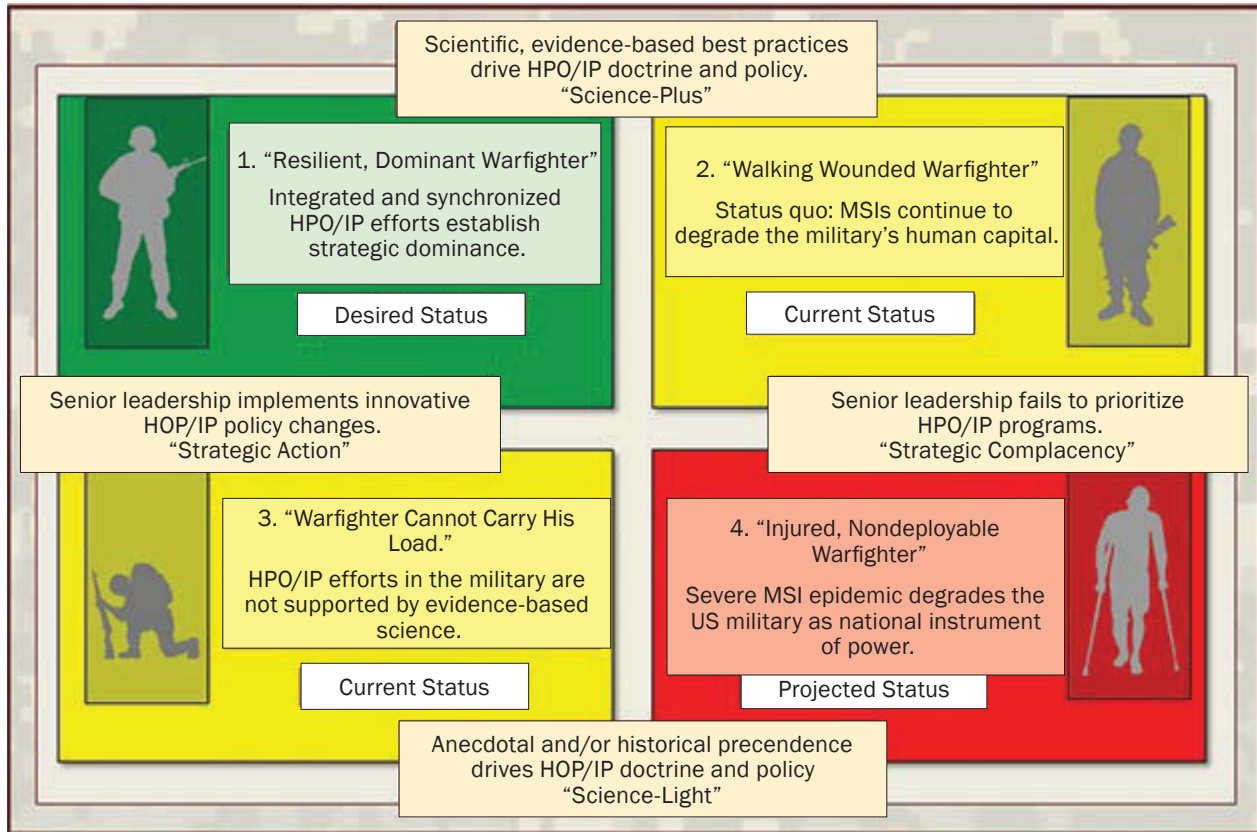


Figure 6. Conceptual alternative future scenario framework portrays 2 major variables: the vertical axis depicts the extent to which HPO/IP practices in the Army are supported by scientific evidence-based best practices (Science Plus vs Science Light). The horizontal axis depicts the extent to which senior leadership supports, prioritizes, and implements innovative, synchronized, and integrated HPO/IP policy changes (Strategic Action vs Strategic Complacency). Each quadrant uses a pairing of these 4 states to frame a scenario, examine possible strategic intervention measures, and explore potential strategic outcomes: 1. Resilient, Dominant Warfighter; 2. Walking Wounded Warfighter; 3. Warfighter Cannot Carry His Load; and 4. Injured, Nondeployable Warfighter. The narratives for the best case (Resilient, Dominant Warfighter) and worst case (Injured, Nondeployable Warfighter) scenarios are presented in the text.

### Scenario 1: Resilient, Dominant Warfighter

As the military becomes smaller, senior leadership will prioritize and place a greater emphasis on preservation of the force by focusing on proven preventive and public health practices. A more selective screening process will be used to recruit new military trainees based on established baseline physical and cognitive requirements to perform military occupations and duties. Better predictive models and analytics will yield better placement of Soldiers in military occupational specialties.

The military prioritizes investment in research and development. Technological advances in materiel science and further refinement of exoskeletons result in lighter external loads. Biosensor technologies provide great insight for training physiology and recovery and are used as important adjuncts to planning physical training. A detailed cost-benefit analysis indicates that significant cost savings can result from embedding medical, physical fitness, and nutritional subject matter experts into

operational units. Deliberate and detailed physiological studies on women in the military will identify risk mitigation and HPO/IP strategies to protect against increased MSI risk. When data systems are integrated and able to communicate with one another, the information gathered is used to refine models predicting risk; new models are applied to pre-identify injuries and negative outcomes before they occur.

The HPO/IP and human systems are given the same attention as weapons systems. The military strategically partners with leading nonprofit HPO/IP organizations (eg, the American College of Sports Medicine, National Strength and Conditioning Association) to assist in disseminating credible and validated HPO/IP information. Logically extending from the MFT course, additional occupational specialties or additional skill identifier dedicated toward HPO/IP are implemented. Identifiers exist for units and Soldiers to engage in healthy behaviors, which lead to improved HPO/IP efforts. The HPO/IP

IP efforts are individualized and exploit the latest scientific and technological breakthroughs. Additionally, military environments are redesigned and organized to take advantage of the latest HPO/IP scientific and technological breakthroughs. Dining facility administration centers employ dietary specialists to ensure quality throughout all food venues on bases.

Science is embraced by senior Army leadership, and HPO/IP science advisors are embedded in major Army commands to facilitate policy decisions governing the health and fitness of Soldiers. A joint DoD HPO/IP center is created to ensure a rapid process for systemic reviews and increased research funding for HPO/IP translational research. Research is communicated effectively and in a timely fashion to the operational force. The military becomes the worldwide leader in HPO/IP, resulting with the emergence of resilient and dominant Warfighters who effectively project our military power and act as deterrents to hostile action from our adversaries.

#### Scenario 2: Injured, Nondeployable Warfighter

With the downsizing of the military and further budget cuts, a danger exists that preventive medicine, public health, and HPO/IP research initiatives will be forsaken. Fewer medical assets, allied health professionals, and other HPO/IP enablers (MFTs, health promotion officers, resiliency and wellness centers, and so forth) will be available in the personnel inventory. Fewer resources result in the military experiencing a technology lag, which leads to a decline in personal protective equipment development and, consequently, a continued increase in external loads Soldiers are required to carry. A moderate “brain drain” occurs in the military research and development community as research budgets shrink further to marginalize HPO/IP research efforts. As scientific conference attendance restrictions are sustained, military scientists lose relevance and expertise resulting in more scientists leaving government service.

Increased use of drones and alternate technologies changes the dynamics of the fighting force. Commanders become less interested in maintaining military physical readiness as the nature of warfare becomes more technological, while there is a focus shift from physical to cognitive performance. The associated increase in physical health problems and degradation of individual health lead to more injuries and chronic disease; this amplifies behavioral health concerns as a result of increased cognitive trauma and stress. Long-term health care and long-term disability costs rise, which overwhelms the federal budget and results in diminished quality of care. The societal trends for decreased fitness continue. The implosion of obesity and the medically

unfit results in even higher injury rates halting progress toward a system for health.

Implementation of validated science-based best-practices is lost in a cacophony of messages, marketing, and voices, many driven by non-DoD “pseudo” HPO/IP subject matter experts motivated primarily by financial profit and/or personal gain. Confused and demoralized Soldiers obtain their HPO/IP information from unvetted sources available through the internet and companies catering to the military for profit.

The end result is a military characterized as injured and nondeployable. The military has compromised stamina and ceases to be an effective instrument of national political power. Seeking to exploit this vulnerability, other hostile nation states and nonstate actors provoke aggression to create internal and external conflicts and “small wars.”

#### CONCLUSION

It is imperative for military leaders to understand that physical training-related MSIs are preventable when composite risk management principles are closely followed and pragmatic strategy and policy changes are considered. Figure 5 provides a list of some authoritative HPO/IP sources for military leaders reference as needed. The following recommendations are offered to establish a comprehensive, evidence-based approach to military HPO/IP<sup>60</sup>:

- Increase HPO/IP knowledge and expertise across the military. Implementation of additional occupational specialties or additional skill identifiers dedicated toward HPO/IP (ie, MFTs) could be productive.
- Implement/adapt evidence-based, proven physical training and injury prevention strategies based on preestablished priorities.
- Evaluate effectiveness of all implemented policies, procedures, and interventions/countermeasures on a continuous basis.
- Identify gaps in knowledge of human physical performance optimization and injury prevention, and target these gaps for research.
- Establish routine channels for disseminating information based on each public health and evidence-based decision-making process to ensure key stakeholders receive the information and training necessary to effectively reduce the impact of injuries on the health and readiness of military personnel.
- Use readily available military surveillance databases to identify the largest, most serious military injury problems.

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- Commission systematic reviews of prevention and safety literature to determine what works for the largest, most serious military injury problems.
- Establish committees of medical and safety subject matter experts to routinely assess and prioritize both injury prevention research and program/policy implementation.

As our military transforms and responds to current and emerging threats, it is increasingly clear that we must ensure optimal human performance of our military. By taking advantage of the science and applications of physical fitness and injury prevention, we can leverage our increased understanding to reduce the risk of injuries with the optimal application of our physical and mental readiness processes, ensuring that we maintain our Soldiers as Army Strong.

### RELEVANCE TO PERFORMANCE TRIAD

The Army Surgeon General has provided visionary guidance for Army Medicine to transform from a healthcare system to a system for health. The foundation for this is the Performance Triad of activity, nutrition, and sleep.

LTG Horoho is particularly timely and insightful in her vision for Army Medicine following 12 years of war. The time is ripe for a paradigm shift, and this article highlights the many ongoing efforts within the DoD and Army that are indicative of a climate of change. In this article we provide a strategic vision for Army leadership and policy makers on a path for enhanced military physical readiness, which directly supports the Activity Line of Effort for the Performance Triad. By identifying, prioritizing, resourcing, and assigning pronency for HPO/IP solutions, we believe success can be realized. A continued dialogue and forging of partnerships with all relevant stakeholders will be critical for altering the mindset for behavior change to drive HPO/IP solutions and develop healthy and resilient Warfighters.

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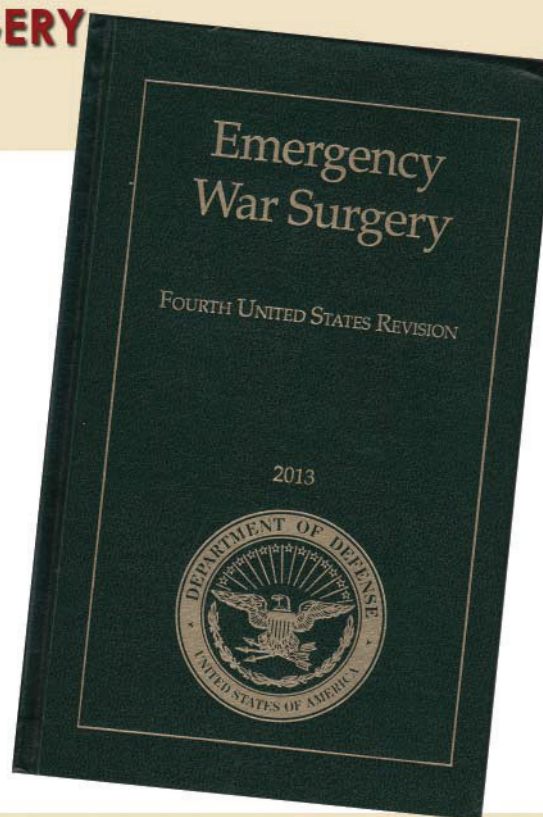
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# Physical Fitness: A Pathway to Health and Resilience

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## ABSTRACT

Various groups representing a number of different perspectives (for example, operational, architectural, community, institutional, and individual resilience) use the term *resilience*. We define resilience as the ability to withstand, recover, and grow in the face of stressors and changing demands. Physical fitness is one pathway toward resilience because it is associated with many traits and attributes required for resilience. In addition, physical fitness confers resilience because regular exercise and/or physical activity induces positive physiologic and psychological benefits, protects against the potential consequences of stressful events, and prevents many chronic diseases. This article presents a brief historical overview of the health-promoting effects of exercise and physical activity, followed by a discussion on the concept of hardiness and mental toughness and how they relate to resilience and physical fitness; how physical fitness promotes resilience; the clinical implications of a sedentary lifestyle; and the relevance of physical fitness and resilience to Army Medicine's Performance Triad.

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*...physical fitness is not only one of the most important keys to a healthy body; it is the basis of dynamic and creative intellectual activity.*

President-Elect John F. Kennedy<sup>1</sup>

Various groups representing a number of different perspectives (for example, operational, architectural, community, institutional, and individual resilience) have defined the term resilience. For the purposes of this article, we define resilience as the ability to withstand, recover, and grow in the face of stressors and changing demands.<sup>2</sup>

In recent reviews and papers on resilience, one factor that continues to appear as promoting and/or conferring resilience is physical fitness<sup>3,4</sup> and regular physical activity.<sup>5-7</sup> Thus, we focus on the role of physical fitness in overall individual resilience. The benefit of physical fitness on resilience is in part based on the recognition that physical fitness, achieved through physical activity and/or regular exercise, can induce positive physiologic and psychological benefits, protect against the potential consequences of stressful events, and prevent many chronic diseases.<sup>8-11</sup> After a brief historical overview of the health-promoting effects of exercise and physical activity, the following topics are discussed: the concept of hardiness and mental toughness and how they relate to resilience and physical fitness; how physical fitness promotes resilience; the clinical implications of a sedentary lifestyle; and the relevance of physical fitness and resilience to Army Medicine's Performance Triad. Throughout this article, the terms physical activity and exercise are used interchangeably, depending on the literature,

recognizing that exercise represents a planned, structured, and regular form of physical activity.

## HISTORICAL OVERVIEW

The quest for physical fitness has been unremitting, however, its importance and application have changed and/or transitioned over time with both high and low points. Hunting and gathering for survival were the initial impetus for fitness, which was later followed by the recognition that selected physical movements and activities were important for developing the body and preventing and curing diseases.<sup>12-14</sup> In fact, the importance of regular exercise and physical activity has been touted for over 7,000 years.<sup>12,13</sup> In China, the philosophical teachings of Confucius encouraged participation in regular physical activity, as physical inactivity was recognized as associated with certain diseases.<sup>12</sup> The Chinese developed many perspectives on how to achieve and maintain health, and they deemed exercise essential for increasing strength, prolonging life, preventing and curing diseases, and minimizing the accumulation of fat.<sup>12</sup> Quigong, Cong fou (later Kung Fu), and Tai-Chi were some of the gymnastic/movement forms developed in China sometime around 3,000 BC.<sup>12</sup> Among the Greeks, Herodicus (circa 450 BC) was the first to promote physical activity, and he even considered exercise a form of medicine. Nonetheless, Hippocrates is usually considered the father of exercise and medicine.<sup>13</sup> These 2 Greeks were followed by Galen (129-210 AD)<sup>15</sup> who was perhaps the most advanced, as he wrote not only about when to exercise, but he also described various types of exercises, identified qualities of exercise, specific places to exercise, and factors to think about prior to exercise.<sup>13</sup> Although the

importance of exercise and physical fitness diminished during various periods of time, such as after the fall of the Roman empire when the church became the dominant influence,<sup>16</sup> during the period of industrialization,<sup>12</sup> and notably during the 1920s (often called the Roaring Twenties) when relaxation and enjoyment were key.<sup>12</sup> However, the importance of exercise remains widely recognized. It is interesting to reflect on the comment of Edward Stanley, the 15th Earl of Derby, who stated in an address at Liverpool College on December 20, 1873 that:

Those who think they have not time for bodily exercise will sooner or later have to find time for illness.<sup>14</sup>

It is discouraging to realize we have made little progress over the centuries.

#### PERSONALITY TRAITS/ATTRIBUTES ASSOCIATED WITH RESILIENCE

Although the term resilience, as it is used today, emerged from work on children living under conditions of deprivation,<sup>17-20</sup> it is now applied to diverse disciplines<sup>5-7</sup> and populations.<sup>21-24</sup> Identifying how and why some individuals are seemingly able to bear up, and sometimes thrive, under adverse conditions with no observable negative physical or psychological outcomes, is a continuous quest.<sup>5-7,25-33</sup> Personality traits associated with resilience include hardiness and mental toughness.<sup>9,34-46</sup> The term hardiness, as considered by Kobasa et al,<sup>34,37-43</sup> was typified by “interrelated orientations of commitment (vs alienation), control (vs powerlessness), and challenge (vs threat).”<sup>41</sup> This original characterization was later refined by Maddi,<sup>11</sup> who proposed that hardiness is an attitude (or set of attitudes) and personality trait that helps an individual restructure stressors into growth opportunities rather than allowing them to be or become catastrophes.

Bartone et al<sup>47,48</sup> developed the dispositional hardiness scale to assess hardiness, and this scale has been used in a number of studies to relate hardiness characteristics in persons exposed to challenging occupations and experiences.<sup>45,49-52</sup> Bonanno<sup>53</sup> noted that hardiness is one of the pathways to resilience. Crust et al<sup>36</sup> developed the model of mental toughness by applying the traits of hardiness to reflect the unique demands of sports and exercise; the trait of confidence was added to control, commitment, and challenge.<sup>35,36,44,46,54,55</sup> As noted by Crust et al<sup>36</sup>:

Mentally tough individuals are considered to be competitive, resilient to errors or stress, and have high self-confidence and low anxiety.

The literature clearly shows that both hardiness and mental toughness are highly related to resilience.<sup>28,56-58</sup> In addition to the personality traits of hardiness and

mental toughness, other psychological attributes and social-cognitive variables have been associated with resilience, including self-esteem, self-efficacy and motivation.<sup>20,21,59-62</sup> How do these closely associated traits or attributes relate to physical fitness and physical activity?

#### PERSONALITY TRAITS/ATTRIBUTES ASSOCIATED WITH PHYSICAL FITNESS

Interestingly, regular physical activity and aerobic fitness have been shown to be associated with specific personality traits and psychological attributes<sup>63-72</sup> associated with resilience. For example, anxiety and depression are inversely related to maximal aerobic capacity, a primary indicator of physical fitness.<sup>73,74</sup> Moreover, our unpublished data show a significant positive association between aerobic capacity and hardiness ( $r=0.24$ ), and an inverse relation with perceived stress ( $r=-0.26$ ) and trait anxiety ( $r=-0.17$ ). Of note, Skirka et al<sup>10</sup> reported significantly higher hardiness scores, less perceived stress, and fewer psychological symptoms in varsity college athletes than college nonathletes, which further supports a strong association between regular exercise, aerobic fitness, and hardiness. Furthermore, mental toughness, the personality trait associated with athletes and athletic competition, has been shown to mitigate the relationship between high stress and depressive symptoms.<sup>57</sup>

Two determinants of physical activity, self-esteem and self-efficacy, be they enduring traits or modifiable attributes, are essential for resilience.<sup>65,66,75</sup> Self-efficacy generally reflects how self-confident a person is with regard to undertaking a particular action under challenging situations,<sup>67,72,76,77</sup> and self-esteem signifies one's sense of self-worth or personal value.<sup>68</sup> Multiple studies have shown that children and young adults who participate in regular exercise score higher on measures of self-esteem and self-efficacy<sup>67,70-72,76,78-80</sup> and competitiveness<sup>81</sup> compared to sedentary, untrained controls. Moreover, these two attributes are improved through regular physical activity.<sup>69,72</sup> Netz et al<sup>72</sup> conducted a meta-analysis of 36 studies examining how physical activity interventions affected well-being in healthy adults. Moderate intensity aerobic exercise was shown to be most beneficial and had a strong effect on self-efficacy, in addition to conferring improvements in aerobic capacity and strength. Ekland et al<sup>69</sup> likewise conducted a systematic review of 12 studies to assess how exercise affected self-esteem in children and young people. They concluded that exercise has positive short-term effects on self-esteem and that it might be an important strategy for improving self-esteem. Interestingly, one hypothesis as to how physical activity enhances self-efficacy and self-esteem is that it requires the application of self-management strategies (eg, thoughts, goals, plans, and acts) to achieve a goal.<sup>76</sup>

## PHYSICAL FITNESS: A PATHWAY TO HEALTH AND RESILIENCE

Self-management strategies require commitment, control, and motivation, and although each strategy is important, motivation appears to be key in terms of regular physical activity.<sup>70,78,82-85</sup> Research has shown that motivation is very important with regard to commencing and maintaining participation in regular physical exercise.<sup>76,84</sup> According to the literature, motivation is some force or stimulus that leads an individual to undertake a particular task or activity in which they have a specific objective or derive personal meaning.<sup>78,82,83</sup> Overall, these studies strongly suggest that personality traits (hardiness and mental toughness) and other attributes (self-esteem, self-efficacy, motivation, self-management strategies) may contribute to the buffering effect of physical fitness and how fitness confers resilience. Further, one must be motivated to be committed, and possess self-efficacy and self-esteem to accept a challenge. Clearly, strong relationships exist between and among hardiness or mental toughness, self-efficacy, self-esteem, and motivation; all essential resources for resilience, and all associated with physical fitness.

### PHYSICAL FITNESS AND STRESS RESILIENCE

That physical fitness is essential for health and well-being is not in question, as noted in the earlier historical overview. However, scientific data documenting the essentiality of physical activity for health did not emerge until the late 1800s and early 1900s when epidemiological studies demonstrated that sedentary persons were more likely to have coronary heart disease than those who led active lifestyles.<sup>16,86-90</sup> Since those first studies, the literature has become replete with evidence that physical fitness and regular exercise confer resilience and serve as a resistance resource in a variety of ways, including blunting stress reactivity in response to both physical and psychosocial stressors, conferring multiple physiologic and psychological benefits, serving as a buffer against stress, and protecting against stress-related disorders and many chronic illnesses.<sup>57,74,78,91-95</sup> A conceptual model of the personality traits and attributes associated with physical fitness and resilience is presented in the Figure.

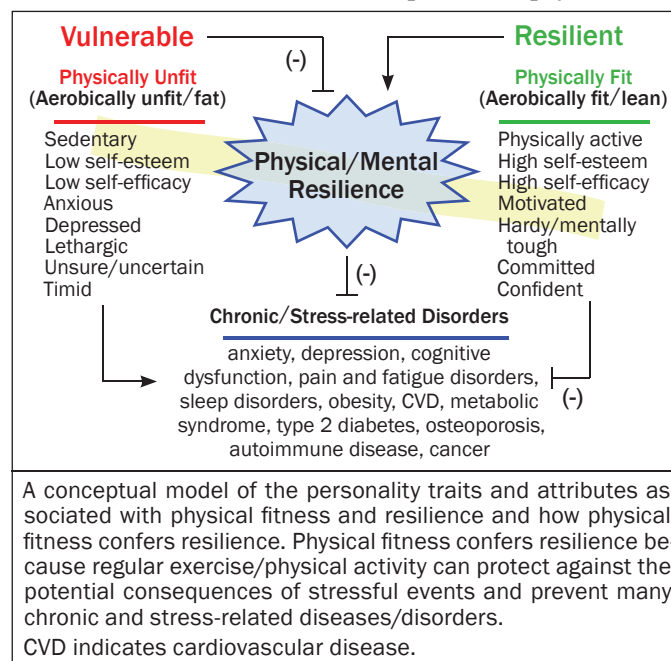
#### Physical Fitness Blunts Stress Reactivity in Response to Both Physical and Psychosocial Stressors: Physiologic and Psychological Benefits

The 2 main neuroendocrine/neural systems that mediate the stress response are the hypothalamic-pituitary-adrenal axis, with the resultant release of cortisol, and the sympathetic nervous system, which releases the catecholamines epinephrine (adrenaline) and norepinephrine. Activation of these stress systems mediates the fight or flight response, which entails the rapid mobilization of energy from storage sites to critical muscles and the brain (getting one ready for action, increasing

alertness/arousal). Moreover, increased heart rate, blood pressure, and breathing rate facilitate the rapid transport of nutrients and oxygen to relevant parts of the body. Together, these stress systems orchestrate the physiologic and behavioral adaptations to stress. However, chronic activation can lead to dysregulation of multiple physiologic and behavioral systems, leading to maladaptive stress responses, including anxiety and depression.<sup>96,97</sup> Physical fitness and aerobic fitness have been related to a reduction in stress reactivity, physiologically and psychologically, for both physical and mental/psychosocial stress.<sup>65,98-107</sup>

Interestingly, neuroendocrine and physiologic responses to exercise at the same absolute workload are significantly lower in physically fit than unfit persons.<sup>108-111</sup> Additionally, physically active people show reduced sympathoadrenal reactivity to physical stressors.<sup>109,110</sup> When untrained persons are enrolled in a regular exercise program for 8-12 weeks, their response to the same physical stress prior to beginning exercise training is significantly higher than after the training.<sup>112</sup> Thus, when trained and untrained persons have to work at the same rate, the untrained person will experience significantly more stress than someone who is physically fit and aerobically trained.<sup>108-110</sup> Therefore, the higher the level of aerobic fitness, the greater the ability to tolerate high workloads and be minimally stressed by low ones.

Physical training also appears to confer protection against nonphysical stressors, mental and/or psychological.<sup>98,111,113,114</sup> Rimelle et al<sup>115</sup> documented significantly lower cortisol and heart rate responses to psychosocial



stress in trained men compared to untrained men. Moreover, significantly greater calmness and better mood, and a trend toward lower state anxiety were noted in the trained relative to untrained men. In addition, others have noted blunted cortisol responses<sup>115</sup> and reduced cardiovascular responses<sup>98,99,115</sup> to psychological laboratory stressors in physically active as compared to less active persons. Webb et al<sup>111</sup> administered a dual challenge of physical and mental stress and noted that low-fit participants had greater cortisol responses compared to high-fit individuals. Importantly, in a meta-review of 34 studies, Crews et al<sup>99</sup> reported that aerobically fit individuals had reduced responses to psychosocial stress in comparison to controls. These findings are consistent with those from the Aerobics Center Longitudinal Study, which found a significant inverse dose-response relationship between aerobic fitness and depressive symptomatology and a positive association between fitness and emotional well-being.<sup>116</sup>

In addition to cross-sectional studies, longitudinal studies have demonstrated positive effects of exercise training and regular physical activity, and negative effects of exercise withdrawal on mood and depressive symptoms.<sup>68,117-121</sup> Nabkasorn et al<sup>117</sup> studied adolescent females with depressive symptoms and noted significant decreases in total depressive score, as well as in 24-hour urinary cortisol and epinephrine excretion, following 8 weeks of physical training (jogging). Importantly, studies by Berlin et al<sup>118</sup> and Weinstein et al<sup>121</sup> demonstrated that when someone who exercises regularly is forced to withdraw from exercise for 2 weeks, negative mood increases significantly and correlates with decreases in fitness.<sup>118,121</sup> In addition, a reduction in parasympathetic nervous system activity, as measured by heart rate variability, predicted the development of negative mood after deprivation of exercise.<sup>121</sup> These findings are relevant to understanding both short-term exercise withdrawal and exercise initiation, and how they affect overall stress resilience and reactivity.

Despite the multiple positive findings, not all are consistent,<sup>65,122,123</sup> particularly with regard to catecholamine release, with both blunted and augmented responses noted in high- versus low-fit persons.<sup>112,123</sup> Along those same lines, de Geus et al<sup>65</sup> were unable to detect changes in psychological make-up (for example, personality traits of neuroticism, introversion, hostility, anger expression) or acute neurophysiologic reactivity (for example, heart rate, blood pressure, urinary catecholamine excretion, or cardiac beta-adrenergic drive) after 4 and 8 months of training. Thus, although the majority of studies support positive effects of regular exercise and aerobic fitness, not all studies are consistent.

#### Physical Fitness Serves as a Buffer against Stress and Stress-Related Disorders

Physical activity may provide a protective effect against stress-related disorders, as physically fit persons appear to be less susceptible to life stressors, in particular with regard to illnesses: physical fitness may serve as a buffer against stress,<sup>63,124,125</sup> with stress being highly associated with various illnesses.<sup>20,34,73,124,126,127</sup> A comprehensive review of the literature from 1982 to 2008 in which exercise was examined as a stress-buffer concluded that the majority of studies, both cross-sectional and prospective, found exercise to be an effective buffer, but the amount and type of exercise necessary for protection were not stated.<sup>93</sup> The concept of stress buffering was first proposed by Kobasa et al,<sup>34</sup> and later by others<sup>9,11</sup> who clearly showed that regular exercise and hardiness interact to decrease illness in the face of serious life stressors.<sup>34</sup> Persons who scored high in hardiness and participated in regular exercise were usually more healthy than those high only in hardiness or exercise alone.<sup>34</sup> Collectively, the data suggest that participation in leisure physical activity is important to the stress-buffering effect of exercise.<sup>128</sup>

Physical fitness and regular exercise also appear to buffer against depression<sup>63,68,125,129-134</sup> and anxiety.<sup>100,125,134-136</sup> In fact, the beneficial effects of physical activity on positive mood are well recognized.<sup>83,137</sup> Rethorst et al<sup>131</sup> conducted a meta-analysis of all studies investigating the effects of exercise on depression, and 12 of 16 exercise treatment groups with clinically depressed patients were classified as “recovered” or “improved” after the treatment. Similarly, a number of prospective studies have demonstrated reductions in state anxiety.<sup>129,138</sup> Manger et al<sup>129</sup> had persons diagnosed with posttraumatic stress disorder (PTSD) undergo a 12-session aerobic exercise program and showed significant reductions in PTSD, anxiety, and depression following the intervention. Moreover, these positive results were stable over 1 month of follow-up.<sup>129</sup> Finally, Wipfli et al<sup>135</sup> conducted a meta-analysis (based on 49 randomized, controlled trials) examining the effects of exercise on anxiety, and demonstrated clear reductions in anxiety among those who exercised compared to the respective control groups. Of interest was their finding that exercise was more effective in reducing anxiety relative to other anxiety-reducing treatments.<sup>135</sup>

#### CLINICAL IMPLICATIONS OF A SEDENTARY LIFESTYLE

The short- and long-term consequences of low physical fitness and a sedentary lifestyle are clear. Physical inactivity serves a major role in the rising prevalence of obesity, cardiovascular disease (CVD), hypertension, type II diabetes mellitus (T2DM), metabolic syndrome, insulin resistance, hyperlipidemia, and breast and colon cancers,

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to name a few.<sup>91,94,95,116,139,140</sup> Of course, excess energy intake also contributes to obesity,<sup>78,94,95</sup> but lack of physical activity is the leading contributor<sup>91,94,95,116,139,140</sup> and also the fourth leading cause of death worldwide.<sup>95</sup> In contrast to a sedentary lifestyle, high aerobic fitness is inversely related to obesity, metabolic syndrome, CVD, hypertension, and T2DM.<sup>74,141-145</sup>

In addition to the major chronic diseases mentioned above, low aerobic fitness has been associated with fibromyalgia (FM),<sup>146,147</sup> chronic fatigue syndrome (CFS),<sup>148,149</sup> osteoarthritis,<sup>150-152</sup> rheumatoid arthritis,<sup>150,153,154</sup> and inflammatory muscle disorders.<sup>155,156</sup> Low aerobic fitness is also associated with elevations in serum C-reactive protein (CRP), a well-known marker of inflammation. Many studies have shown that maximal aerobic capacity is inversely related to CRP,<sup>142,157</sup> and that exercise interventions, both aerobic and resistance in nature, reduce levels of CRP.<sup>157-159</sup> However, not all studies showed a significant effect.<sup>160-162</sup> A meta-analytic study by Kelley et al<sup>162</sup> of 5 randomized controlled trials reported an approximately 3% reduction in CRP levels across the exercise groups, which was not significant. However, the studies that were negative found other positive benefits of exercise, regardless of its effect on CRP.

With regard to FM, exercise as an intervention has been shown to be beneficial, particularly in relation to pain management. Ellingson et al<sup>147</sup> conducted a prospective study and emphasized how a sedentary lifestyle was likely deleterious for pain regulation in FM. Likewise, Curtis et al<sup>163</sup> conducted a study wherein women with FM who engaged in a 75-minute yoga class twice weekly for 8 weeks reported reduced pain and catastrophizing, and increased acceptance of pain. Chronic fatigue syndrome is another debilitating disorder characterized by minimal physical activity during daily life and lower muscle strength and aerobic capacity compared to healthy sedentary subjects.<sup>149,154</sup> As with FM, when persons with CFS are entered into a regular exercise program, significant benefits in terms of physical capacity, quality of life, fatigue severity, and depressive symptomatology are reported.<sup>164,165</sup> Interestingly, Heins et al<sup>166</sup> reported that physical activity is intentionally limited in CFS patients, possibly because they expect negative bodily symptoms and catastrophize in such a way as to negatively affect their performance. This underscores the importance of the exercise-derived resilience resources self-efficacy, self-esteem, and motivation, which, unfortunately, were not measured in the above studies.

Overall, the clinical implications of a sedentary, physically inactive lifestyle are profound, and the literature clearly demonstrates that having a valid measure of

physical fitness, in particular aerobic fitness, may be one of the best indicators of resilience, as well as long-term health and risk of chronic diseases. Most of the above mentioned chronic diseases/disorders are also associated with depression, anxiety, low self-efficacy, and other barriers to critical resilience resources. Promoting regular physical activity in these populations has been shown to exert profound beneficial changes, and should be the key intervention for all such populations who are able to engage in regular physical activity.

### LIMITATIONS AND FUTURE DIRECTIONS

Limitations of studies examining how physical fitness contributes to resilience must be acknowledged. First, many studies examining reactivity to both physical and psychosocial stress did not quantify aerobic fitness or regular physical activity. This is essential for being able to accurately interpret the results, as they may be important confounders. Secondly, the intimate relation between hardiness/mental toughness, and aerobic capacity/physical activity must be further evaluated to document their interrelationship. Certainly, the mental toughness model was specifically developed for athletes who are physically fit and have self-confidence, so one would expect them to have many resilience resources. However, what happens when they become injured? In addition, many people with chronic diseases are able to cope and are physically unfit (they may be unable to engage in regular exercise), so physical fitness is important, but not an absolute.<sup>23,24</sup>

### CONCLUSIONS

Physical fitness is associated with many traits and attributes required for resilience. As such, it is one pathway toward resilience. Promoting physical fitness as a pathway to resilience is based on solid, scientific evidence as noted in many ancient and current sources showing that physical fitness blunts stress reactivity, confers physiologic and psychological benefits, serves as a buffer against stress, and can protect against stress-related disorders and chronic illness. Perhaps the role of physical fitness as a pathway to resilience was most eloquently stated by then President-Elect John F. Kennedy in 1960 when he said:

...physical fitness is not only one of the most important keys to a healthy body; it is the basis of dynamic and creative intellectual activity. ...intelligence and skill can only function at the peak of their capacity when the body is healthy and strong; hardy spirits and tough minds usually inhabit sound bodies.<sup>1</sup>

### RELEVANCE TO THE PERFORMANCE TRIAD

Physical activity is a key component of the Performance Triad and is clearly essential to optimal performance.

However, physical activity in the absence of adequate fueling (ie, healthy dietary patterns, appropriate timing and types of nutrients) and an adequate quantity and quality of sleep and recovery is not the solution. Excessive activity can lead to overtraining, musculoskeletal injuries, and similar problems. Only when physical activity is balanced with a healthy diet and restorative sleep will the benefits described above be realized.

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# Extreme Conditioning Programs and Injury Risk in a US Army Brigade Combat Team

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## ABSTRACT

**Context:** Brigades and battalions throughout the US Army are currently implementing a variety of exercise and conditioning programs with greater focus on preparation for mission-specific tasks. An Army physical therapy clinic working with a light infantry brigade developed the Advanced Tactical Athlete Conditioning (ATAC) program. The ATAC program is a unique physical training program consisting of high-intensity aquatic exercises, tactical agility circuits, combat core conditioning, and interval speed training. Along with ATAC, battalions have also incorporated components of fitness programs such as the Ranger Athlete Warrior program and CrossFit (Crossfit, Inc, Santa Monica, CA) an extreme conditioning program (ECP).

**Objective:** To determine if these new programs (ATAC, ECP) had an effect on injury rates and physical fitness.

**Design:** Surveys were administered to collect personal characteristics, tobacco use, personal physical fitness training, Army physical fitness test results, and self-reported injuries. Medical record injury data were obtained 6 months before and 6 months after the implementation of the new program. Predictors of injury risk were assessed using multivariate logistic regression. Odds ratios (OR) and 95% confidence intervals (CI) were reported.

**Results:** Injury incidence among Soldiers increased 12% for overall injuries and 16% for overuse injuries after the implementation of the ATAC/ECPs. However, injury incidence among Soldiers not participating in ATAC/ECPs also increased 14% for overall injuries and 10% for overuse injuries. Risk factors associated with higher injury risk for Soldiers participating in ATAC/ECPs included:

greater mileage run per week during unit physical training (OR (>16 miles per week ÷ ≤7 miles per week)=2.24, 95% CI, 1.33-3.80)

higher body mass index (BMI) (OR (BMI 25-29.9 ÷ BMI <25)=1.77, 95% CI, 1.29-2.44),  
(OR (BMI ≥30 ÷ BMI <25)=2.72, 95% CI, 1.67-4.43)

cigarette use (OR (smoker ÷ nonsmoker)=1.80, 95% CI, 1.34-2.42)

poor performance on the 2-mile run during the Army Physical Fitness Test (APFT)  
(OR (≥15.51 minutes ÷ ≤13.52 minutes)=1.76, 95% CI, 1.13-2.74)

Injury risk was lower for those reporting resistance training

(OR (<1 time per week ÷ none)=0.53, 95% CI, 0.31-0.92)

(OR (1-2 times per week ÷ none)=0.50, 95% CI, 0.29-0.84)

(OR (≥3 times per week ÷ none)=0.45, 95% CI, 0.24-0.85)

**Conclusions:** Given that Soldiers participating in ATAC/ECPs showed similar changes in injury rates compared to Soldiers not participating in ATAC/ECPs, no recommendation can be made for or against implementation of ATAC/ECPs.

Soldiers must maintain high levels of physical fitness to endure demanding tasks, harsh deployment environments and military occupational specialty requirements. However, routine training required to maintain high levels of physical fitness can result in musculoskeletal injuries, limited duty days, and significant health care costs.<sup>1-3</sup> Studies have shown that injuries related to physical training (PT) account for 30% to 50% of all injuries

in US Army Soldiers.<sup>4-6</sup> An investigation examining injury incidence in light infantry Soldiers found that physical training caused 50% of all injuries, and 30% of these injuries were associated with running.<sup>4</sup> Injuries caused approximately 10 times the number of limited duty days compared to illness. The investigators concluded that physical training is associated with a high number of injuries in infantry Soldiers.<sup>4</sup> It has also been

shown that musculoskeletal injuries are a leading cause of hospitalization.<sup>7</sup> In a study investigating hospitalizations for sports and Army physical training injuries, 11% of 120,430 hospital admissions over a 6-year period were attributed to sports or Army physical training injuries. This resulted in 29,435 total lost duty days, with an average of 13 days of limited duty per injury for male Soldiers and 11 days per injury for female Soldiers.<sup>3</sup> These investigations indicate that physical training-related injuries have a considerable impact on the health and readiness of Soldiers.

Previous research has identified a number of risk factors for injury in infantry Soldiers. In one study, higher risk of injury was associated with fewer sit-ups on the Army Physical Fitness Test (APFT) and slower 2-mile run times,<sup>8</sup> while another study showed higher risk of injury was associated with smoking and a body mass index (BMI) of 25 or more.<sup>9</sup> In an investigation of British infantry Soldiers, higher risk of injury was associated with younger age, previous lower limb injury, and previous back injury.<sup>10</sup> More work to identify the most important risk factors among infantry Soldiers is needed.

Only a few investigations have explored injury risk during the implementation of a new military fitness program.<sup>11-15</sup> In 3 investigations, Knapik et al compared Soldiers performing Army Physical Readiness Training (PRT) to Soldiers performing traditional Army physical training. Physical readiness training consists of calisthenics, movement drills, climbing drills, dumbbell exercises, interval training, and ability group long-distance running whereas traditional Army physical training consists primarily of warm-up and stretching exercises followed by calisthenics, push-ups, sit-ups, some sprint training, and group long-distance running. For all 3 studies, the adjusted risk of injury was 1.5 to 1.8 times higher in the groups performing traditional physical training compared to those performing PRT. It was also found that scores on the APFT were higher or similar for groups using the PRT program. Knapik et al concluded that the PRT program results in fewer injuries and equal or greater improvements in fitness and military performance compared to traditional Army physical training.<sup>11-13,16</sup>

In a US Air Force study, a new PT program implemented within the combat controller training pipeline was evaluated. The goal of this new PT program was to reduce overuse and overtraining injuries and transition from a traditional PT program to a functional PT program. For the new PT program, running mileage decreased by 50%, and long-distance runs were replaced with interval

running and agility training. In addition, bodybuilding type resistance training (single joint) was replaced with functional strength training movements (multiple joint, standing exercises), and an athletic trainer was hired to visit the group twice per week. Investigators found that by replacing traditional training with the new functional training program, overall injuries decreased by 67%, and improvements were made in body composition, aerobic capacity, ventilatory threshold, upper body power, and graduation rates. The authors concluded that the new fitness program decreased injury rates, increased fitness performance and graduation rates, and suggested that other combat athletes would benefit from adopting these practices.<sup>14</sup>

A variety of exercise and conditioning programs with greater focus on preparation for mission-specific tasks are currently being implemented by various brigades and battalions throughout the US Army. As a result, Soldiers are transitioning from traditional Army PT to a more intensive, combat-focused PT program. Injury rates and risk factors associated with these programs are not well known. The purpose of this project was to examine physical training, fitness, and injury rates, and to identify injury risk factors in a light infantry brigade beginning a new PT program incorporating elements of extreme conditioning programs (ECPs).

## METHOD

### Population

The population consisted of Soldiers in a light infantry brigade combat team (N=1,393). The brigade combat team consisted of 2 infantry battalions, a cavalry battalion, a field artillery battalion, a brigade support battalion (hereinafter referred to as Infantry A, Infantry B, Cavalry, Field Artillery, and Brigade Support), and a brigade special troops battalion. Rosters of unit members were requested and obtained through the brigade medical officer. Roster information included each Soldier's battalion.

### Surveys

A survey was used to collect information from Soldiers about personal characteristics, tobacco use, unit and personal physical fitness training, Army physical fitness test results, and injuries. The survey was administered in September 2010, approximately 4 months after the new physical fitness and conditioning programs began.

### Interviews

Battalion commanders were interviewed to obtain their views and opinions on physical training and fitness. They were also asked about training equipment and injury prevention.

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### Exercise Instructor Certification and Programs Conducted by the Brigade Combat Team

Selected Soldiers from every battalion in the brigade combat team attended a 1-week certification class on the fundamentals of the Advanced Tactical Athlete Conditioning (ATAC) program. The ATAC Program consisted of workouts employing plyometrics, kettlebells, medicine balls, high-intensity water exercises, wrestling, ladder and cone agility drills, tire flipping, speed interval training, and cinderblock throwing. Some of the battalions also required their Soldiers to attend additional certification classes in exercise and fitness performance involving other exercise programs such as CrossFit (CrossFit Inc, Washington, DC) and the Ranger Athlete Warrior program (RAW), developed within the US Army's 25th Infantry Division.

CrossFit is a core strength and conditioning program that aims to prepare athletes for any physical contingency. CrossFit consists of continuously varied, high-intensity functional movements that generally fall into 3 categories: gymnastics, Olympic weightlifting, and metabolic conditioning or "cardio."\* There are 4 components to the RAW program: functional fitness, performance nutrition, sports medicine, and mental toughness. The functional fitness component of RAW consists of movement drills (before each PT session), muscular endurance workouts, heavy resistance workouts, power and power endurance workouts, endurance training workouts, movement skills training, hybrid drills, and recovery exercises (at the end of each workout).†

CrossFit and RAW or parts of these exercise programs can also be classified as ECPs,<sup>17</sup> which are characterized by high-volume, aggressive exercise workouts with a variety of high-intensity exercise repetitions and short rest periods between sets. Popular ECPs include P90X and Insanity (Beachbody LLC, Santa Monica, CA), and Gym Jones (Gym Jones LLC, Salt Lake City, UT).

### New Physical Training Program

Soldiers began a new physical training program that incorporated ATAC and components of fitness programs such as the RAW program and CrossFit.

### Army Physical Fitness Test Scores

The APFT was used as a measure of physical fitness. Self-reported scores from each Soldier's most recent APFT were obtained from the surveys. Close correlations have been found between actual APFT scores

and self-reported APFT scores.<sup>18</sup> The APFT consisted of 3 events: a 2-minute maximal effort push-up event, a 2-minute maximal effort sit-up event, and a 2-mile run performed for time. Events were performed in accordance with instructions contained in *Field Manual 7-22: Army Physical Readiness Training*.<sup>19</sup> Performance metrics obtained included the number of push-ups and sit-ups successfully completed within separate 2-minute time periods. The performance measure for the run was the time taken to complete a 2-mile distance.

### Demographics and Injury Outcome Measures

The Armed Forces Health Surveillance Center (AFHSC) provided demographic data obtained from the Defense Manpower Data Center (DMDC). Demographics included date of birth, education level, marital status, race, and gender.

Data on injuries treated in military treatment facilities or paid for by the Military Health System (purchased care) were obtained from the Defense Medical Surveillance System (DMSS). A brigade unit roster was provided to the AFHSC, which returned DMSS data containing visit dates and International Classification of Disease 9th Revision (ICD-9)‡ diagnosis codes for all inpatient and outpatient medical encounters captured electronically by the DMSS occurring between November 1, 2009 and October 28, 2010. Injuries were categorized into 3 groups—overall injury, overuse injuries, and traumatic injuries—using the primary (first) ICD-9 diagnosis code in a manner consistent with prior studies of military training injuries.<sup>20,21</sup>

Overall injuries comprise all ICD-9 codes from the 800-999 and 710-739 code series related to acute and chronic musculoskeletal injuries, including environmental injuries. Overuse injuries contain a subset of musculoskeletal injuries resulting from cumulative microtrauma due to repetitive motion, typically in the 710-739 ICD-9 code series. This series indicates such diagnoses as stress fractures, stress reactions, tendonitis, bursitis, fasciitis, shin splints, and musculoskeletal pain (not otherwise specified). Traumatic injuries contain a subset of musculoskeletal injuries resulting from a strong sudden force or forces being applied to the body, including events such as a fall from a ladder, an automobile crash, or being struck by a bullet. These injuries are contained in the 800-999 ICD-9 code series.

### Data Analysis

The IBM SPSS Statistics (V 18.0) application (IBM Corp, Chicago, IL) was used for statistical analysis.

\*CrossFit Forging Elite Fitness – <http://www.crossfit.com/cf-info/what-crossfit.html>

†RAW PT Program Manual – [http://www.25idl.army.mil/pt/rawpt/guide\\_bp.pdf](http://www.25idl.army.mil/pt/rawpt/guide_bp.pdf)

‡<http://www.cdc.gov/nchs/icd/icd9.htm>



Descriptive statistics (frequencies, distributions, means, SDs) were calculated for personal characteristics, physical training, and physical fitness. Body mass index was calculated as weight in kilograms divided by height in meters squared (kg/m<sup>2</sup>). The BMI was categorized according to the Centers for Disease Control and Prevention (CDC) classifications for normal, overweight, and obese.<sup>22</sup> Current cigarette smokers were identified as smoking at least 1 cigarette within the last 30 days, and smoking 100 or more cigarettes in their lifetime.

To assess changes in injury rates pre- and postimplementation of the physical training programs, the McNemar test was used to compare injury incidence among Soldiers in the 6 months before the new programs were initiated (November 2009 to April 2010) with injury incidence in the 6 months following full implementation of the program (May 2010 to October 2010) for the overall, overuse, and traumatic injury categories. For each of the 2 periods, injury risk (percentage) for each category was calculated as:

$$\frac{\text{number of Soldiers with 1 or more injuries}}{\text{total number of Soldiers}} \times 100\%$$

To investigate potential injury risk factors among Soldiers in the brigade, injury risk ratio and 95% CI, were calculated using the electronic medical record data on overall injuries occurring after the implementation of the new exercise programs. Potential injury risk factors included demographic characteristics obtained from AFHSC as well as health behavior, physical training, and physical fitness data collected by survey.

A backward-stepping multivariate logistic regression and a forced multivariate logistic regression model were used to assess key factors for association with injury risk in this population. Odds ratios and 95% CIs were calculated for each potential risk factor (independent variables).

**RESULTS**

The average age of Soldiers in the brigade was 26.8±5.9 years with a range of 18 to 52 years. A majority of the Soldiers were classified as overweight or obese (61%), white (62%), rank of E4 to E6 (61%), high school graduates (82%), and married (55%). The descriptive statistics are presented in Table 1.

Due to the small number of Soldiers who participated in the ATAC program (n=87), the ATAC and ECP groups were combined in further analyses, comparing Soldiers who participated in ATAC/

ECPs with Soldiers who did not report participating in those programs. Using injuries recorded in the medical records, injury rates of Soldiers in units participating in ATAC/ECPs were compared to injury rates for Soldiers in units that did not participate. A total of 1,032 Soldiers reported that their units were participating in ATAC/ECPs, while the other 340 Soldiers did not report participation. Soldiers were either exercising on their own time or were performing traditional PT. The baseline overall injury rates for Soldiers participating in ATAC/ECPs and Soldiers who did not participate were 41% and 50%, respectively, as shown in Tables 2 and 3.

After full implementation of the ATAC/ECPs, injury incidence increased by 12% and 16% for overall injuries

Table 1. Descriptive Statistics for Men and Women in the Light Infantry Brigade.

Variable	Subcategory of Variable	Men M=1,248		Women W=145		Men and Women N=1,393	
		n	%M	n	%W	n	%N
Gender	Men					1,248	90%
	Women					145	10%
Age	<23	374	30%	46	32%	420	30%
	23-25	333	27%	40	28%	373	27%
	26-29	258	21%	28	19%	286	21%
	30+	283	23%	31	21%	314	23%
Body mass index	≤25 (normal)	450	37%	85	60%	535	40%
	25-29 (overweight)	593	49%	49	35%	642	48%
	30+ (obese)	161	13%	7	5%	168	13%
Rank	E1-E3	331	27%	44	30%	375	27%
	E4-E6	769	62%	86	59%	855	61%
	E7-E9	67	5%	5	3%	72	5%
	W1-W2	5	0.4%	1	0.7%	6	0.4%
	O1-O3	72	6%	9	6%	81	6%
	O4-O6	4	0.3%	0	0%	4	0.3%
Race	White	803	64%	61	42%	864	62%
	Black	186	15%	53	37%	239	17%
	Hispanic	138	11%	15	10%	153	11%
	American Indian	9	1%	2	1%	11	1%
	Asian	100	8%	13	9%	113	8%
	Unknown	12	1%	1	1%	13	1%
Education Level	No High School	6	0.5%	0	0%	6	0.4%
	High School	1,021	82%	114	79%	1,135	82%
	Some College	88	7%	12	8%	100	7%
	Bachelor's	98	8%	16	11%	114	8%
	Master's	5	0.4%	2	1%	7	0.5%
	Unknown	30	2%	1	1%	31	2%
Marital Status	Married	690	55%	76	52%	766	55%
	Single	506	41%	53	37%	559	40%
	Other	52	4%	16	11%	68	5%
Battalion	Infantry A	445	36%	15	10%	460	33%
	Infantry B	150	12%	0	0%	150	11%
	Cavalry	185	15%	11	8%	196	14%
	Field artillery	201	16%	11	8%	212	15%
	Brigade support battalion	135	11%	72	50%	207	15%
	Brigade special troops battalion	132	11%	36	25%	168	12%

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and overuse injuries, respectively, for Soldiers who participated (Table 2). Injury incidence for Soldiers who did not participate increased by 14% for overall injuries and 10% for overuse injuries (Table 3). The absolute percentage change in overall injury incidence for the ATAC/ECPs and no-ATAC/ECPs groups was an increase of 5% and 7%, respectively (Tables 2 and 3).

for initial comparisons of risk by gender. The number of responses may slightly vary between questions due to missing answers on some of the surveys. Higher risk of injury was associated with female gender; overweight or obese status; current smoking; and Infantry B, Cavalry, and Brigade Support battalions. An examination of physical training risk factors determined that injury risk

Table 2. Comparison of Injury Incidence Before and After the Implementation of ATAC/ECPs (N=1,032).

Injury Type	Injury Incidence Before ATAC/ECP	Injury Incidence After ATAC/ECP	Absolute Change	Change	P (McNemar Test)
Overall	41%	46%	+5%	+12%	.02
Overuse	32%	37%	+5%	+16%	.02
Traumatic	19%	18%	-1%	-5%	.95

ATAC indicates Advanced Tactical Athlete Conditioning program.  
ECP indicates extreme conditioning program.

Table 3. Comparison of Injury Incidence Before and After the Implementation of ATAC/ECPs on all Soldiers Who did not Participate in ATAC/ECPs (N=340).

Injury Type	Injury Incidence Before ATAC/ECP	Injury Incidence After ATAC/ECP	Absolute Change	Change	P (McNemar Test)
Overall	50%	57%	+7%	+14%	.05
Overuse	42%	46%	+4%	+10%	.28
Traumatic	22%	23%	1%	+5%	1.00

ATAC indicates Advanced Tactical Athlete Conditioning program.  
ECP indicates extreme conditioning program.

Table 4. Personal Characteristics and Risk Factors for Injury Among Men Participating in ATAC/ECPs (N=1,032).

Variable	Subcategory of Variable	N	Injury After ATAC/ECP	Risk Ratio (95%CI) After ATAC/ECP	P
Gender	Men	950	45%	1.00	
	Women	82	60%	1.34 (1.11-1.63)	<.01
Age	<24	306	44%	1.09 (0.88-1.38)	.43
	24-25	185	46%	1.15 (0.91-1.45)	.23
	26-29	203	40%	1.00	
	30+	240	48%	1.21 (0.98-1.50)	.08
Body Mass Index	<25	341	37%	1.00	
	25-29	464	47%	1.27 (1.07-1.51)	<.01
	30+	115	60%	1.61 (1.31-1.98)	<.01
Current Smoking Status	Nonsmoker	470	39%	1.00	
	Smoker	443	51%	1.32 (1.14-1.53)	<.01
Smokeless Status	Nonsmokeless	655	43%	1.00	
	Smokeless User	295	49%	1.15 (0.99-1.33)	.07
Battalion	Infantry A	394	38%	1.00	
	Infantry B	116	52%	1.38 (1.11-1.71)	<.01
	Cavalry	136	52%	1.37 (1.11-1.69)	<.01
	Field artillery	163	42%	1.13 (0.90-1.40)	.30
	Brigade support battalion	84	60%	1.59 (1.28-1.97)	<.01
	Brigade special troops battalion	57	46%	1.21 (0.89-1.66)	.24

ATAC indicates Advanced Tactical Athlete Conditioning program.  
ECP indicates extreme conditioning program.

### Risk Factors for Men Participating in ATAC/ECPs

Tables 4 and 5 display the injury risk ratio variables for factors possibly associated with risk of injury. Since there were only 82 women participating in ATAC/ECPs, the following analysis excluded women, except

was higher for Soldiers who participated in unit PT less than 5 times a week and ran more than 16 miles per week. Soldiers who performed resistance and agility training had a lower risk of injury. Analysis of APFT data indicated that those with lower performances on any of the 3 elements of the physical fitness test (push-ups, sit-ups, 2-mile run) were at a higher risk of being injured.

### Multivariate Analysis of Injury Risk Factors Following Implementation of ATAC/ECPs

Table 6 displays the results of a backward-stepping multivariate logistic regression analysis that examined unit PT and personal risk factors. Soldiers who were overweight, obese, used tobacco (cigarettes) and were in the Infantry B, Cavalry, or Brigade Support battalions were at a higher risk of injury. For unit PT, men who ran the greatest amount of miles per week were at a higher risk of injury, while men who performed any resistance training were at a lower risk of injury. Further analysis of total miles ran per week revealed that Soldiers who ran more than 16 miles per week during unit PT had identical 2-mile run time scores at 14.6±1.51 minutes compared to Soldiers who ran less than 16 miles per week during unit PT at 14.6±1.61 minutes.

Table 7 displays the results of a multivariate logistic regression analysis examining components of the physical fitness test controlling for age and battalion. Soldiers who performed poorly on the 2-mile run were at a higher risk of injury.

### COMMENT

One of the major findings of this investigation was the increase in overall injury incidence for Soldiers who did and did not participate in this new program after its

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Table 5. Physical Training and Physical Fitness Risk Factors for Injury among Men Participating in ATAC/ECPs (n=950).

Variable	Subcategory of Variable	n	Injury After ATAC/ECP	Risk Ratio (95% CI) After ATAC/ECP	P
Physical training at prior assignment	Traditional PT	767	46%	1.00	
	Extreme conditioning programs	47	43%	0.93 (0.66-1.31)	.67
	Combination ECP and traditional	93	39%	0.85 (0.65-1.11)	.20
	Other and/or traditional	36	39%	0.85 (0.56-1.29)	.42
How often do you participate in unit PT?	<5 times per week	109	59%	1.00	
	5-7 times per week	730	42%	0.72 (0.60-0.86)	<.01
	>7 times per week	104	45%	0.77 (0.59-1.00)	.05
Does your unit perform cross-training/ extreme conditioning programs for PT?	Extreme conditioning programs	610	45%	1.00	
	ATAC and/or combination of ATAC/ other programs	340	44%	1.00 (0.86-1.16)	.96
How many times per week do you perform cross-training/ECP?	<1 time per week	66	50%	1.00	
	1-2 times per week	400	44%	0.88 (0.67-1.15)	.36
	3-4 times per week	286	43%	0.86 (0.65-1.13)	.30
	>4 times per week	167	45%	0.90 (0.67-1.21)	.48
Estimated total miles per week ran (unit PT)	≤7 miles per week	445	39%	1.00	
	7.01-9.00 miles per week	63	48%	1.23 (0.92-1.63)	.19
	9.01- 16 miles per week	320	44%	1.14 (0.96-1.35)	.13
	>16 miles per week	81	59%	1.52 (1.23-1.89)	<.01
Times per week performed sprint training	No sprint training	15	53%	1.00	
	<1 time per week	163	45%	0.85 (0.52-1.41)	.56
	1-2 times per week	620	44%	0.82 (0.50-1.32)	.45
	≥3 times per week	146	47%	0.89 (0.54-1.47)	.65
Times per week of resistance training	No resistance training	102	59%	1.00	
	<1 time per week	254	48%	0.82 (0.66-1.00)	.07
	1-2 times per week	458	41%	0.69 (0.57-0.84)	<.01
	≥3 times per week	130	41%	0.69 (0.53-0.90)	<.01
Times per week of agility drills	No agility training	110	58%	1.00	
	<1 time per week	297	45%	0.78 (0.63-0.95)	<.02
	1-2 times per week	431	42%	0.72 (0.59-0.87)	<.01
	≥3 times per week	106	41%	0.70 (0.53-0.92)	<.01
How often performed road marches	No road marching	29	41%	1.00	
	<1 time per month	134	55%	1.32 (0.83-2.09)	.20
	1 time per month	148	41%	0.98 (0.61-1.58)	.93
	2 times per month	237	48%	1.15 (0.73-1.81)	.52
	3 times per month	150	37%	0.89 (0.55-1.43)	.63
	>3 times per month	230	44%	1.05 (0.66-1.66)	.83
Push-ups	20-56 repetitions	208	47%	1.21 (0.97-1.50)	.09
	57-67 repetitions	221	48%	1.23 (0.99-1.52)	.06
	68-76 repetitions	230	41%	1.05 (0.84-1.31)	.69
	77-111 repetitions	233	39%	1.00	
Sit-ups	19-61 repetitions	223	54%	1.40 (1.14-1.72)	<.01
	62-69 repetitions	218	43%	1.11 (0.89-1.39)	.36
	70-78 repetitions	227	40%	1.03 (0.82-1.30)	.78
	79-109 repetitions	224	38%	1.00	
2-mile Run (minutes and fraction of a minute)	11.12-13.52 minutes	233	34%	1.00	
	13.53-14.50 minutes	222	42%	1.23 (0.98-1.56)	.08
	14.51-15.50 minutes	204	44%	1.27 (1.00-1.61)	.05
	15.51-32.22 minutes	203	51%	1.49 (1.18-1.86)	<.01

ATAC indicates Advanced Tactical Athlete Conditioning program.  
ECP indicates extreme conditioning program.

implementation. The increase in injury incidence was approximately the same for both groups. Overuse injuries also increased after the implementation of ATAC/ECPs, while traumatic injuries showed little change. It has been stated that overuse injuries typically occur at the beginning of new exercise programs and account for a majority of the injuries incurred.<sup>23,24</sup> Some of the

common causes of overuse injuries include engaging in too much physical activity too soon, exercising too long, performing too much of one activity, and improper technique. Some studies have also found that the majority of injuries occurring in Army infantry Soldiers are attributed to physical fitness and sports activities.<sup>6-10,25</sup> However, the increase in overuse injuries was similar

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Table 6. Unit PT and Personal Risk Factors for Injury Among Men Participating in ATAC/ECPs Using Multivariate Logistic Regression.

Variable	Subcategory of Variable	n	Odds Ratio (95% CI)	P
Body mass index (BMI)	<25	310	1.00	
	25-29.9	414	1.77 (1.29-2.44)	<.01
	30+	98	2.72 (1.67-4.43)	<.01
Tobacco	Nonsmoker	430	1.00	
	Smoker	392	1.80 (1.34-2.42)	<.01
Battalion	Infantry A	342	1.00	
	Infantry B	100	1.62 (1.01-2.61)	.05
	Cavalry	128	1.87 (1.20-2.92)	<.01
	Field artillery	139	1.36 (0.89-2.08)	.15
	Brigade support battalion	64	1.96 (1.09-3.54)	.03
	Brigade special troops battalion	49	1.20 (0.62-2.32)	.60
Times per week performing resistance training	No resistance training	80	1.00	
	<1 time per week	218	0.53 (0.31-0.92)	.03
	1-2 times per week	409	0.50 (0.29-0.84)	.01
	≥3 times per week	115	0.45 (0.24-0.85)	.01
Estimated miles per week of running	≤7 miles a week	401	1.00	
	7.01-9.00 miles a week	54	1.05 (0.57-1.94)	.87
	9.01-16 miles a week	290	1.00 (0.72-1.40)	.99
	>16 miles a week	77	2.24 (1.33-3.80)	<.01

ATAC indicates Advanced Tactical Athlete Conditioning program.  
ECP indicates extreme conditioning program.

Variables entered into the model:

Age	How often do you participate in unit physical training?
BMI	Estimated total miles per week ran
Current smoking status	Agility Training
Battalion	Resistance Training

Table 7. Physical Fitness Test Risk Factors for Injury Among Men Participating in ATAC/ECPs Using Multivariate Cox Regression.

Variable	Level of Variable	n	Odds Ratio (95%CI)	P
Push-ups	20-56 repetitions	188	1.01 (0.62-1.63)	.97
	57-67 repetitions	207	1.11 (0.71-1.72)	.50
	68-76 repetitions	218	1.00 (0.66-1.50)	.99
	77-111 repetitions	222	1.00	
Sit-ups	19-61 repetitions	199	1.53 (0.94-2.50)	.09
	62-69 repetitions	205	1.03 (0.66-1.60)	.91
	70-78 repetitions	213	0.92 (0.60-1.39)	.68
	79-109 repetitions	218	1.00	
2-mile Run (minutes and fraction of a minute)	11.12-13.52 minutes	226	1.00	
	13.53-14.50 minutes	217	1.42 (0.95-2.12)	.09
	14.51-15.50 minutes	195	1.45 (0.95-2.20)	.08
	≥15.51 minutes	197	1.76 (1.13-2.74)	.01

Variables entered into the model: Age, battalion, push-ups, sit-ups, and 2-mile run.  
Note: controlled for age and battalion.

ATAC indicates Advanced Tactical Athlete Conditioning program.  
ECP indicates extreme conditioning program.

in both groups; therefore, no recommendations can be made for or against either program.

### Unit PT Injury Risk Factors

For male Soldiers participating in ATAC/ECPs, those who ran greater distances, performed no resistance training, and served in either the Infantry B, Cavalry,

or Brigade Support battalion were at a higher risk of injury. Male ATAC/ECPs participants who ran more miles per week during unit PT were at a higher risk of being injured than those who ran fewer miles per week. Other studies have also shown that risk of injury increases with miles run per week.<sup>26-28</sup> As mentioned earlier, analysis of APFT scores indicated those who ran greater distances per week (16 miles or more) had an average 2-mile run time of 14.6 minutes (±1.51 minutes), and those who ran fewer miles per week (less than 16 miles per week) had identical average 2-mile run times of 14.6 minutes (±1.61 minutes). Based on these data, running more than 16 miles per week for unit PT increases injury risk and provides no additional aerobic performance benefits.

Soldiers performing resistance training with their unit at least once per week were at a lower risk of injury than were Soldiers in units that did not perform resistance training. In a US Air Force study, Walker et al found that replacement of a majority of the traditional long-distance

running with interval running, agility training, and functional strength training decreased the overall injury rates by 67%, and trainees scored higher on nearly all of the measured fitness parameters.<sup>14</sup> Adding resistance training to an aerobic training program can also be beneficial in the completion of job tasks or mission requirements. It has been shown that endurance training concurrent with resistance training improves load-bearing performance<sup>29-32</sup> and heavy lifting tasks,<sup>32</sup> and increases both short-term and long-term endurance capacity in sedentary and trained individuals.<sup>33</sup> In a meta-analysis, both strength training and concurrent training (combination of strength and endurance training) had larger effects on strength, 1.76 (95% CI, 1.34-2.18) and 1.44 (95% CI, 1.03-1.84) respectively,

when compared to endurance training only (0.78, 95% CI, 0.36-1.19).<sup>34</sup> The evidence suggests that implementation of a combined resistance and endurance training program will enable Soldiers to complete specific mission tasks more effectively and with lower risk of injury than Soldiers who do not incorporate resistance training into their physical fitness programs.

Infantry A had the lowest injury incidence (38%) after the implementation of ATAC/ECPs. This battalion also had the youngest Soldiers, one of the lowest average BMIs, performed less running per week during unit PT, and performed the most sprint, resistance, and agility training per week in comparison to the other battalions. As previously mentioned, running more miles per week increases injury risk.<sup>26-28</sup> In addition, injury risk is higher for recruits with lower levels of lower-extremity muscle strength or who lack a consistent lower-extremity weight training program.<sup>35,36</sup> The Infantry A battalion's unit PT program involved less running and more cross-training activities, likely contributing to its lower injury rates.

Interviews of battalion commanders concerning their views regarding physical training and fitness offered additional insights into the difference in injury rates. For example, the Infantry A battalion commander spent the largest amount of money on fitness equipment for the unit and stated he considered mobility/agility to be the most important fitness ability. In comparison, other commanders (including the Infantry B commander) rated endurance as the most important fitness component. Upon examination of the 2 infantry groups (Infantry A and Infantry B), a difference in injury incidence of 15% was observed. Both commanders had also implemented an injury surveillance tracking system to collect injury metrics in their respective battalions. However, the Infantry A battalion reported its injury metrics every 3 weeks, whereas the Infantry B battalion collected them at the company level only and did not review or report them on a set schedule. Infantry A and Field Artillery, the 2 battalions with the lowest injury rates, ran the fewest miles per week for unit PT (10.1 miles and 9.2 miles, respectively), and both units tracked and reported their injury metrics at least once a month. Therefore, running fewer miles per week during unit PT and implementing an injury surveillance system<sup>11</sup> in which metrics are reported at least monthly may have a positive influence on lowering injury rates. In a consensus paper concerning military personnel involved with ECPs, Bergeron et al state that regular monitoring and accurate injury reporting may help reduce injury rates and optimize the physical fitness benefits of ECPs.<sup>17</sup>

**Soldier Injury Risk Factors**

In the current study, 62% of the men were considered either overweight or obese, which is similar to the US population, of which 64% of men aged 20 to 39 years are also considered either overweight or obese.<sup>37</sup> Injury

Table 8. Mean BMIs and Physical Fitness Test Scores Grouped by Quartiles of Poor to High Performance for Men.

Mean BMIs for Fitness Variables	n	Q1	Q2	Q3	Q4	ANOVA P
		low performance	→			
2-mile run (mean BMI)	1,091	28.2 BMI	26.1 BMI	25.2 BMI	24.6 BMI	<.01
Push-ups (mean BMI)	1,137	26.6 BMI	26.1 BMI	26.1 BMI	25.8 BMI	.03
Sit-ups (mean BMI)	1,134	27.0 BMI	26.1 BMI	25.7 BMI	25.5 BMI	<.01

BMI indicates body mass index.

risk for men was higher for those with a BMI classifying them as overweight or obese. Other investigations have found that Soldiers with a higher BMI are at a greater risk of being injured.<sup>9,25,38</sup> In a study involving infantry Soldiers, Reynolds et al found that Soldiers with a BMI of 25 or higher were at 2.2 times greater risk of being injured.<sup>9</sup> These findings are similar to the results found in this evaluation (1.8 and 2.7 times greater risk of injury for overweight or obese Soldiers, respectively).

According to the CDC, BMI is a fairly reliable indicator of body fatness for most people.<sup>24</sup> Therefore, Soldiers with higher BMIs will most likely have larger amounts of excess body fat. Investigations examining excessive body fat have shown that it adversely affects performance on military tasks that require both aerobic and strength components.<sup>39-42</sup> In a study investigating physical and physiological performance in Army Soldiers, Crawford et al found that Soldiers with 18% or less body fat performed significantly better on 7 of 10 fitness tests, compared to Soldiers with body fat greater than 18%. The authors suggested that Soldiers who have an excess amount of body fat may possess musculoskeletal and physiological fitness deficits, thereby decreasing military readiness and increasing risk for injury.<sup>39</sup> In an investigation of active duty Navy personnel, Bohnker et al examined mean BMI and overall physical readiness test scores (outstanding, excellent, good, satisfactory, and fail). As physical fitness test scores decreased, the mean BMI increased for both men and women.<sup>42</sup> This trend was also observed in the current study (analysis performed on all men who completed the survey and had injury data). Soldiers with lower physical fitness test results as examined by quartile also had higher average BMIs.<sup>43</sup> Being overweight or obese may not only increase a Soldier's risk of incurring an injury, but may also have an adverse effect on aerobic and strength performance. The data is presented in Table 8.

Injury risk was higher in smokers than in nonsmokers. Previous studies have also demonstrated an increased general risk of injury in smokers compared to nonsmokers, and a definable increased risk of musculoskeletal

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injury.<sup>25,44-52</sup> Also, among smokers themselves, the risk of injury has been shown to increase in direct relation to the number of cigarettes smoked per day.<sup>25,44,47</sup> The relationship between tobacco use and injury may be due to a compromised ability to repair damaged tissues, thereby increasing susceptibility to the repetitive microtrauma that presumably causes overuse injuries.<sup>53</sup> In one investigation, researchers showed that tibial fracture healing to clinical union took 24% longer in smokers compared to nonsmokers,<sup>54</sup> while another study showed that smokers experienced impaired wound healing when compared to nonsmokers.<sup>55</sup> Therefore, harsh deployment environments and military occupational specialty requirements may result in weakened tissues from training and overuse, which may result in a greater susceptibility to injury among smokers who maintain high levels of physical fitness to meet demanding tasks.

Injury risk for Soldiers with the slowest 2-mile run times was higher when compared to those showing the fastest 2-mile run times. Previous studies investigating run times during basic combat training have also found that slower run times place Soldiers at a higher risk of injury.<sup>8,21,45,56,57</sup> The Soldiers with the slowest 2-mile run times would have lower aerobic capacities than those with the fastest 2-mile run times.<sup>58</sup> Soldiers with lower aerobic capacities will likely experience greater physiological stress and/or fatigue during tasks such as running, cross-training, and calisthenics due to exercising at a higher percentage of their maximum aerobic capacity in comparison with Soldiers with greater fitness levels. Soldiers of lower fitness levels will not only be exercising at a higher percentage of their aerobic capacity to accomplish the same task as a more fit Soldier, but they will also perceive tasks as more difficult.<sup>59</sup> The greater physiological stress and/or fatigue experienced may lead to a higher risk of injury. Studies on fatigue have demonstrated decrements in proprioceptive ability,<sup>60</sup> a decrease in joint stability,<sup>61</sup> alterations in muscle activity,<sup>60</sup> changes in gait,<sup>62-66</sup> balance,<sup>67,68</sup> low-frequency fatigue,<sup>69</sup> neuromuscular function,<sup>70</sup> and ligament laxity.<sup>71</sup>

### CONCLUSION

This project found similar increases in injury rates for units performing ATAC/ECPs and units not performing ATAC/ECPs. Therefore, no recommendations can be made for or against use of those programs. Risk factors associated with higher risk of injury following the start of a new exercise program included running longer distances during unit physical training, having a BMI of 25 or more, and smoking cigarettes. However, almost any level of resistance training appeared to produce a

noticeable protective effect. A lower risk of injury was found for Soldiers who performed any resistance training compared to Soldiers who performed no resistance training.

Soldiers should recognize the challenges and limitations of ECPs or exercise programs with ECP components and approach them with discretion. The goal of all fitness programs should be to meet occupational and operational demands and expectations while minimizing injury risks.

### RELEVANCE TO PERFORMANCE TRIAD

A key aspect of The Army Surgeon General's Performance Triad is the promotion of optimal physical activity among Army Soldiers, family members, retirees, and civilians. Optimal physical activity involves incorporating regular physical activity into daily routines while also minimizing injury risk. Prevention of injury during physical activity is crucial to preserving Soldier and unit readiness. The results of this analysis suggest that injuries can be minimized by limiting longer running distances and adding resistance training to unit physical training. The results also suggest that injury risks were lower for nonsmokers, Soldiers with higher aerobic endurance, and Soldiers maintaining a healthy body weight.

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# Measuring Physical Activity During US Army Basic Combat Training: A Comparison of 3 Methods

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## ABSTRACT

**Background:** An understanding of the demands of physical activity (PA) during US Army Basic Combat Training (BCT) is necessary to support Soldier readiness and resilience. The purpose of this study was to determine the agreement among 3 different PA measurement instruments in the BCT environment.

**Methods:** Twenty-four recruits from each of 11 companies wore an ActiGraph accelerometer (Actigraph, LLC, Pensacola, FL) and completed a daily PA log during 8 weeks of BCT at 2 different training sites. The PA of one recruit from each company was recorded using PAtacker, an Army-developed direct observation tool. Information obtained from the accelerometer, PA log, and PAtacker included time spent in various types of PA, body positions, PA intensities, and external loads carried. Pearson product moment correlations were run to determine the strength of association between the ActiGraph and PAtacker for measures of PA intensity and between the PAtacker and daily PA log for measures of body position and PA type. The Bland-Altman method was used to assess the limits of agreement (LoA) between the measurement instruments.

**Results:** Weak correlations ( $r=-0.052$  to  $r=0.302$ ) were found between the ActiGraph and PAtacker for PA intensity. Weak but positive correlations ( $r=0.033$  to  $r=0.268$ ) were found between the PAtacker and daily PA log for body position and type of PA. The 95% LoA for the ActiGraph and PAtacker for PA intensity were in disagreement. The 95% LoA for the PAtacker and daily PA log for standing and running and all PA types were in disagreement; sitting and walking were in agreement.

**Conclusions:** The ActiGraph accelerometer provided the best measure of the recruits' PA intensity while the PAtacker and daily PA log were best for capturing body position and type of PA in the BCT environment. The use of multiple PA measurement instruments in this study was necessary to best characterize the physical demands of BCT.

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Butte et al defined physical activity (PA) as “any bodily movement produced by the contraction of skeletal muscle that increases energy expenditure above a resting level.”<sup>1</sup> Investigators in the field of PA monitoring have been interested in capturing the broad range of human behaviors encompassing “activity” and “inactivity.”<sup>1</sup> This also includes PA in physically demanding occupations such as those in the military setting. An understanding of the amount, type, and intensity of PA is needed to help prevent injury while maintaining unit performance and morale.<sup>2</sup> The US Army's Performance Triad initiative seeks to improve Soldier readiness and resilience by improving Soldiers' PA, nutrition, and sleep behaviors. An understanding of the present level of PA during Basic Combat Training (BCT) will help determine if those levels should be maintained or altered in order to meet guidelines for Soldier health and performance.

Measurement tools used to assess PA have included subjective measures such as self-report questionnaires, logs, and diaries, as well as objective measures such as pedometers, accelerometers, heart rate monitors, and direct observation. Pedometers are small, lightweight, portable, nonintrusive, inexpensive devices that record daily step counts. More recently, researchers have used accelerometers to provide more detailed information about PA. Unlike pedometry, accelerometry allows for the characterization of PA intensity and duration. Direct observation is considered one of the most valid, reliable, and objective methods for assessing PA.<sup>3</sup> However, direct observation is often viewed as labor-intensive and tedious. Consequently, it has not often been used to assess PA. Self-report techniques are the instruments of choice for assessing PA levels in large-scale epidemiological studies.<sup>4</sup> This is because they are practical, easy

to administer, and incur a relatively low cost and low participant burden, but their validity may be in question.<sup>4,5</sup> Self-report methods rely on the subject's ability to recall and are prone to misrepresentation, including accurately recalling the time and intensity of the PA performed.<sup>4,5</sup>

During BCT, new recruits learn basic soldiering skills and participate in physical readiness training between 5 AM and 7 AM. The recruits are often required to move on foot from one training activity to another. Multiple measurement instruments may be needed to characterize all of the demands of PA during BCT, including the amount, type, and intensity. On the other hand, only one measurement instrument may be required to characterize a specific component of PA. Therefore, the purpose of this study was to determine the agreement between an ActiGraph accelerometer and PAtacker (direct observation) for characterizing PA intensity, and between the PAtacker and a daily PA log (self-report) for characterizing body position and PA type in the BCT environment.

## METHODS

### Study Overview

Data for this study was collected from recruits in 2 training battalions during separate BCT cycles. The first iteration took place from June to August 2010, at Fort Jackson, South Carolina, during which recruits from 6 training companies were studied. The second iteration took place from July to September 2011, at Fort Sill, Oklahoma, during which recruits from 5 training companies were studied. The companies included in the study were determined based solely upon their availability.

Prior to the start of the study, recruits in each training company were informed of the requirements and potential risks of participation. Recruits voluntarily signed an informed consent document approved by the Institutional Review Board of the US Army Research Institute of Environmental Medicine (USARIEM), Natick, Massachusetts. Investigators followed the policies for protection of human subjects as prescribed in *Army Regulation 70-25*,<sup>6</sup> and the research was conducted in compliance with the provisions of 45 CFR Part 46, Protection of Human Subjects. Recruits were included in the study if they were at

least 18 years of age, were assigned to a battalion for a 10-week BCT course, and were able to participate fully in all BCT activities.

### Physical Activity Assessment

#### ActiGraph Accelerometer

The accelerometer used in this study was the ActiGraph GT3X triaxial accelerometer (Actigraph, LLC, Pensacola, FL) shown in Figure 1. This device is capable of sensing acceleration along the vertical, anterior-posterior, and mediolateral axes. The accelerometer's output is recorded in "counts," which are the summation of the absolute values of the sampled changes in acceleration during a user-defined time period.<sup>7</sup> From the accelerometers, average daily time (minutes) each recruit spent in sedentary, light (<3 metabolic equivalent (MET)), moderate (3-6 MET), and vigorous (>6 MET) intensity activities was determined using the Freedson categories.<sup>7</sup> Sedentary to light intensity activity is defined as 0 to 1,951 counts per minute, moderate intensity PA is defined as 1,952 to 5,724 counts per minute, and vigorous intensity PA is defined as 5,725 or more counts per minute.<sup>7</sup>



Figure 1. The Actigraph accelerometer.

Within each training company, 24 recruits (Fort Jackson n=144, Fort Sill n=120) were outfitted with an ActiGraph GT3X accelerometer. Each group of 24 recruits was comprised of 6 recruits in each of 4 platoons (6 recruits/platoon×4 platoons/company=24 recruits/company). When possible, at least one of the 6 recruits from each platoon was female. Research staff distributed the accelerometers to participants before the first formation each morning (5 AM) and collected them immediately before or after the dinner meal (approximately 4 PM). Recruits wore the accelerometer in a pouch attached to a belt and placed over their left hip Monday through Saturday for 8 weeks. If a recruit became injured, ill, or was separated from the platoon for a portion of the day while wearing the accelerometer, the ac-

celerometer was worn by another recruit from the same training company. Compliance checks were performed by research staff at morning formation and morning meal times to ensure the devices were being worn properly. Although 24 recruits wore the ActiGraph, accelerometer data was treated as unit data reflective of the PA performed by the entire company.

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### Direct Observation

The USARIEM and L-3 Communications Corporation (San Diego, CA) developed the PAtacker, a novel PA tracking software designed specifically for direct observation in the BCT environment. The PAtacker software was installed on HTC smartphone devices (Figure 2), which allowed activities to be logged by selecting them from a predetermined menu on a touch-sensitive screen. The software automatically added a time stamp to each activity recorded. Activities were coded into the following operational definitions:

- ▶ Time spent asleep versus awake.
- ▶ Time spent in the following body positions: lying, sitting, standing/on feet, and kneeling.
- ▶ Time spent in the following types of PA: cadence marching, calisthenics, combatives, crawling, lift/carry, barracks chores/menial tasks, obstacles/climbing, running, stationary, and walking.

Physical activity was also classified by load carried (0-10 lbs, 10-25 lbs, 25-50 lbs, 50-75 lbs, >75 lbs) and PA



Figure 2. The PAtacker application screen interface on a smartphone.

intensity, including the categories of sedentary, light, moderate, and vigorous. The direct observation portion of this study employed the continuous duration recording method, which allowed trained observers to record changes in a recruit's PA behaviors when changes in activity occurred.<sup>8</sup>

There were 6 observation teams at Fort Jackson and 5 observation teams at Fort Sill. Each team consisted of 3 to 6 observers who monitored and recorded a recruit's activities. Observers were recruited from the local area and completed 10 hours of training over 3 consecutive days to become familiar with the PAtacker device and the operational definitions. Direct observation commenced at the beginning of each training day, and all activities during the day were recorded until the recruits returned to their barracks. The team observed a recruit in the designated platoon who was wearing an ActiGraph. If the designated recruit was not training that day, another recruit wearing the device was identified and followed. Although individual recruits in each company were observed, the direct observation data was treated as unit data reflective of the PA performed by the entire company.

### Self-Report Daily Physical Activity Log

At the end of each training day, all recruits wearing an ActiGraph completed a 24-hour PA recall log, as shown in Figure 3. Recruits were asked to report the amount of time they spent wearing the ActiGraph during the day and the amount of time they spent sleeping the night before. In addition, they were asked to report the amount of time they spent sitting, standing, walking/marching, running, performing chores or barracks maintenance, doing calisthenics/obstacle courses, carrying a load pack, and participating in moderate to vigorous intensity activities during the day. All times were recorded as hours and minutes.

### Statistical Analyses

Pearson product moment correlations were run to determine the strength of association between the ActiGraph and PAtacker on measures of intensity and between the PAtacker and the daily PA log on measures of body position and PA type. Absolute agreement between the measurement instruments was assessed using the Bland-Altman method<sup>9</sup> to determine if similar values for PA intensity, body position, and type of PA had been captured between 2 measurement instruments. First, differences in average daily time spent in each PA intensity, body position, or type of PA as measured by each instrument (ActiGraph, vigorous; PAtacker, vigorous) were plotted against their mean (mean of the average daily time obtained while in vigorous activity as measured by

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Figure 3. Physical Activity Log.

the ActiGraph and PAtacker). The data were then analyzed for the presence of heteroscedasticity by plotting the absolute values of individual differences between the 2 measurement instruments versus the means between the 2 instruments for PA intensity, body position, and type of PA.<sup>9,10</sup> Data were defined as homoscedastic if  $R^2 < 0.1$ , or as heteroscedastic if  $R^2 > 0.1$ .<sup>9,10</sup> Significant Pearson product-moment correlation coefficients were considered indicative of heteroscedastic data (the random error increased as the average daily time increased). If the data were heteroscedastic, the 95% ratio limits of agreement (LoA) was calculated as follows:

$$95\% \text{ ratio LoA} = (\text{SD of the difference scores} \div \text{average of the mean values}) \times 1.96$$

If the data were homoscedastic, the 95% LoA was calculated as follows:

$$95\% \text{ LoA} = \text{SD of the difference scores} \times 1.96$$

The LoA indicates that the average daily time spent in PA intensity, the body position, or the type of PA obtained from the 2 measurement instruments will differ due to measurement error by no more than  $X$  average

daily minutes (for LoA) or  $X\%$  (for ratio LoA in either the positive or negative direction).<sup>11</sup> Pearson correlations were performed with IBM SPSS Statistics (V 14.0) (IBM Corp, Chicago, IL) for Windows. Bland-Altman plots were performed with Microsoft Excel 2007.

## RESULTS

Weak but positive Pearson correlations (association) ( $r = -0.052$  to  $r = 0.302$ ) were found between the ActiGraph and PAtacker for average daily time spent in sedentary, moderate, and vigorous PA. Alternatively, the association was negative and weak for average daily time spent in light PA (Table 1). The 95% LoA analyses for intensity measurements between the ActiGraph and PAtacker were heteroscedastic. The ratio LoA are provided in Table 1.

Weak but positive Pearson correlations (association) ( $r = 0.033$  to  $r = 0.268$ ) were found between the PAtacker and daily PA log for body position and type of PA (Table 2). The 95% LoA analyses for the PAtacker and daily PA log for the body positions of standing and running were heteroscedastic (Table 2). The 95% LoA analyses

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for the body positions of walking and sitting were homoscedastic (Table 2). The mean bias line (31.7) and random error lines (259, -195) forming the 95% limits of agreement for sitting are presented in Figure 4. The mean bias line (74.0) and random error lines (196, -93) forming the 95% limits of agreement for walking are presented in Figure 5.

### COMMENT

To our knowledge, this is the first time the physical demands, including PA intensity, body position, and type of PA, of US Army BCT have been characterized in detail. The findings in this study support the use of the ActiGraph as the instrument to measure PA intensity and the PAtacker and daily PA log to measure body position and PA type in the BCT environment. To date, no single field measure of PA has proven valid, reliable, and logistically feasible over a wide range of population settings and uses.<sup>12</sup>

Table 1. Comparisons Between the Data Collected by the ActiGraph Accelerometer and PAtacker Regarding Time Spent in Various PA Intensities During Army Basic Combat Training.

Measure	ActiGraph Average Daily Min	PAtacker Average Daily Min	Difference Average Daily Min	Pearson Correlation (r)	Ratio LoA	PAtacker Reporting
Sedentary	445±93	393±52	-52	0.302*	81%	Underreports
Light	144±73	295±139	150	-0.052	143%	Overreports
Moderate	93±25	56±80	-37	0.211*	208%	Underreports
Vigorous	37±19	7.1±14	-30	0.077	202%	Underreports
Moderately Vigorous	131±35	63±83	-68	0.282*	163%	Underreports

PA indicates physical activity.  
LoA indicates limits of agreement.  
\*P<.01

Table 2. Comparisons Between the Data Collected by PAtacker and the PA log Regarding Daily Average Time Spent in Various Body Positions and PA Types During US Army Basic Combat Training.

Measure	PAtacker Average Daily Min	PA Log Average Daily Min	Difference Average Daily Min	Pearson Correlation (r)	95% LoA (mins/day)	Ratio LoA	PA Log Reporting
Stand	432±119	180±57	-252	0.144*		79%	Underreports
Sit	255±108	287±66	32	0.186*	227.3		Underreports
Walk	78±69	129±44	51	0.198*	145.0		Underreports
Run	10±13	36±16	26	0.268*		153%	Underreports
Menial Chores	212±127	26±14	-186	0.033		209%	Underreports
Calisthenics	29±25	59±35	30	0.150*		177%	Overreports
Carry Load	755±81	139±66	-674	0.040		65%	Underreports

PA indicates physical activity.  
LoA indicates limits of agreement.  
\*P<.01

Pearson product moment correlations are often used to interpret the degree of association between measurement tools, but not the agreement. A high correlation may suggest a strong association but does not imply close agreement between instruments, and may reflect the possibility of measurement bias.<sup>9,10</sup> In this study, weak correlations were noted when comparing the use of the ActiGraph and PAtacker for measures of PA intensity, and the PA tracker and daily PA log for measures of body position and type of PA. These findings suggest that the measurement instruments were quantifying the intensity of PA, body position, and type of PA in a similar manner and direction. However, the correlations provided no definitive conclusions regarding the agreement between the measurement instruments for PA intensity, body position, and type of PA.

Understanding the intensity of PA during the course of BCT is important for assessing its potential role in the incidence of musculoskeletal injuries and Soldier performance. The LoA method as proposed by Bland and Altman<sup>9</sup> was used to assess agreement between the ActiGraph accelerometer and PAtacker for measures

of PA intensity, and between the PAtacker and daily PA log for measures of body position and type of PA. How far apart the measurements can be without causing difficulties depends on the interpretation of method comparison and the sample size.<sup>9,10</sup> The resulting 95% LoA indicates that for the measure of intensity, the random error increased as the average daily minutes spent in each intensity increased. More specifically, there was disagreement between the ActiGraph and the PAtacker for all categories of intensity. The accelerometer provides an objective measure of movement including intensity and has been used as a criterion measure in studies validating other PA instruments, such as the self-report instruments.<sup>4</sup> The PAtacker also provides an objective measure of intensity through direct observation. However, correctly categorizing PA intensity through direct observation may be highly dependent on the training and experience of the observer and the environment in which the PA is occurring. The PAtacker underreported for all categories of intensity except light, which was overreported. In this study, the ActiGraph accelerometer provided a better measure of PA intensity compared to the PAtacker.

Disagreement was also observed between the PAtacker and daily PA log for both PA type and body position for some categories. The difference between the observer's perception and a recruit's recollection of time spent in various body positions and types of PA may have contributed to the lack of agreement between these 2 measurement instruments. The differences between interpretations of operational definitions by an observer and a recruit may have also contributed to the disagreement. When compared with other PA studies that used one instrument alone, such as a pedometer for step counts or an accelerometer for intensity, the combined use of the PAtacker and daily PA log added to the characterization of PA in the BCT environment.<sup>13,14</sup> The use of both of these measurement instruments provided greater detail regarding the amount of time a recruit spent in different body positions and PA types, possible contributing factors in the incidence of musculoskeletal injuries during BCT.

A careful overview of the strengths and limitations of all available techniques is essential before an appropriate assessment method for a specific research question is chosen.<sup>15</sup> The method of choice for any environment should be accurate, precise, objective, simple to use, robust, time-efficient, cause minimal intrusion into habitual activity patterns, be socially acceptable, allow continuous and detailed recording of usual activity patterns, and be applicable to large population groups.<sup>16</sup> In this study, the ActiGraph accelerometer provided the best measure of a recruit's PA intensity while the PAtacker and daily PA log were best at capturing body position and type of PA in the BCT environment.

RELEVANCE TO PERFORMANCE TRIAD

The Army Surgeon General's Performance Triad initiative seeks to improve Soldier readiness and resilience by improving Soldiers' PA, sleep, and nutritional health behaviors. The ability to assess the quantity as well as the quality of current PA demands (PA type, body position, PA intensity, and load carried), and recovery (rest and sleep) from PA are necessary

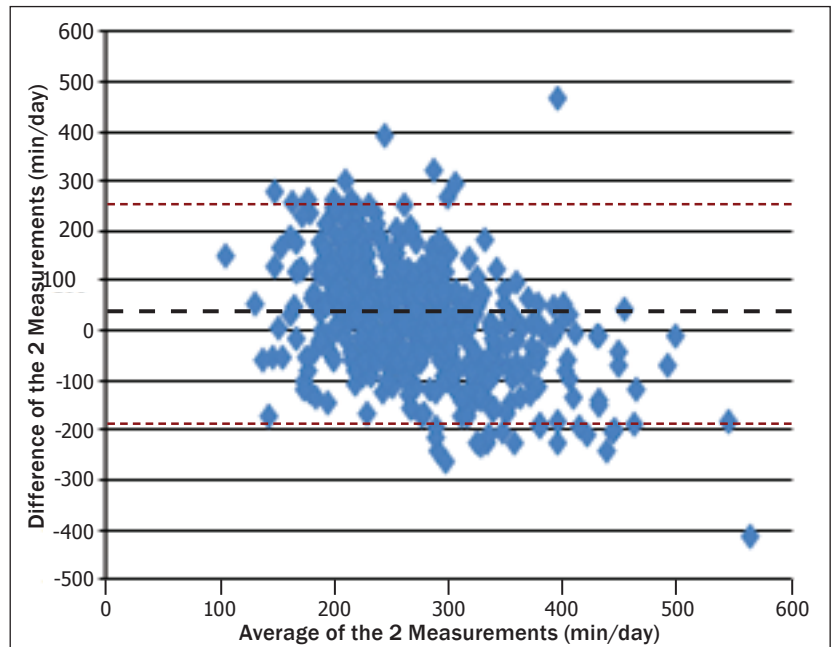


Figure 4. Bland-Altman plots of time spent sitting each day between the PAtacker and PALog methods.

Legend:  
 - - - Mean bias line (31.7)  
 - - - Random error lines (259, -195)

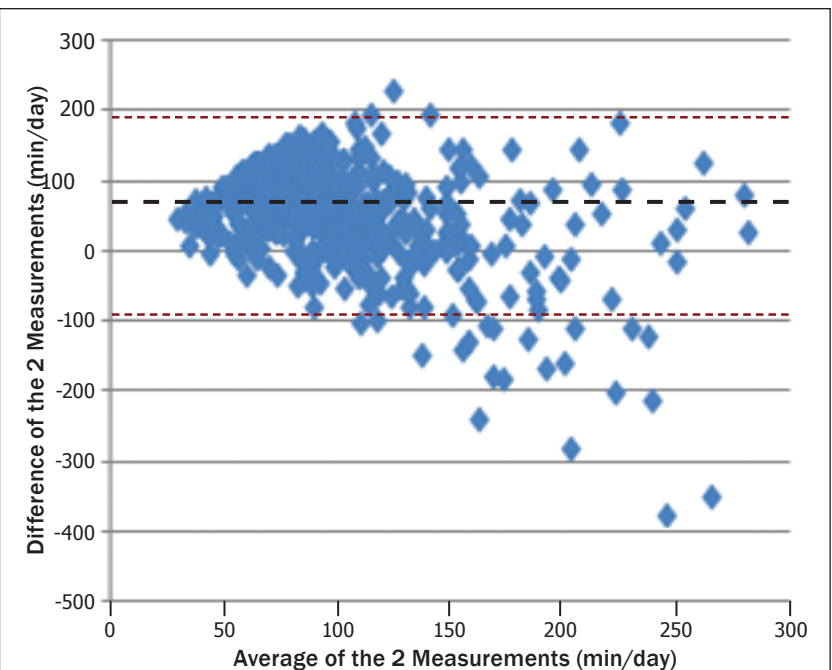


Figure 5. Bland-Altman plots of time spent walking each day between the PAtacker and PALog methods.

Legend:  
 - - - Mean bias line (74.0)  
 - - - Random error lines (196, -93)

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to ensure Soldier safety along with optimal health and performance. The findings of this study suggest that in order to understand the current demands of PA in BCT, it is necessary to use a combination of self-report, direct observation, and electronic motion detection measurement instruments.

### ACKNOWLEDGEMENT

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# Quantification of Physical Activity Performed During US Army Basic Combat Training

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## ABSTRACT

**Purpose:** During US Army Basic Combat Training (BCT), graduation requirements, including physical readiness training (PRT), are standardized across training sites. However, there are concerns that the standardization may not be closely followed. Therefore, the purpose of this study was to measure and compare physical activity (PA) performed by recruits at 2 Army BCT sites.

**Methods:** Twenty-four recruits per company from 11 companies (n=144 at Fort Jackson, SC; n=120 at Fort Sill, OK) wore an accelerometer and completed a daily PA log. The PA of one recruit from each company was recorded using an Army-developed direct observation tool (PAtracker). Amounts of time spent in various activity types, intensities, body positions, and in carrying external loads were obtained from the accelerometer, PA log, and PAtracker. Independent samples *t* tests were used to compare PA percentage time (%T) across training sites. Repeated measures analysis of variance was used to examine weekly differences in time spent in moderate to vigorous intensity PA during morning PRT.

**Results:** Physical activity was measured for 47 days at Fort Jackson and 44 days at Fort Sill. Differences in the percentage of time spent in various physical activities between the 2 sites ranged from 0.4% to 15.3% (2.0-93.7 minutes). At Fort Jackson, time spent in moderate to vigorous PA during PRT significantly increased each week for the first 4 to 6 weeks of BCT. No difference was observed in PAtracker data between the 2 training sites in the percentage of time recruits spent in calisthenics (3.9%±3.6% vs 3.8%±3.0%, *P*=.700), and only a small difference was observed in percentage of time recruits spent running (1.2%±1.7% vs 1.6%±2.0%, *P*=.037).

**Conclusion:** Army recruits at the 2 BCT sites spent similar amounts of time in each PA variable, regardless of the training site and measurement method.

Army Basic Combat Training (BCT) is a physically demanding, 10-week training program designed to develop basic soldiering skills and prepare recruits for the physical and mental rigors of military service.<sup>1-3</sup> Depending on their military occupational specialty, Soldiers may be required to perform a number of tasks involving a high degree of physical effort during their military careers. Therefore, developing and maintaining a high level of physical fitness among Soldiers is often regarded as a priority by the US Army.<sup>2</sup>

While BCT is designed to enhance the physical fitness and military performance of the recruit, it also has the potential to produce less positive outcomes. To improve physical fitness, the physical activity (PA) performed by recruits must be of the appropriate frequency, intensity, and duration.<sup>2,4</sup> If the volume of physical training is too low, it results in little or no change in physical performance, but if the volume is too high, it can lead to injury.<sup>2</sup> Previous studies show that as the amount of

physical training increases, so does the risk of injuries in a number of populations, including runners,<sup>5-12</sup> military recruits,<sup>3,13,14</sup> and participants in sports and other leisure-time activities.<sup>15,16</sup> Injury among recruits poses a problem for the military in that it can result in significant medical expenses, decrease the number of deployable Soldiers, and ultimately compromise military readiness.<sup>2,17,18</sup>

To improve the physical fitness of Soldiers while also reducing the risk of injury, the Army Physical Fitness School, working with the Army Institute of Public Health, developed a training program known as Physical Readiness Training (PRT).<sup>2</sup> The PRT program is a precise series of calisthenics, dumbbell drills, climbing drills, running, and other activities that are performed by recruits 3-6 times per week, typically between 5 AM and 7 AM.<sup>2</sup> One of the major principles of PRT is that exercise intensity should increase progressively over time by increasing the number of repetitions of some exercises and/or the speed at which some exercises are performed

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(progressive overload). Compared to traditional BCT physical training programs, PRT has been shown to result in the same or greater improvements in physical fitness while causing fewer injuries.<sup>2,19</sup> In addition to PRT, BCT recruits are also required to perform other physical activities such as obstacle course negotiation, rifle training, unarmed combat (combatives) training, drill and ceremony, land navigation, and road marches with rucksacks and other load-bearing equipment.<sup>1,3</sup>

Although knowledge of the types of activities performed is available, information regarding the exposure of new recruits to PA (ie, the actual dose) at each of the 4 BCT sites is lacking. Additionally, although the graduation requirements of BCT are identical across training sites, battalions, and companies,<sup>20</sup> the amount of time needed to teach specific soldiering skills may vary. Finally, although doctrine requires that PRT and training for military skill development be standardized across BCT sites, there are concerns that the standardization may not be closely followed. Therefore, the purposes of this study were to (1) characterize and quantify the amount of PA actually performed by recruits during a BCT cycle at 2 of the Army's 4 BCT sites, and (2) determine the intensity and types of physical training at the 2 locations. One of the principles of PRT is progressive overload (progressive, systematic increase in exercise intensity over days), so the average weekly intensity of physical training between 5 AM and 7 AM (when physical training was likely to be conducted) was examined.

### METHODS

#### Subjects

Data for this study were collected from recruits in 2 training battalions during separate 10-week BCT cycles. The first iteration took place June to August 2010 at Fort Jackson, South Carolina, during which time recruits from 6 training companies were observed. The second iteration took place July to September 2011 at Fort Sill, Oklahoma, during which time recruits from 5 training companies were observed.

Prior to the start of the study, the principal investigator informed the recruits in all training companies of the requirements and potential risks of participating in the study. Those who chose to volunteer signed an informed consent document approved by the Institutional Review Board of the US Army Research Institute of Environmental Medicine (USARIEM). The investigators followed the policies for protection of human subjects as prescribed in *Army Regulation 70-25*,<sup>21</sup> as well as the provisions of 45 CFR Part 46, Protection of Human Subjects.<sup>22</sup> Recruits were included in the study if they were

at least 18 years of age, were assigned to one of the study battalions for the 10-week BCT course, and were able to fully participate in all the activities of BCT at the start of the investigation.

#### Procedures

The length of a typical BCT cycle is 10 weeks. In this study, study personnel spent the first week of each BCT cycle recruiting volunteers and obtaining their consent. During the last week, recruits spent most of their time cleaning and turning in equipment, and practicing for graduation. Therefore, complete data was obtained for the majority of volunteers for the middle 8 weeks of their BCT cycle.

Physical activity was assessed by 3 methods: instrumentation with an accelerometer, direct observation, and daily PA logs.

#### Accelerometer

The accelerometer used in this study was the ActiGraph GT3X triaxial accelerometer (ActiGraph, LLC, Pensacola, FL). The accelerometer senses acceleration along 3 axes: vertical, anterior-posterior, and mediolateral. The accelerometer output is then recorded in "counts," which are the summation of the absolute values of the sampled changes in acceleration measured during a user-defined time period. The accelerometer has previously been shown to be a valid and reliable tool for measuring PA intensity among adults.<sup>23,24</sup>

At the beginning of each BCT cycle, recruits received both written and verbal instructions on how to wear the accelerometer: over their left hip in a pouch on a belt, Monday through Saturday, during most of the BCT cycle. Since Sundays were typically reserved for religious observance and rest rather than training, recruits were not asked to wear the accelerometer on this day. If a recruit who had been selected to wear the accelerometer became injured, ill, or was separated from the platoon for a portion of the day (Monday–Saturday), that recruit was replaced with another from the same training company. Research staff performed compliance checks to ensure all volunteers wore the devices properly.

Research staff distributed the accelerometers to participants before the first formation each morning and collected them near the end of training each day, usually preceding the evening meal. This allowed for equipment accountability, data downloading, and battery recharge. From the accelerometers, daily time (minutes) each recruit spent in sedentary-, light- (<3 metabolic equivalent (MET)), moderate- (3-6 MET), and vigorous-intensity (>6 MET) activities was categorized by means of the

Freedson categories, which define sedentary or light-intensity activity as 0 to 1,951 counts/minute, moderate PA as 1,952 to 5,724 counts/minute, and vigorous intensity PA as 5,725 or more counts/minute.<sup>25</sup>

### Direct Observation

The direct observation portion of this study employed the continuous duration recording method. Trained observers recorded changes in a recruit's PA as the change in activity occurred.<sup>24</sup> A novel PA tracking software (PAtracker), designed specifically for this type of direct observation and developed jointly by L3-Communications (San Diego, CA) and the USARIEM, was used in this study. The PAtracker software was installed on smartphone devices. Trained observers logged a recruit's PA by selecting it from a predetermined menu on a touch-sensitive screen. The software automatically added a time stamp and recorded the data in each activity to a data file.

Within the PAtracker software, PA was coded by body position, intensity, activity type, and external load. Body positions included kneeling, lying, sitting, and standing. Activity types included stationary, mental tasks, walking, calisthenics, cadence marching, combatives, running, obstacles/climbing, crawling, and lifting/carrying. Physical activity was also classified by intensity (sedentary, light, moderate, vigorous) and load carried (0-10 lbs, 10-25 lbs, 25-50 lbs, 50-75 lbs, or >75 lbs).

Observers recruited from the local BCT geographic area were hired to perform the direct observation portion of this study. Prior to the start of the study, all observers completed training (10 hours over 3 consecutive days) on the use of the PAtracker device as well as the body positions, activity types, loads, and intensities they would observe during the study.

Direct observation commenced at the beginning of each training day when recruits received their accelerometers, and all activities during the day were recorded. Within each company, a single recruit who was wearing an accelerometer was followed and observed by one trained observer. If this recruit was not training that day, another recruit wearing an accelerometer was identified and followed. Although individual recruits in each company were observed, the direct observation data were treated as unit data reflective of the PA performed by the entire company.

### Daily Physical Activity Log

At the end of each training day, all recruits wearing an accelerometer completed a daily PA log; they were asked to report the amount of time (hours:minutes)

they spent wearing the accelerometer that day as well as the amount of time (hours:minutes) they spent sleeping during the night before. Regarding the time spent wearing the accelerometer that day, recruits were asked to account for how much of that time they spent sitting, standing, walking/marching, and running. Finally, recruits were asked to report the amount of time they spent doing chores or barracks maintenance, doing calisthenics/obstacle courses, and carrying a load. Upon the recruit's completion of the PA log, a study investigator checked the questionnaire to ensure it had been completed properly and then clarified any discrepancies by speaking with the recruit.

### Statistical Analyses

Descriptive statistics (mean  $\pm$  SD) were calculated for all study variables. Independent sample t-tests were performed to examine differences between training sites in PA measured by the accelerometer, direct observation, and self-report PA Logs. Repeated measures analysis of variance was used to examine weekly differences in time spent in moderate- to vigorous-intensity PA measured by the accelerometer while recruits performed PRT at each training site (between 5 AM and 7 AM). All statistical analyses were performed with IBM SPSS Statistics (V 14.0) software (IBM Corp, Chicago, IL) for Windows with  $P < .05$  established as the level of statistical significance.

## RESULTS

Within each of the 11 training companies included in this study, 24 recruits were outfitted with an accelerometer and completed a daily PA log. This resulted in a total of 144 recruits at Fort Jackson and 120 recruits at Fort Sill. From each company, 6 recruits from each of 4 platoons totaled 24 recruits from each company (6 recruits/platoon  $\times$  4 platoons/company = 24 recruits/company). When possible, at least one of the 6 recruits from each platoon was a woman.

### Accelerometer

The Fort Jackson recruits wore the accelerometer a total of 47 days, and the recruits at Fort Sill wore it 44 days. Table 1 lists the cumulative time as well as the number of days that recruits from both training sites spent in each intensity category measured by the accelerometer. On average, recruits at Fort Jackson wore the accelerometer for a longer period of time each day than the recruits at Fort Sill (754.0  $\pm$  112.6 minutes/day vs 677.4  $\pm$  102.6 minutes/day,  $P < .001$ ). Therefore, all accelerometer comparisons between the two training sites in this study were made using the average daily percentage of time. The exception was time spent in moderate- to vigorous-intensity PA between 5 AM and 7 AM, which

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was examined using average daily minutes. This variable was an exception because weekly changes were examined at each training site as opposed to being compared between the 2 training sites.

Figure 1 shows the average daily percentage of time that recruits from each training site spent in each activity intensity over the course of the BCT cycle. Recruits at Fort Jackson spent a larger percentage of their time engaged in light-intensity activities ( $23.0\% \pm 10.4\%$  vs  $15.8\% \pm 2.0\%$ ,  $P < .001$ ) and a smaller percentage of their time in sedentary activities ( $58.9\% \pm 10.6\%$  vs  $65.9\% \pm 4.9\%$ ,  $P < .001$ ) when compared to recruits at Fort Sill. Additionally, recruits at both training sites spent most of their time (60% to 70%) in sedentary activities and less time (<10%) in vigorous activities.

Figure 2 shows the average daily percentage of time that recruits at both training sites spent in moderate- to vigorous-intensity activity between 5AM and 7AM, when recruits were likely participating in PRT. Over the course of BCT, recruits at Fort Jackson spent an average of

Table 1. Cumulative time recruits at both training sites spent in each Activity Intensity category measured by the ActiGraph during a Basic Combat Training cycle. Days represent the total number of days recruits spent in an intensity at least once.

	Fort Jackson			Fort Sill		
	Days Recorded	47		44		
Total Time Recorded (minutes/hours)	28,256.2 $\pm$ 1,458.5/5470.9 $\pm$ 24.3			29,597.6 $\pm$ 596.2/493.3 $\pm$ 9.9		
	Days	Time (minutes)	Time (hours)	Days	Time (minutes)	Time (hours)
Sedentary	47	20,847.5 $\pm$ 702.7	347.5 $\pm$ 11.7	44	19,667.7 $\pm$ 1,558.6	327.8 $\pm$ 26.0
Light	47	8,193.6 $\pm$ 512.8	136.6 $\pm$ 8.5	44	4,687.6 $\pm$ 217.3	78.1 $\pm$ 3.6
Moderate	47	4,799.5 $\pm$ 360.8	80.0 $\pm$ 6.0	44	3,624.3 $\pm$ 357.6	60.4 $\pm$ 6.0
Vigorous	47	1,602.0 $\pm$ 313.2	26.7 $\pm$ 5.2	44	1,827.4 $\pm$ 207.9	30.5 $\pm$ 3.5

46.1 $\pm$ 4.9 minutes/day while recruits at Fort Sill spent an average of 44.4 $\pm$ 3.8 minutes/day participating in moderate- to vigorous-intensity PA between 5AM and 7AM ( $P = .443$ ). Repeated measures analysis of variance indicated that time spent in moderate- to vigorous-intensity PA changed week to week at Fort Jackson ( $P = .009$ ) but did not significantly change week to week at Fort Sill ( $P = .211$ ).

### PAtracker

Table 2 shows the number of days trained observers followed and observed recruits using the PAtracker. Table 2 also lists the average daily time recruits from both training sites spent in each body position, activity type, intensity, and carrying various external loads, as measured with the PAtracker. Recruits were followed with the PAtracker an average of 783.4 $\pm$ 135.3 minutes/day for 47 days at Fort Jackson and 708.9 $\pm$ 128.5 minutes/day for 44 days at Fort Sill ( $P < .001$ ). As was the case with the accelerometer, the recruits at Fort Jackson were observed with the PAtracker for a longer period of time each day than were the recruits at Fort Sill. Therefore, all PAtracker comparisons between the 2 training sites in this study were made using the average daily percentage of time.

The average daily percentage of time recruits at Fort Jackson and Fort Sill spent in each body position is shown in Figure 3A. Recruits at Fort Jackson spent a larger percentage of time sitting ( $38.6\% \pm 12.9\%$  vs  $30.9\% \pm 11.8\%$ ,  $P < .001$ ) and a smaller percentage of time kneeling ( $1.2\% \pm 1.8\%$  vs  $1.9\% \pm 2.6\%$ ,  $P < .001$ ) and standing

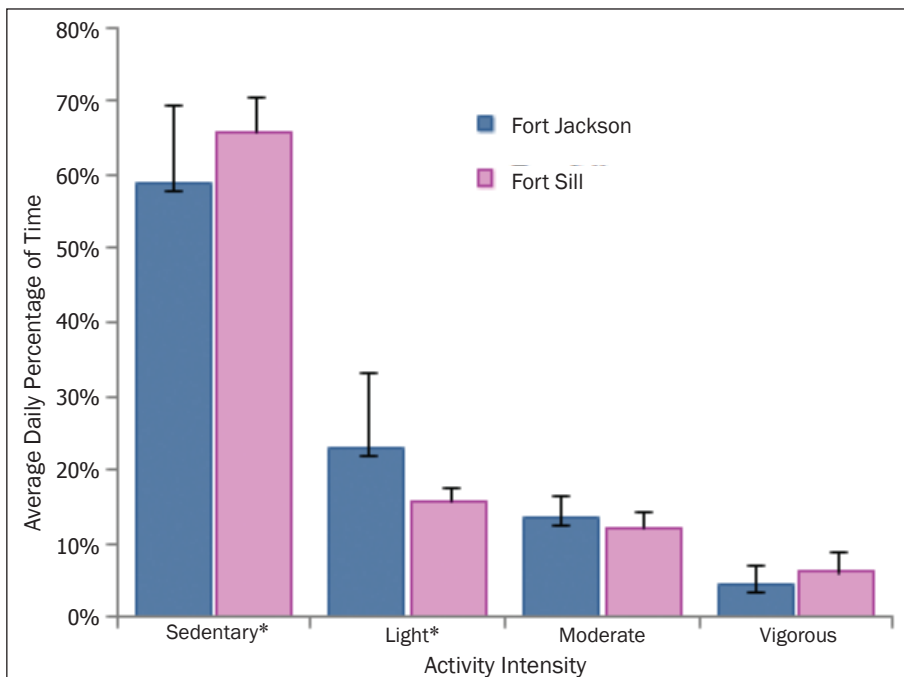


Figure 1. Average daily percentage of time ( $\pm$ SD) recruits spent in each activity intensity measured with the accelerometer.

\*Fort Jackson vs Fort Sill:  $P < .05$

(57.0%±12.6% vs 64.0%±12.2%,  $P<.001$ ) compared with recruits at Fort Sill. Little difference was observed in the percentage of time recruits at both training sites spent lying down (2.9%±3.4% vs 3.1%±2.1%,  $P=.951$ ).

Figure 3B shows the average daily percentage of time recruits at Fort Jackson and Fort Sill spent in each activity intensity category. Recruits at Fort Jackson spent a larger percentage of time sedentary (54.5%±18.1% vs 48.2%±22.6%,  $P=.001$ ) and a smaller percentage of time in light-intensity activities (36.5%±15.5% vs 44.1%±21.8%,  $P<.001$ ) when compared to recruits at Fort Sill. Little difference was observed between the 2 training sites in terms of percentage of time spent in moderate- (8.0%±11.9% vs 6.8%±7.3%,  $P=.193$ ) or vigorous- (1.1%±2.3% vs 0.9%±1.9%,  $P=.290$ ) intensity activities. As was the case with the accelerometer, recruits at both training sites spent a large percentage of time (about 50%) in sedentary activities and a small percentage of time (about 1%) in vigorous-intensity activities.

Figure 4 shows the average daily percentage of time recruits at both Fort Jackson and Fort Sill spent in different types of activities. Recruits at Fort Jackson spent a larger percentage of time engaging in combatives (1.6%±4.0% vs 0.4%±2.0%,  $P<.001$ ), being stationary (55.1%±14.3% vs 41.8%±16.8%,  $P<.001$ ), and walking (11.6%±8.5% vs 8.6%±9.7%,  $P<.001$ ), and a smaller percentage of time cadence-marching (3.3%±3.3% vs 4.7%±4.0%,  $P<.001$ ), completing obstacles (0.5%±2.1% vs 1.1%±4.0%,  $P=.030$ ), performing menial tasks (22.3%±15.0% vs 37.6%±17.9%,  $P<.001$ ), and running (1.2%±1.7% vs 1.6%±2.0%,  $P=.037$ ) when compared to recruits at Fort Sill. Little difference was observed between the 2 training sites in terms of percentage of time recruits spent in calisthenics (3.9%±3.6% vs 3.8%±3.0%,  $P=.700$ ), crawling (0.2%±1.1% vs 0.1%±0.3%,  $P=.102$ ), and lifting/carrying (0.2%±0.9% vs 0.3%±0.8%,  $P=.097$ ).

The average daily percentage of time recruits at both training sites spent carrying various external loads over the course of a BCT cycle is shown in Figure 5. Recruits

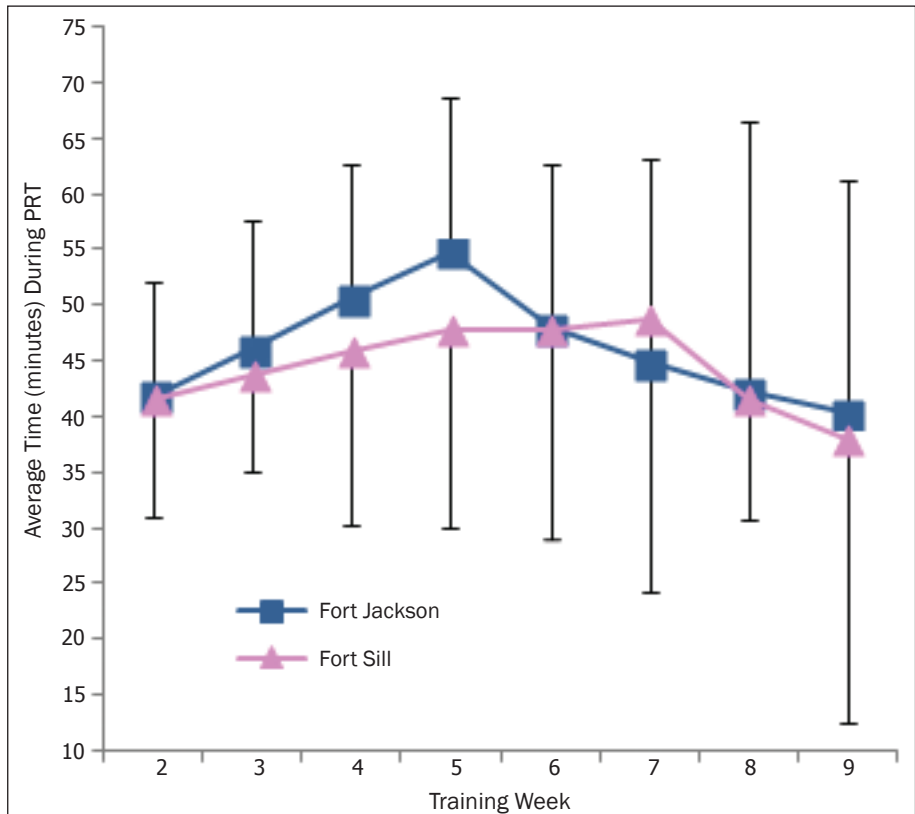


Figure 2. Average time (mean±SD) by training week that recruits spent in moderate to vigorous intensity physical activity between 5 AM and 7 AM as measured with accelerometers.

at Fort Jackson spent a larger percentage of time carrying 0-10 lbs (84.0%±19.0% vs 79.6%±19.7%,  $P=.011$ ) and a smaller percentage of time carrying 25-50 lbs (3.5%±7.5% vs 9.7%±13.6%,  $P<.001$ ) and 50-75 lbs (0.2%±1.2% vs 1.0%±3.2%,  $P<.001$ ). Little difference was observed between the two training sites in terms of percentage of time recruits spent carrying 10-25 lbs (12.2%±16.6% vs 9.6%±14.8%,  $P=.066$ ) or greater than 75 lbs (0.1%±0.3% vs 0.2%±1.3%,  $P=.064$ ). Recruits at both training sites spent a large percentage of time (about 80%) carrying 0-10 lbs and a very small percentage of time (≤1%) carrying over 50 lbs.

#### Physical Activity Log

Table 3 lists the cumulative time (hours and minutes) recruits from both training sites reported sitting, standing, walking, running, participating in calisthenics, doing chores, and carrying loads, based on their daily PA logs. Recruits at Fort Jackson accounted for an average of 601.1±52.5 minutes/day for 47 days, while recruits at Fort Sill accounted for an average of 672.7±28.3 minutes/day for 44 days ( $P<.001$ ). Recruits at Fort Sill accounted for a longer period of time each day than recruits at Fort Jackson did. Therefore, all PA Log comparisons between the 2 training sites in this study were

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Table 2. Cumulative time recruits at both training sites spent in each body position, activity type, activity intensity, and carrying each external load, as measured by the PAtacker during a Basic Combat Training cycle. Days represent the total number of days recruits participated in each body position, activity type and intensity, and carried each load at least once.

		Fort Jackson			Fort Sill		
Days Observed		47			44		
Time Observed (minutes/hours)		36,463.2±8,444.3/607.7±140.7			30,367.2±8,884.3/506.1±148.1		
Body Position	Days	Time (minutes)	Time (hours)	Days	Time (minutes)	Time (hours)	
Kneeling	34	409.2±172.7	6.8±2.9	37	602.5±252.2	10.0±4.2	
Lying	37	1,071.8±284.0	17.9±4.7	37	943.0±184.9	15.7±3.1	
Sitting	47	13,187.2±1,193.8	219.8±19.9	44	9,374.1±1,056.5	156.2±17.6	
Standing/On Feet	47	19,216.3±476.2	320.3±7.9	44	19,447.6±1,752.5	324.1±29.2	
Varying	41	2,578.6±344.2	43.0±5.7	NA	NA	NA	
Activity Type							
Cadence March	39	1,195.6±325.0	19.9±5.4	40	1,414.6±210.3	23.6±3.5	
Calisthenics	38	1,391.9±146.6	23.2±2.4	39	1,128.4±46.5	18.8±0.8	
Combatives	12	559.6±155.3	9.3±2.6	4	113.5±75.9	1.9±1.3	
Crawl	7	63.4±75.2	1.1±1.3	5	16.5±7.2	0.3±0.1	
Lifting/Carrying	12	71.1±50.4	1.2±0.8	13	97.8±62.8	1.6±1.0	
Menial Tasks	47	7925.0±495.2	132.1±8.3	44	11,335.9±2,180.3	188.9±36.3	
Obstacle/Climbing	7	181.0±55.7	3.0±0.9	8	302.4±38.8	5.0±0.6	
Run	33	427.7±91.1	7.1±1.5	31	479.7±58.8	8.0±1.0	
Stationary	47	20,402.9±1,510.9	340.0±25.2	44	12,871.7±2,922.4	214.5±48.7	
Walk	47	4,244.9±720.9	70.7±12.0	44	2,606.8±435.2	43.4±7.3	
Intensity							
Sedentary	47	19,995.7±2902.8	333.3±48.4	44	14,604.6±3,835.6	243.4±63.9	
Light	47	13,126.8±1325.2	218.8±22.1	44	13,506.0±3,380.0	225.1±56.3	
Moderate	44	2,975.9±1333.2	49.6±22.2	40	2,018.7±238.1	33.6±4.0	
Vigorous	25	360.6±105.0	6.0±1.7	18	238.0±151.3	4.0±2.5	
External Load							
0-10 lbs	47	30,533.1±2282.2	508.9±38.0	44	24,323.4±859.1	405.4±14.3	
10-25 lbs	36	4,585.4±1461.4	76.4±24.4	28	2,869.6±1,416.3	47.8±23.6	
25-50 lbs	19	1,266.6±588.3	21.1±9.8	30	2,796.2±628.6	46.6±10.5	
50-75 lbs	4	70.0±57.0	1.2±0.9	7	322.1±226.8	5.4±3.8	
>75 lbs	3	8.0±11.2	0.1±0.2	4	55.9±68.3	0.9±1.1	

made using the average daily percentage of time, with the exception of time spent sleeping each night.

The average daily percentage of time recruits from both training sites reported sitting, standing, walking, and running is shown in Figure 6. Recruits at Fort Jackson reported spending a larger percentage of time sitting (48.7%±13.6% vs 42.2%±5.7%,  $P<.001$ ) and walking (21.8%±8.7% vs 18.5%±2.7%,  $P<.001$ ), and a smaller percentage of time standing (24.0%±7.3% vs 33.5%±4.8%,  $P<.001$ ) and running (5.4%±3.2% vs 5.9%±1.5%,  $P=.034$ ) than recruits at Fort Sill.

Over the course of BCT, recruits at Fort Jackson reported spending less time sleeping each night than recruits

at Fort Sill (364.7±41.1 minutes/night vs 376.6±17.5 minutes/night,  $P<.001$ ). Recruits at Fort Jackson also reported spending a larger percentage of time doing chores (4.5%±2.8% vs 3.8%±1.3%,  $P=.002$ ), performing calisthenics (10.0%±7.7% vs 8.6%±2.5%,  $P=.006$ ) and carrying loads (16.9%±12.8% vs 7.9%±2.4%,  $P<.001$ ) than recruits at Fort Sill.

### COMMENT

To the best of our knowledge, this study was the first to characterize and quantify the amount of PA recruits actually perform during BCT conducted at 2 different training sites. The results of this study revealed that although there were some differences between the 2 sites in terms of the PA performed, these differences were

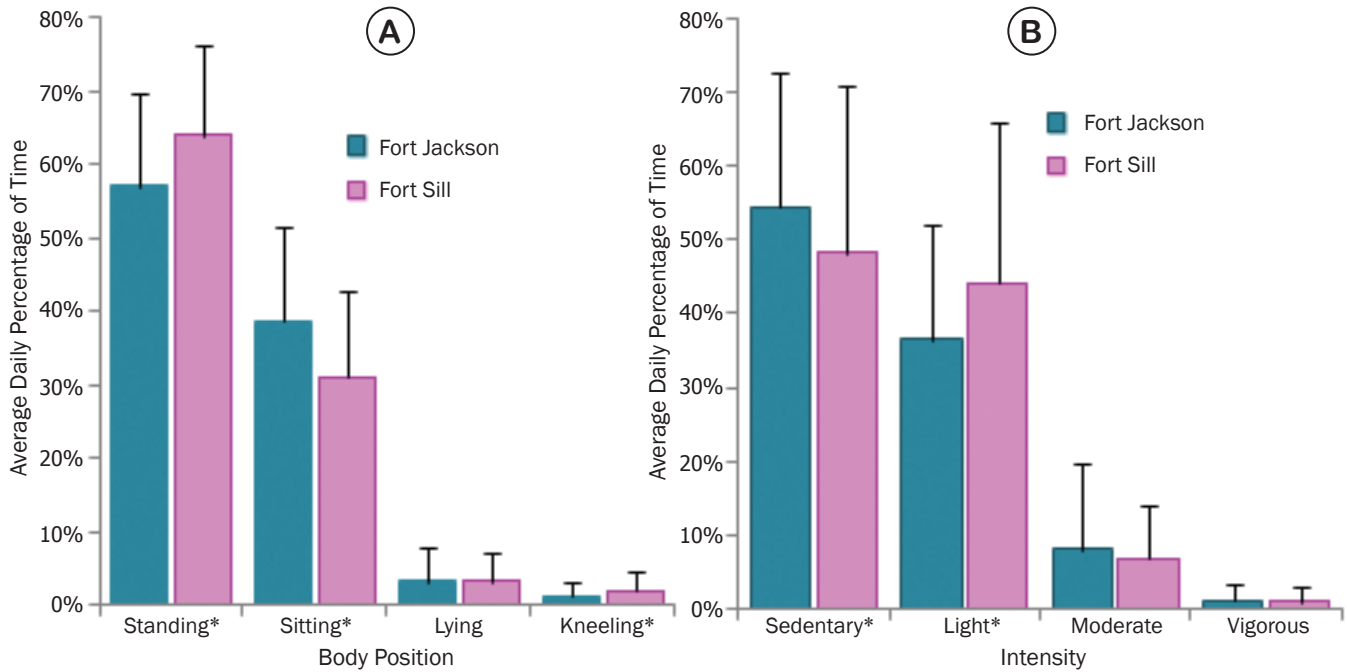


Figure 3. Average daily percentage of time that recruits spent in various body positions (A) and intensities of physical activity (B) as measured with the PAttracker.  
\*Fort Jackson vs Fort Sill:  $P < .05$

small, for the most part, and likely have little practical importance. Furthermore, it appeared that the intensity and types of PA were similar at the 2 sites.

**Quantification of Physical Activity**

The major purpose of this study was to characterize and quantify the PA performed by recruits during the middle 8 weeks of BCT and determine whether or not there were differences in PA between the training sites. The PA performed by recruits was characterized and quantified using accelerometry, direct observation, and daily PA logs. Despite statistical significance, the differences in PA observed between the 2 BCT sites were small. The magnitude of the differences between sites can be appreciated by examining the range of differences (lowest and highest) in the amount of time recruits spent in various physical activities. From the accelerometer, the lowest difference was 7% (3.4 minutes) for sedentary

activities, and the highest difference was 7.2% (67.8 minutes) for light-intensity activities. From the PAttracker, the lowest difference between the 2 training sites was 0.4% (2 minutes) for running, and the highest difference was 15.3% (93.7 minutes) for mental tasks. From the PA log, the lowest difference between the 2 training sites was 0.5% (7.2 minutes) for running and 9.0% (50.3 minutes) for carrying loads. This result suggests that Army BCT recruits spent similar amounts of time in each PA intensity, activity type, body position, and carrying various external loads at the 2 locations tested. Whether or

Table 3. Cumulative time (mean±SD) recruits at both training sites spent in various physical activities, as reported on the daily PA logs during a Basic Combat Training cycle. Days represent the total number of days recruits participated in each variable at least once.

	Fort Jackson			Fort Sill		
	Days Self-reported	Time Self-reported (minutes/hours)		Days Self-reported	Time Self-reported (minutes/hours)	
	47	28256.2±1458.5 / 470.9±24.3		44	29597.6±596.2 / 493.3±9.9	
Sit	47	13,672.7±1,620.9	227.9±27.0	44	12,430.8±1,296.4	207.2±21.6
Stand	47	6,848.0±743.8	114.1±12.4	44	9,907.6±1,233.9	165.1±20.6
Walk/March	47	6,204.5±1,204.6	103.4±20.1	44	5,506.4±392.2	91.8±6.5
Run	47	1,531.0±263.6	25.5±4.4	44	1,752.8±238.9	29.2±4.0
Sleeping	47	17,140.7±985.7	285.7±16.4	44	16,569.4±567.7	276.2±9.5
Chores/Maintenance	43	1,256.7±323.4	20.9±5.4	44	1,135.4±321.5	18.9±5.4
Calisthenics/Obstacle Course	45	2,795.5±669.0	46.6±11.2	44	2,532.8±473.7	42.2±7.9
Carrying Load	46	4,857.8±1,738.4	81.0±29.0	44	2,336.0±289.2	38.9±4.8

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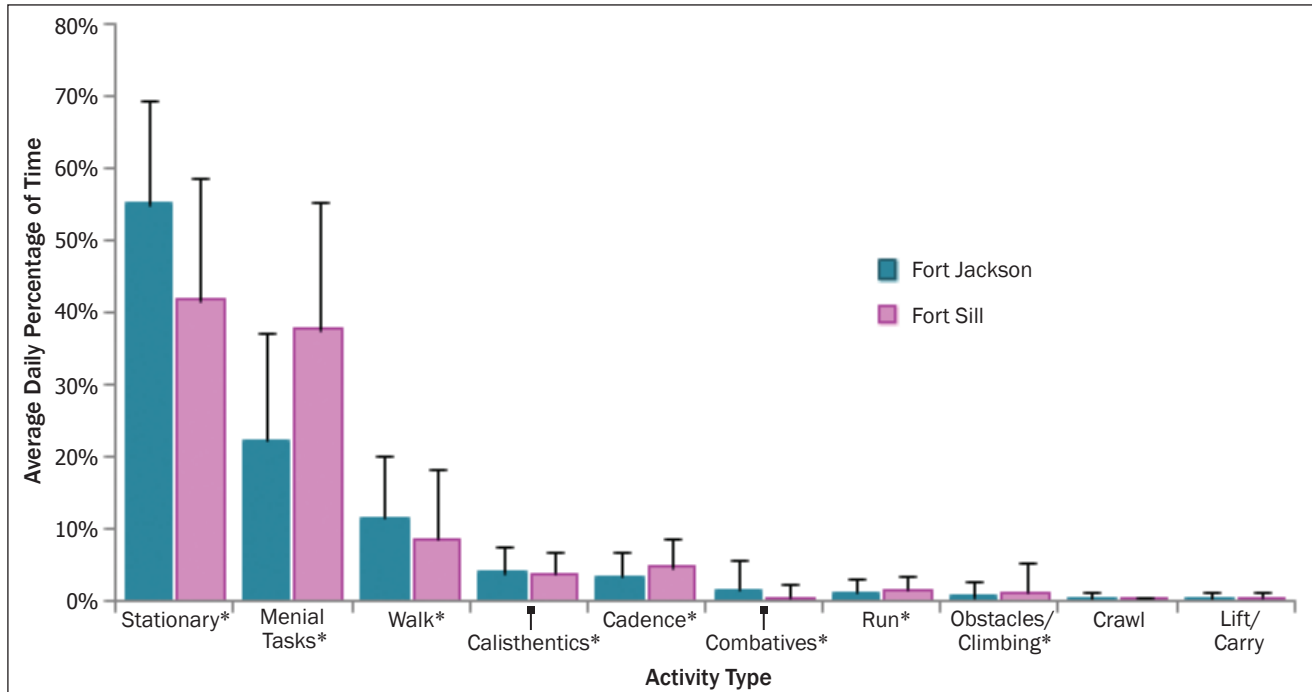


Figure 4. Average daily percentage of time that recruits spent in various activity types as measure with the PAtacker.  
\*Fort Jackson vs Fort Sill:  $P < .05$

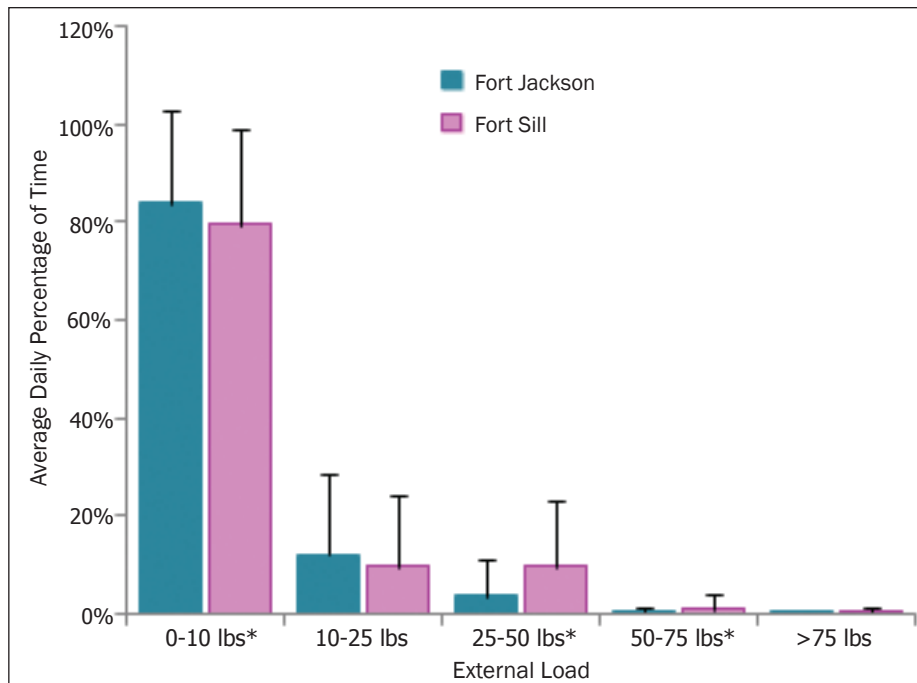


Figure 5. Average daily percentage of time that recruits spent in various activity types as measured with the PAtacker.  
\*Fort Jackson vs Fort Sill:  $P < .05$

intensity (for example, accelerometer or direct observation). Recruits at both training sites spent a very large percentage of time sedentary (about 80%) and a very small percentage of time in vigorous-intensity activities (about 5%). Between the training sites, there was little difference in the percentage of time recruits spent in moderate- or vigorous-intensity PA. These results further support the idea that the intensity of PA at each training site was similar.

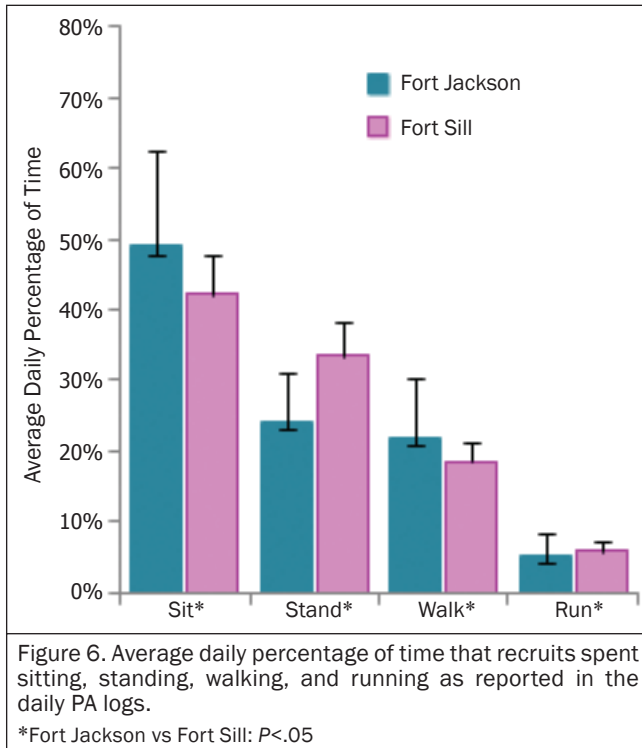
External loads carried by recruits were obtained from direct observation (PAtacker). Recruits from both training sites spent a very large percentage of time (roughly 80%) either unloaded or carrying very light loads (0-10 lbs) and a very small

percentage of time carrying loads weighing over 50 lbs (1%-2%). During their military service, Soldiers may be expected to carry extremely heavy loads for long distances over various types of terrain.<sup>27</sup> Current US Army doctrine recommends that Soldiers carry no more than

not this result applies to all BCT sites will need to be determined with future studies.

In terms of intensity, the results of this study were the same regardless of the technique used to measure PA





48-72 lbs (or 30%-45% of their body weight) in the fighting load and approach march loads, respectively.<sup>28,29</sup> Recruits at both training sites had some training in heavy loads, providing further evidence that the PA performed at each training site was similar.

Using the daily PA log, recruits from both training sites reported getting an average of about 6 hours of sleep each night. Current Army doctrine mandates that recruits be given the opportunity to receive 7 hours of continuous sleep each night while in garrison unless they are scheduled for duty.<sup>20</sup> The results of this study suggest that although they may be allowed the full 7 hours, BCT recruits at both training sites reported getting slightly less than the recommended amount of sleep. Additionally, the self-reported amount of sleep in this study is similar to the results of a previously published study in which US Military Academy cadets reported receiving an average of 5 hours and 40 minutes of sleep per night during the 6 weeks of cadet basic training.<sup>30</sup> The current study's findings indicate that recruits received the same, or similar, amounts of recovery time regardless of the training site to which they were assigned.

#### Physical Training Intensity and Type

The second purpose of this study was to examine the intensity and types of physical training over the course of BCT. Intensity was examined to determine whether the principle of progressive training (progressive overload),

one of the major principles of PRT, was being followed.<sup>31</sup> The PRT program consists of a variety of standardized exercises (such as preparatory drills, conditioning drills, movement drills, climbing drills, interval running, long distance running, and flexibility training) and is designed to progressively train Soldiers while reducing the risk of developing injuries.<sup>2,19</sup>

The results of this study show time spent in moderate- to vigorous-intensity PA between 5AM and 7AM (when recruits were presumably engaged in PRT) tended to increase during the first 4 weeks of BCT at Fort Jackson (Figure 2). Although there was no significant difference in the weekly moderate- to vigorous-intensity activity at Fort Sill, the graph does show a gradual increase, the slope of which is much lower than that shown for Fort Jackson. This suggests some increase in exercise intensity but perhaps not enough to be consistent with the progressive overload principle. After week 4 (Fort Jackson) or week 7 (Fort Sill), the amount of time recruits spent in moderate- to vigorous-intensity PA from 5 AM to 7 AM at both training sites tended to decrease. This decrease could be related to increased time spent in military operations (road marching, basic rifle marksmanship, land navigation, field training exercises, etc). When physically demanding activity was scheduled, physical training was either reduced or was not conducted at all in the early morning. The more physically demanding operational soldiering tasks are generally conducted later in training.

Over the course of the 8-week BCT monitoring period, the average daily percentage of time recruits spent engaging in calisthenics was not significantly different between the training sites. The average daily time spent running differed slightly; however, this difference was not large. Although we cannot determine from these data if the specific drills of PRT were followed, it appears that the amount of time spent in these general activities was similar at the 2 sites.

#### Strengths and Limitations

This study was limited by the fact that recruits were only observed during the middle 8 weeks of training as opposed to the entire 10 weeks. Eliminated were the first week of BCT, which consists mostly of classroom training; and the final week, consisting primarily of cleaning equipment, completing paperwork, and preparing for graduation. We also did not monitor the evening activities of the recruits (after the evening meal, generally after 1800). Thus, we missed some of the activities performed by recruits, but previous observations suggested that there was little PA taking place in the evening hours.<sup>1,3</sup>

## QUANTIFICATION OF PHYSICAL ACTIVITY PERFORMED DURING US ARMY BASIC COMBAT TRAINING

Due to limited personnel and resources, we were unable to instrument and observe all recruits in each training company. Therefore, the PA performed by the 24 recruits per company who were instrumented with an accelerometer and the 1 recruit per company who was followed and observed using the PAtracker was assumed to be representative of the PA performed by all recruits in each respective company.

If a recruit wearing an accelerometer or being observed using the PAtracker was sick, injured, or not training with his or her company that day for any reason, that recruit was immediately replaced with another consented volunteer. Due to study design, a limitation to this process was the number of times recruits had to be replaced, which was not tracked. However, since recruits were immediately replaced, the appropriate number of accelerometers was always distributed, and one recruit per company was observed. Therefore, data was never lost due to attrition.

This study also used multiple methods of measuring PA, including accelerometry, direct observation, and self-report questionnaires, all of which allowed study investigators to capture a good quality representation of the PA actually performed by recruits during BCT. Additionally, the standardization of activities during BCT enabled investigators to ensure that recruits filled out the daily PA log each day.

### RELEVANCE TO PERFORMANCE TRIAD

The Army Surgeon General's Performance Triad initiative seeks to improve Soldier readiness and resiliency by improving the activity, sleep and nutritional aspects of Soldier health behaviors. This study examined the activity and sleep aspects of the Performance Triad. Physical activity is an important variable to support health and improve performance. It is important to document the physical demands of the training program followed during BCT in order to ensure that the activities performed are sufficient for developing the Soldier's fitness, but not so excessive that the demands lead to the development of musculoskeletal injuries, a key barrier to individual and unit readiness. Additionally, these data suggest recruits during BCT are meeting the minimum PA recommendations for healthy adults set forth by the American College of Sports Medicine.<sup>32</sup>

In terms of sleep, these data suggest that recruits are receiving slightly less than the recommended 7-8 hours per night during BCT, despite being allotted 7 hours each night to devote to sleep. This lack of rest and

recovery during BCT may adversely impact a recruit's ability to perform his or her job sufficiently and maintain adequate health and resiliency.

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# Nutrition as a Component of the Performance Triad: How Healthy Eating Behaviors Contribute to Soldier Performance and Military Readiness

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## ABSTRACT

**Objective:** Nutrition is a critical element of Soldier health and performance. Food choices, meal timing, and dietary intake behaviors contribute to nutritional fitness. The objectives of this study were to describe Soldier dietary behaviors and quantify the association between healthy eating behaviors and demographic, lifestyle, and psychosocial factors.

**Methods:** The Comprehensive Soldier and Family Fitness Global Assessment Tool (GAT) assesses emotional, social, family, and spiritual fitness. In 2012, 57 pilot questions were added to the GAT to create a physical dimension that included nutrition assessments. Participants included 13,858 Active Duty, Reserve, and National Guard Soldiers: 83% male; 85% enlisted; a mean age of 28±9 years. A Healthy Eating Score (HES-5) was calculated from 5 questions assessing frequency of fruit, vegetable, whole grain, dairy, and fish intake (Cronbach  $\alpha=0.81$ ). Associations between HES-5 and other dietary habits, physical activity patterns, and GAT psychosocial dimension scores were examined.

**Results:** Soldiers who ate breakfast regularly (6 times/week or more), drank 7 servings or more of water/day, and met weekly exercise recommendations were more likely to be in the highest HES-5 quartile than those who did not. Those who passed their Army Physical Fitness Test (APFT) in the top quartile were also more likely to report high HES-5 scores than those who failed ( $P<.001$ ). Soldiers with healthy anthropometric measures and the highest emotional, social, family, and spiritual fitness scores were also more likely to be in the top HES-5 quartile than those with unhealthy measures and with the lowest fitness scores ( $P<.001$ ).

**Conclusion:** The HES-5 may be a useful index for characterizing dietary intake behaviors. Healthy dietary intake behaviors are associated with all dimensions of health, physical fitness, and psychosocial status.

Nutrition is a critical element for sustaining Soldier health and performance. Nutritional fitness is defined as the availability and consumption of quality food in appropriate quantities to ensure mission performance and protect against disease.<sup>1</sup> Accordingly, the dietary behaviors and intake patterns of a Soldier form the basis of his/her nutritional fitness. Optimal nutrition supports health, an ideal body composition, positive psychological and cognitive status,<sup>2-4</sup> and physical readiness.<sup>5,6</sup> This is of particular importance since military personnel are often subjected to physical and environmental extremes that demand optimal cognitive, psychosocial, and physical performance.<sup>7,8</sup> Thus, an appropriate body composition, high fitness, good health, and adequate substrates to fuel cognitive and physical activities can positively impact

individual performance and force readiness.<sup>9</sup> A healthy diet is a key countermeasure for individuals to ensure optimal body weight and adequate fuels for cognitive and physical activity.<sup>10,11</sup>

Dietary choices and habits affect every aspect of life: physical performance,<sup>5,6</sup> cognitive performance,<sup>4,12</sup> sleep,<sup>13,14</sup> mood,<sup>7</sup> and overall health.<sup>15-17</sup> The protective effects of fruit and vegetable consumption from diseases have been investigated extensively, yet based on the 2011 Military Survey of Health Related Behaviors, only 11.2% and 12.9% of military personnel met the US Dietary Goals of 3 or more servings of fruits and vegetables per day, respectively.<sup>18</sup> These numbers, which are lower than those from the 2008 survey<sup>19</sup> and the Healthy

People 2010 objectives of 75% or more for fruits and 50% or more for vegetables, are also significantly lower than those reported for the civilian sector.<sup>20</sup> Conversely, excess energy intakes above daily requirements may lead to weight gain, increased adiposity, and adverse health consequences.<sup>21,22</sup> A poor diet and the inappropriate use of dietary supplements (DS) can negatively impact human performance and health outcomes.<sup>5,6,23,24</sup>

This study examined lifestyle habits—nutrition behaviors, sleep quality, psychosocial status, health habits, and physical activity—in US Army Soldiers through the introduction of a set of questions added to the Global Assessment Tool (GAT) as part of the Comprehensive Soldier and Family Fitness (CSF2) program, and characterized differences between the healthiest and least healthy eaters. The objectives of this study were (1) to describe Soldiers’ dietary practices using a brief healthy eating score and (2) to evaluate the association between demographic and lifestyle factors affecting performance (eg, sleep quality, physical activity, and various psychosocial measures) with self-reported dietary behaviors.

## METHODS

The CSF2 GAT, an annual requirement for all Soldiers, consists of 105 questions and was developed in part by Seligman et al<sup>25</sup> and others<sup>26</sup> to assess fitness in 4 psychosocial dimensions: emotional, social, family, and spiritual fitness.<sup>27,28</sup> In 2012, the CSF2 program introduced a physical dimension by adding 57 pilot questions to assess nutrition behaviors, sleep quality, DS use, physical fitness, and other lifestyle behaviors. During 2 weeks in July 2012, anyone completing the GAT was directed to the expanded GAT. Upon GAT completion, respondents were informed that physical domain answers

would not be included in their overall GAT score, and they were given the option to consent to the use of their GAT responses for further study. The Uniformed Services University of the Health Sciences Institutional Review Board concluded that a full review was not required for this investigation. This study was not classified as human subjects research since the CSF2 program provided data stripped of identification elements to the Consortium for Health and Military Performance per an established data use agreement.

## Population

A total of 14,850 participants completed the CSF2 GAT physical domain pilot questions and consented for their data to be used for further study. Three family members, 599 Department of Defense (DoD) civilians, and 390 participants with missing data were excluded from analyses. Hence, we are reporting data from 13,858 Active Duty, Reserve, and National Guard Soldiers.

## Measures

### Nutrition Behaviors

Nutrition behaviors were assessed in the pilot physical GAT domain by means of a 5-question Healthy Eating Score (HES-5). The HES-5 was modified from the US Department of Agriculture’s (USDA) Healthy Eating Index.<sup>29-32</sup> The Healthy Eating Index, developed in 2005 (HEI-2005) to evaluate if an individual is meeting the 2005 Dietary Guidelines for Americans,<sup>31,32</sup> assesses 12 food components (fruit, vegetables, grains, milk/dairy, meat and beans, fish, oils, fats, sodium, and added sugar). The HEI-2005<sup>29-32</sup> responses are summed for an overall score ranging from 0-100 points,<sup>31,32</sup> and the index has been modified to assess special populations.<sup>33</sup> Since the GAT nutrition behavior questions assessed respondents’

Over the last 30 days, how often did you eat/drink the following foods/beverages? (Note: Only a few examples of each category are listed to remind you of the types of foods—many more are possible.)	3 or More Times per Day	Twice per Day	Once per Day	3 to 6 Times per Week	1 or 2 Times per Week	Rarely or Never
FRUIT: fresh, frozen, canned or dried, or 100% fruit juices	5	4	3	2	1	0
VEGETABLES: fresh, frozen, canned, cooked or raw: dark green vegetables (broccoli, spinach, most greens), orange vegetables (carrots, sweet potatoes, winter squash, pumpkin), legumes (dry beans, chick peas, tofu), starchy vegetables (corn, white potatoes, green peas), and other (tomatoes, cabbage, celery, cucumber, lettuce, onions, peppers, green beans, cauliflower, mushrooms, summer squash, etc)	5	4	3	2	1	0
WHOLE GRAINS: rye, whole-wheat, or heavily seeded bread; brown or wild rice; whole-wheat pasta or crackers; oatmeal; corn tacos	5	4	3	2	1	0
DAIRY: regular/whole fat milk; low- or reduced-fat milk (2%, 1%, 0.5% or skim), yogurt, cottage cheese, low-fat cheese, frozen low-fat yogurt, soy milk, or other calcium-fortified foods (orange juice, soy/rice milk, breakfast cereals, etc)	5	4	3	2	1	0
FISH: tuna, salmon, or other nonfried fish	5	5	5	5	3	0

Note. Questions and scoring that comprise the Healthy Eating Score-5. Scores were totaled for a range of 0 to 25.

## NUTRITION AS A COMPONENT OF THE PERFORMANCE TRIAD: HOW HEALTHY EATING BEHAVIORS CONTRIBUTE TO SOLDIER PERFORMANCE AND MILITARY READINESS

daily intake of fruits, vegetables, whole grains, dairy, and fish, the HEI-2005 was modified to create the HES-5. The consumption of health-promoting foods assessed by the HES-5 (Table 1) is typically deficient in military populations, and their consumption does not meet national guidelines.<sup>18,19,34</sup> Each HES-5 question represented a sub-scale score ranging from 0-5, with 5 indicating that the respondent met the USDA dietary recommendation for that measure.<sup>35</sup> Thus, the total possible value of HES-5 ranged from 0 to 25. A Cronbach  $\alpha$  analysis of the 5 sub-scale scores was used to determine HES-5 reliability<sup>36,37</sup>; the analysis yielded an internal consistency reliability coefficient of 0.81. Classifications for Cronbach  $\alpha$  vary, but values less than 0.60 are generally considered unacceptable, 0.70 minimally acceptable, and 0.80 very good.<sup>37</sup>

Respondents' HES-5 scores were then partitioned into quartiles for subsequent analyses. The top quartile consisted of HES-5 scores from 20 to 25, or above the 75th percentile. Scores in the third quartile ranged from 17 to 19, those in the second quartile from 13 to 16, and scores of 12 or lower comprised the lowest quartile, representing the lowest 25th percentile.

### Additional Physical Domain Measures

The GAT physical dimension assessed a variety of lifestyle measures that were dichotomized to indicate healthy versus less healthy behaviors. These measures included the number of days per week on which respondents ate breakfast (6 or more days per week versus 5 or fewer days per week), whether the respondent usually consumed a recovery snack (defined as a snack eaten within 60 minutes of strenuous exercise and classified as yes or no), water intake (7 or more glasses per day versus 6 or fewer glasses per day), consumption of health-promoting supplements (ie, multivitamins and/or mineral supplements with 6 or more ingredients; or single-ingredient supplements such as calcium or iron; classified as yes or no), consumption of additional supplements (ie, omega-3 supplements, protein powders; classified as yes or no), and consumption of sodas (diet and/or regular; classified as yes or no for any soda consumption).

Two questions from the Pittsburgh Insomnia Rating Scale (PIRS-2)<sup>38,39</sup> were used to assess sleep quality; responses were summed based on scoring guidelines,<sup>38</sup> and a threshold of 5 or higher distinguished good sleepers from poor sleepers. This cutoff, although different from the typical PIRS-2 threshold, was established in conjunction with the scale's authors to yield a more specific rather than sensitive classification of poor sleepers.<sup>40</sup> Respondents further answered questions related to their perceived health, weight, and alcohol intake. The 3 specific questions were:

1. How do you consider your general health? (excellent, good, fair, poor, don't know; classified as "excellent and good" or "fair and poor")
2. In thinking about your weight, do you consider yourself to be underweight, about the right weight, overweight, obese, don't know? (classified as "about the right weight" versus "overweight or obese")
3. Have you exceeded 5 alcoholic drinks on any single occasion during the past 3 months? (yes or no).

Soldiers' physical activity was assessed by asking how many times per week they participated in aerobic activity for at least 20 minutes, and the frequency with which they participated in strength or resistance exercise. Responses were classified as "met national guidelines" or "failed to meet national guidelines" for both aerobic and strength training, based on the American College of Sports Medicine and Centers for Disease Control and Prevention exercise recommendations.<sup>41</sup> Further, each participant entered his or her most recent raw numbers for push-ups, sit-ups, and timed run from the Army Physical Fitness Test (APFT). Based on this information, an additional variable was created to indicate whether the respondent passed or failed his or her APFT based on Army standards.<sup>42</sup> A respondent failed the APFT if he or she scored less than 60 in any event. To distinguish top APFT performers, those Soldiers who passed the APFT were additionally placed into quartiles based on the distribution of scores.

Lastly, participants self-reported their height in inches, weight in pounds, and waist circumference in inches. Each Soldier's body mass index (BMI) ((weight in kg)/(height in m)<sup>2</sup>) was calculated and classified as healthy or unhealthy using 27.5 kg/m<sup>2</sup> as the upper limit for a healthy BMI per *Army Regulation 600-9*.<sup>43</sup> Waist circumference was classified as healthy or unhealthy using 35 inches or below as healthy values for females, and 40 inches or below as healthy values for males.<sup>44</sup>

### GAT Dimensions

The CSF2 provided composite scores for each original GAT dimension (emotional, social, family, spiritual). Each composite score ranged from 1 to 5, with higher scores indicating higher levels of resilience in each dimension.<sup>27,28</sup> Subscores for each dimension were further classified into quartiles for subsequent analyses.

### Statistical Analyses

The IBM SPSS Statistics software package for Windows, Version 20.0 (IBM Corp, Chicago, IL) was used for all analyses. Using frequency tables and descriptive

statistics, the analysis team reviewed data to remove outliers and confirm assumptions for parametric tests.

Individual indicators on the HES-5 were examined first to measure the extent that Soldiers are currently meeting national nutrition guidelines. Next, HES-5 means and standard deviations for various demographic subgroups were calculated. The HES-5 quartiles (the dependent variable, designated as highest [Q4] versus lowest [Q1]) were assessed to characterize the differences in the most healthy and least healthy eaters; binary logistic regression models were used to calculate the odds of being in the highest HES-5 quartile versus the lowest quartile for a variety of predictors.

Demographic independent variables included age, gender, active duty status, enlistment status, and marital status. Lifestyle independent variables included dietary behaviors (breakfast, hydration, soda intake, DS use) and physical activity, APFT scores, BMI, waist circumference, and GAT fitness dimensions. Reference groups were the “less healthy” as compared to the “more healthy” group. Regarding the 4 original GAT dimensions, only the highest and lowest quartiles were compared, and the lowest quartile served as the reference group. For the APFT analysis, Soldiers who passed the test in the top quartile were compared to those who failed.

To adjust for inflated type I error rates associated with multiple binary analyses, a Bonferroni adjustment was applied, ie, the standard type I error rate ( $P=.05$ ) was divided by 17 (the total number of logistic regression analyses) to achieve a significance level set at  $P<.003$ .

RESULTS

General Characteristics

Demographic characteristics of the study population and mean HES-5 scores are summarized in Table 2. Subjects were predominately male (83%) and enlisted (85%) with a mean age of 28±9 years, and mean BMI of 26.6±4 kg/m<sup>2</sup>.

Dietary Recommendations

Figure 1 shows that 38.7% of participants met the US Dietary Guidelines for fruit intake (at least 2 servings per day); 22.2% met the vegetable recommendation (at least 2 servings per day for females and 3 servings for males); and 16.8% met the whole grain recommendation of at least 3 servings per day. Overall, only 17.3% met the dairy recommendation of at least 3 daily servings, whereas 46.6% met the fish recommendation of at least 2 to 3 servings per week.

Healthy Eating Score and Dietary Behaviors

Means for the HES-5 quartiles are presented in Table 2. The mean HES-5 for this sample was 15.7±3.4, and persons in the highest HES-5 quartile had a mean of 22.1±1.8 compared to those in the lowest quartile who had a mean of 8.6±3.0.

Overall, officers (OR 1.48; 95% CI, 1.29-1.70;  $P<.001$ ), and single, divorced, or legally separated persons (OR 1.21; 95% CI, 1.10-1.33;  $P<.001$ ) had greater odds of being in the highest HES-5 quartile when compared to enlisted and married Soldiers. No significant associations were noted between highest/lowest HES-5 quartile membership and gender (reference group: male [OR

Table 2. Study Sample Demographic Characteristics (N=13,858).

Frequencies	HES-5 Mean±SD	
Age, Mean±SD (years)	28.2±9.2	
Years Range	17.0-61.0	
Age Groups		
17 to 29	66.9%	15.9±3.4
30 and over	33.1%	15.1±5.3
Gender		
Female	16.7%	15.6±5.5
Male	83.3%	15.7±5.3
Army Duty Status		
National Guard/Reserve	47.4%	15.5±5.4
Active Duty	52.6%	15.8±5.3
Service Category		
Enlisted	84.9%	15.5±5.5
Officers	14.6%	16.39±4.7
Marital Status		
Married	49.0%	15.5±5.2
Single/Divorced/Legally Separated	51.0%	15.8±5.4
Army Physical Fitness Test	n=9,845	
Failed	13.7%	15.0±5.6
Passed	86.3%	16.0±5.3
BMI Categories	n=11,119	
Underweight (<18.4 kg/m <sup>2</sup> )	0.5%	15.1±5.1
Normal/Healthy (18.5-27.5 kg/m <sup>2</sup> )	65.3%	15.0±5.3
Overweight (27.6-29.9 kg/m <sup>2</sup> )	16.9%	15.6±5.3
Obese (>30 kg/m <sup>2</sup> )	17.3%	15.1±5.5
BMI, Mean±SD (kg/m <sup>2</sup> )	26.6±4.0	
BMI Range	13.4-56.3	
Waist Circumference	n=5,855	
Healthy	90.9%	16.09±5.3
Unhealthy	9.1%	15.28±5.3
HES-5 Quartiles*		
Low HES-5 - Quartile 1	25.9	8.6±3.0
Quartile 2	26.0	14.4±1.2
Quartile 3	22.2	17.8±0.8
High HES-5 - Quartile 4	25.9	22.1±1.8

Note: Data are represented as means±standard deviation (SD) for continuous variables and as a percentage for categorical variables. Percentages within characteristic groups may not total 100% due to missing data.

\*HES-5 (Healthy Eating Score-5); High HES-5 is defined as a total ≥20 out of 25 or above the 75th percentile; a low HES-5 received a score of 12 or below (lower 25th percentile).

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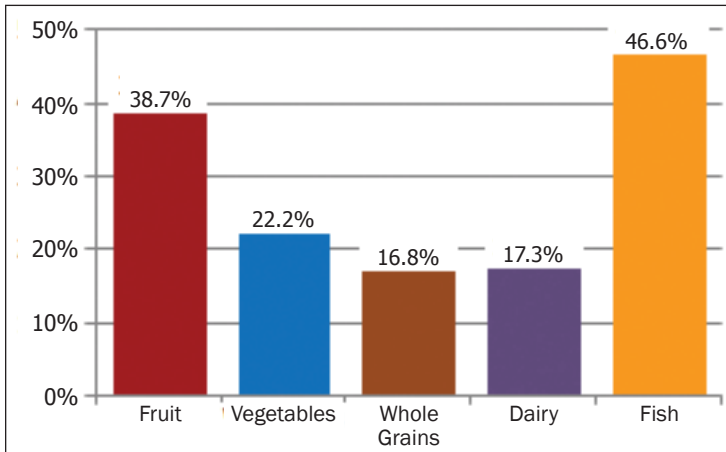


Figure 1. Percentages of Soldiers meeting US Dietary Guidelines by category. Overall, less than half met the dietary guidelines for fruit (2 servings/day), vegetables (2-3 servings/day), whole grains (3 servings/day), dairy (3 servings/day), and fish (2-3 servings/week).

1.03; 95% CI, 0.91-1.16;  $P=.64$ ]) or active duty status (reference group: Reserve or National Guard [OR 1.12; 95% CI, 1.02-1.23;  $P=.02$ ]).

Additional results presented in Figure 2 indicate that those Soldiers who were younger, ate breakfast at least 6 times per week, and ate a postexercise recovery snack were more likely to be in the top HES-5 quartile when compared to older Soldiers and those who did not engage in those behaviors. Figure 2 also indicates that Soldiers with healthy anthropometric measures had greater odds of being in the highest HES-5 quartile than Soldiers without healthy anthropometric measures. Moreover, those Soldiers who considered themselves to be “about the right weight” were more likely to be in the highest HES-5 quartile when compared to those who considered themselves as overweight or obese (OR 2.15; 95% CI, 1.94-2.40;  $P<.001$ ).

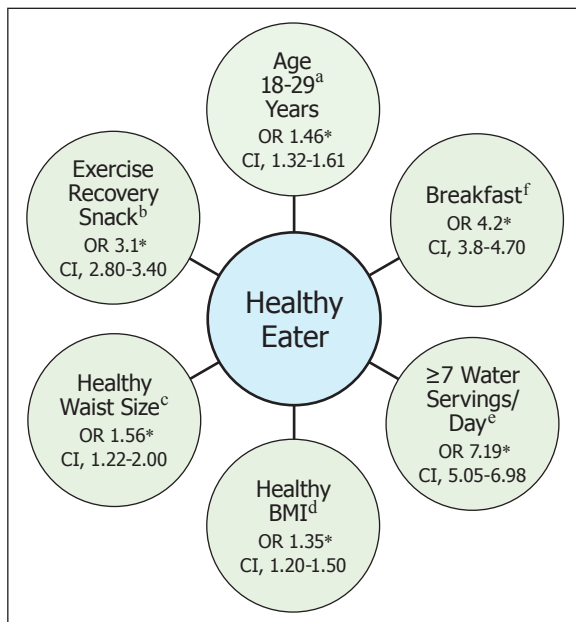


Figure 2. Relative odds of being in the highest HES-5 quartile versus the lowest HES-5 quartile for several indicators. High HES-5 is defined as a total  $\geq 20$  out of 25 or above the 75th percentile; a low HES-5 received a score of 12 or below (lower 25th percentile).

\* $P<.003$ . All reported odds ratios are independent and did not control for other factors.

<sup>a</sup>Reference group: 30 years or older.

<sup>b</sup>Reference group: those who did not regularly consume a recovery snack.

<sup>c</sup>Reference group: waist circumference larger than 35 in for women; larger than 40 in for men.

<sup>d</sup>Reference group: greater than 27.5 kg/m<sup>2</sup>.

<sup>e</sup>Reference group: consumption of 6 or less glasses of water per day.

<sup>f</sup>Reference group: consumption of breakfast 5 or less times per week.

The DS intake data are shown in Figure 3. Many respondents (40%) reported regular use of health-promoting supplements such as a multivitamin/mineral. Soldiers who reported taking a health-promoting supplement at least once a week were more likely to be in the top HES-5 quartile than those who did not. Similarly, those who took an omega-3 fatty acid supplement once a week and a protein supplement at least once a week had greater odds of being in the top HES-5 quartile than Soldiers who did not take these supplements. Soldiers who reported taking a performance-enhancing or bodybuilding product (other than a protein powder) at least once a week were 2 times as likely to be in the top HES-5 quartile when compared to those who did not take these

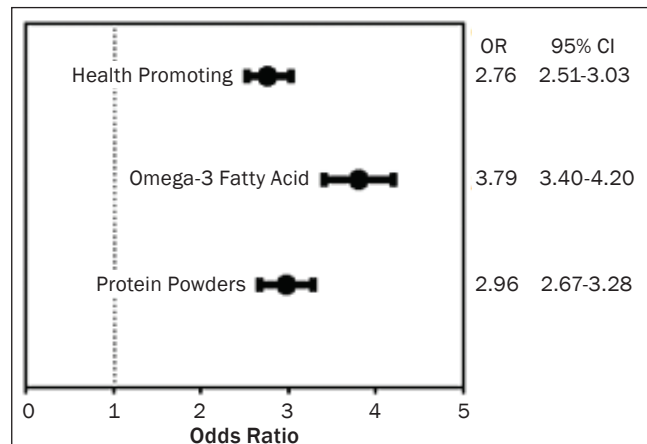


Figure 3. Dietary Supplements. The relative odds of having a high HES-5 and taking a supplement at least once a week (versus less than once a month or never), when compared to low HES-5. All categories are dichotomous. High HES-5 is defined as a total  $\geq 20$  out of 25; a low HES-5 received a score of 12 or lower ( $P<.003$ ).



products (OR 2.06; 95% CI, 1.82-2.32;  $P < .001$ ). Approximately one-fifth (21%) of the total population reported taking all 3 supplements (health-promoting, omega-3, and protein powder), and the majority of this group was classified as being in the highest HES-5 quartile. Soldiers who consumed all three of these supplements experienced 4 times the odds of being in the highest HES-5 group versus the lowest HES-5 group when compared with those who did not consume all 3 supplements (OR 4.04; 95% CI, 3.56-4.60).

Other Lifestyle Behaviors

Approximately 60% of respondents drank regular and/or diet sodas, and 23.1% of respondents reported binge drinking, as defined by exceeding 5 alcoholic drinks on any single occasion during the previous 3 months. Both behaviors were significantly associated with membership in high/low HES-5 quartiles. Soldiers who consumed diet or regular soda (OR 0.56; 95% CI, 0.51-0.61;  $P < .001$ ) were less likely to be in the highest HES-5 quartile than those who did not consume soda. Soldiers who self-reported binge drinking were less likely to be in the highest HES-5 quartile than Soldiers who did not binge drink (OR 0.57; 95% CI, 0.51-0.64;  $P < .001$ ).

Sleep was also related to a Soldier’s likelihood of being in the highest or lowest HES-5 quartile. When compared to “poor” sleepers (defined as 5 or more on the PIRS-2), Soldiers who were classified as “good” sleepers had 4 times the odds of being in the highest HES-5 quartile (OR 4.38; 95% CI, 3.85-4.98;  $P < .001$ ).

A relationship between self-reported health status and being a “healthiest” or “least healthy” eater was also observed. Respondents who considered their health to be “good” or “excellent” had 3 times the odds of being in the highest HES-5 quartile when compared to respondents whose health was “fair” or “poor” (OR 3.37; 95% CI, 2.98-3.82;  $P < .001$ ).

Physical Activity

Respondents’ self-reported frequency of physical activity and its results were analyzed based on the American College of Sports Medicine and Centers for Disease Control and Prevention exercise recommendations. A total of 28.5% of respondents met cardiovascular recommendations, 66.8% met strength-training recommendations, 86.3% passed their APFT overall, and 20.5% passed their APFT in the top quartile. Figure 4 illustrates for each HES-5 quartile the percentage of respondents who met the physical activity

recommendations as well as the number of respondents who passed their APFT in the top quartile.

When compared to Soldiers who did not meet physical activity recommendations, those who engaged in cardiovascular exercise for at least 20 minutes, 5 days per week were more likely to be in the highest than the lowest HES quartile (OR 3.23; 95% CI, 2.90-3.60;  $P < .001$ ), as were those who participated in resistance training at least 2 days per week (OR 3.60; 95% CI, 3.24-3.99;  $P < .001$ ).

Finally, we compared the likelihood of being in the HES-5 high/low quartile among Soldiers who failed their APFT and those who passed in the highest quartile. Those who passed their APFT in the highest quartile had more than twice the odds of being in the highest HES quartile versus the lowest HES quartile when compared to those who failed their APFT ([ $n=3,413$ ] OR 2.53; 95% CI, 2.08-3.08;  $P < .001$ ).

Healthy Eating Score and GAT Dimensions

Figure 5 characterizes the percentage of respondents who scored in the top quartile of the CSF2

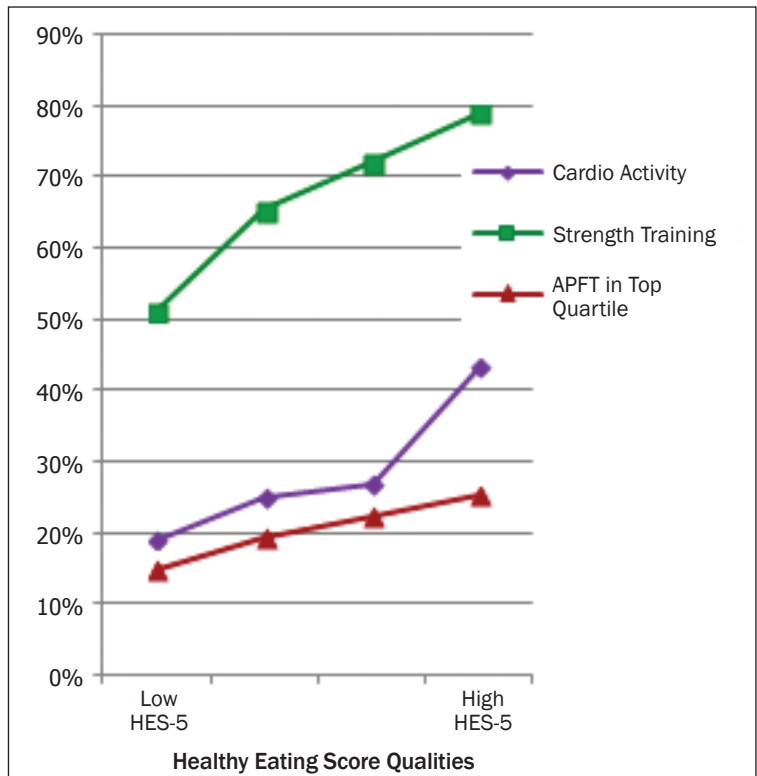


Figure 4. Physical fitness and nutrition. Percentage of Soldiers in each HES-5 quartile who met the Center for Disease Control and the American College of Sports Medicine recommendations for cardiovascular exercise and resistance training or passed the Army Physical Fitness Test (APFT) in the Top Quartile.

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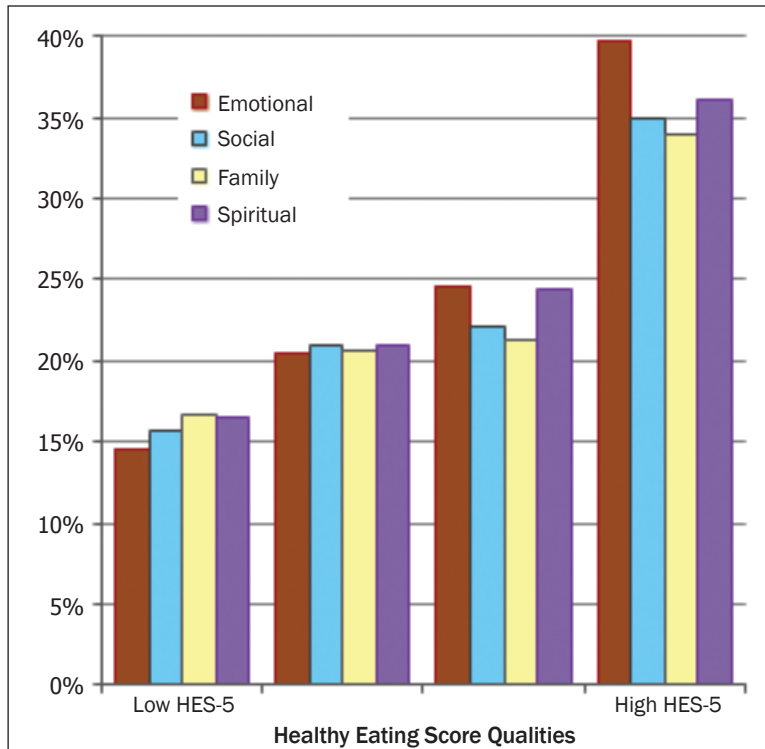


Figure 5. Global Assessment Tool (GAT) Fitness Dimensions and Nutrition. Percentage of each HES-5 quartile scoring in the highest quartile of the GAT psychological dimensions.

dimensions—emotional, social, family, and spiritual—in each of the HES-5 quartiles. High GAT dimension scorers were significantly more likely to be high HES-5 scorers:

- ▶ Emotional Fitness: OR 7.03; 95% CI, 6.08-8.13 (n=3,688)
- ▶ Social Fitness: OR 4.72; 95% CI, 4.10-5.44 (n=3,698)
- ▶ Family Fitness: OR 2.99; 95% CI, 2.99-2.59 (n=3,222)
- ▶ Spiritual Fitness: OR, 4.16; 95% CI, 3.65-4.75 (n=4,046)

### COMMENT

Poor nutritional/dietary habits degrade mission readiness while contributing to other health disorders<sup>9</sup> and affect all domains of performance. Nutrition is thus deemed an essential component of Total Force Fitness.<sup>45</sup> Accordingly, dietary behavior assessment questions were included in the new GAT physical dimension along with other lifestyle questions relating to performance. This study characterized nutritional behaviors of 13,858 Soldiers and examined their interrelationships with other lifestyle behaviors. We showed that dietary behaviors could be characterized by the HES-5. The HES-5 was strongly associated with a number of

health-promoting nutritional behaviors: those with healthier BMIs and waist circumferences, who performed better on the APFT, and who had better psychosocial profiles were also more likely to have the highest HES-5 scores.

Although the beneficial effects of fruit and vegetable consumption are well known, only 38.7% of participants met fruit intake recommendations, and 22.2% met vegetable recommendations. These findings are consistent with health behavior studies reporting suboptimal fruit and vegetable intake in military personnel.<sup>18,19</sup> Even fewer Soldiers met the guidelines of eating at least 3 servings per day of whole grains (16.8%) and dairy (17.3%). Importantly, a higher percentage (46.6%) met the recommendation of at least 2-3 weekly servings of fish, which may reflect the Warriors' focus on tuna as a quick, inexpensive protein. Although it will require further exploration, this is a reasonable hypothesis. Our sample did report higher intakes of key food groups than were noted in the 2011 Health Related Behaviors Survey of Active Duty Military Personnel<sup>18</sup> where only 12.9%, 11.2% and 12.7% of all military personnel met the intake guidelines for vegetables, fruit,

and whole grains, respectively. Of interest is why the percentage of Soldiers meeting the recommendations is higher in the present study than in previous survey findings. This could be related to differences in assessment tools, sample population differences, or ongoing and emerging DoD and Army initiatives targeting nutritional fitness. Further study might reveal the differential effect of these varying campaigns on health outcomes among the military services.

The HES-5 was created to assess overall nutrition. In our military population, high HES-5 scores were strongly associated with a number of key health promoting nutritional behaviors. Those who consumed breakfast at least 6 times per week, 2 snacks daily, 7 or more servings of water daily, and a snack within 60 minutes of strenuous exercise were more likely to have high HES-5 scores than Soldiers who did not consume breakfast, adequate water, or recovery snacks. These behaviors have been shown to influence health and performance. Studies have shown that consumption of breakfast and snacks is associated with lower stress, improved cognitive function, and fewer injuries and accidents at work,<sup>46</sup> along with lower values for BMI and waist circumference.<sup>47</sup> Consistent with those findings, Soldiers with a healthy BMI and with a healthy waist circumference were more likely to have high HES-5 scores than

those with an unhealthy BMI and waist circumference. Furthermore, Deshmukh-Taskar et al<sup>48</sup> indicated that breakfast consumption was associated with more favorable cardiometabolic risk profiles than skipping breakfast. Additionally, carbohydrates, a usual constituent of snacks and meals, enhanced physical and cognitive performance in Soldiers engaged in sustained and intense physical activities.<sup>4,5</sup> Together, these findings demonstrate the influence of dietary behaviors on multiple aspects of health and performance.

Critical components of performance are hydration, (re-) fueling, and recovery. Adequate hydration plays a key role in physical performance, particularly in the heat,<sup>49,50</sup> and those with high HES-5 scores were much more likely to consume recommended amounts of water. Likewise, proper fueling and adequate sleep and rest are essential.<sup>51-56</sup> Res et al<sup>53</sup> found that protein consumption prior to sleep improved physical recovery after training. Thus, appropriate nutrient timing, such as consuming a postworkout snack, can improve performance, delay fatigue,<sup>6,57</sup> refuel depleted muscular energy stores,<sup>6,51</sup> accelerate recovery, decrease muscle soreness following prolonged exercise training, and may positively effect health outcomes.<sup>58</sup> Additional benefits of regular nutrient timing include improved morale, stimulation of muscle protein synthesis, and protection against training injuries.<sup>51,58</sup> It appears that Soldiers may understand this concept in that those who consumed a snack within a short time after strenuous training were also more likely to have high HES-5 scores. More effort should be focused on making this simple nutritional strategy known and ensuring appropriate recovery meals are available.

One question and component of the HES-5 related to the frequency of fish intake, in particular, to fish containing omega-3 fatty acids, such as salmon, tuna, and mackerel. Research has suggested that omega-3 fatty acids may be cardioprotective,<sup>59</sup> and the Food and Drug Administration announced in October 2000 a qualified health claim for dietary supplements containing omega-3 fatty acids and reduced risk of CHD.<sup>60</sup> Omega-3s also appear to serve an important role in brain health.<sup>3,61,62</sup> Specifically, Kang and Gleason<sup>61</sup> concluded that increasing omega-3 intake may be one way to manage depression. Levant et al<sup>62</sup> reported that omega-3 fatty acids may regulate neurobiological substrates of depression, including serotonergic and dopaminergic transmission and the expression of brain-derived neurotrophic factors in the hippocampus. Johnston et al<sup>63</sup> reported that blood levels of omega-3 were significantly below what is considered optimal in a sample of deployed Soldiers with mild depression. Although data are somewhat inconsistent

regarding the benefits of omega-3s for brain/mental health,<sup>64</sup> continuing assessment of this nutrient will help inform targeted strategies and interventions designed to improve cognitive performance, mood, and general brain health. Noteworthy is that in addition to a large proportion meeting the US Dietary Guidelines for fish, 33.3% of study participants reported weekly intake of an omega-3 supplement. Whether this level of intake reflects the widespread discussion of omega-3s throughout the DoD remains to be determined.

Beverage intake, particularly with regard to sodas, is a key dietary behavior that can influence energy balance and consequently, BMI and waist circumference. Of note, those who avoided drinking either diet or regular sodas were more likely to have high HES-5. Sugary beverages likely contribute to excess energy consumption and increased obesity,<sup>65</sup> decreased satiety,<sup>66</sup> and increased risk of developing type 2 diabetes and heart disease.<sup>67-69</sup> Whereas artificial sweeteners may impair neural appetite regulation mechanisms, data also suggest that prolonged consumption may lead to increased body weight, obesity, and metabolic syndrome.<sup>70-72</sup> Interestingly, in our study, 65.8% of those with an unhealthy waist circumference consumed either diet or regular sodas compared to only 34.2% of those who consumed neither type of soda beverage. Clearly, beverage intake behaviors are important to consider with regard to healthy body mass and health. Further investigations into how these dietary behaviors contribute to health and performance could inform the development of targeted campaigns and educational strategies to enhance positive dietary behaviors.

Dietary supplement use by military members is high,<sup>9,73,74</sup> and supplements are universally available at the commissaries and exchanges of all military installations, as well as at convenience and package stores, retail stores, and some fitness centers. Approximately 40% of our respondents reported regular multivitamin use, which is similar to the 2011 Health Related Behaviors Survey of Active Duty Military Personnel<sup>18</sup> where 37.2% of military personnel reported daily use. In addition, those who took one or more supplements per week (health-promoting, omega-3 fatty acids, and protein powders) were also more likely to have high HES-5 than those who did not. Although we cannot determine the motivation for supplement use in this population, previous research suggests individuals consumed supplements to improve or maintain overall health.<sup>75</sup> Supplement users also tended to have lower BMIs, frequent physical activity, and moderate alcohol intake, all of which are reflected in our research population.

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Most supplement users received their vitamins and minerals from food alone when compared to nonusers.<sup>76,77</sup> Our research showed the majority of persons using health-promoting supplements were also the healthiest eaters. Therefore, one important message to disseminate throughout the Army is that supplements should not replace or make up for a poor quality diet. Unfortunately, popular media cater to Warfighters by claiming such products will enhance performance, maximize muscle strength, and build muscle. This is a particular concern given the many manufacturing violations found in half of the firms inspected during the US Food and Drug Administration investigation.<sup>78</sup> An ongoing DoD initiative, Operation Supplement Safety, informs providers and Warfighters about safe supplement use.

Due to the diverse environments and extreme physical demands of military service, Warfighters must maintain a higher level of physical fitness and greater physical work capacity than the civilian population.<sup>79</sup> In particular, lower levels of cardiovascular fitness, as measured by run times, have been consistently and strongly associated with injury risk in both military men and women.<sup>80,81</sup> In this study, Soldiers who met aerobic exercise recommendations had more than 3 times the odds of being the healthiest eater than those who did not. Further, those who met the strength training recommendations had similar odds of being a healthy eater. Importantly, Soldiers who passed their APFT in the top quartile of those who passed were also more likely to be in the top HES-5 quartile than those who failed their APFT. The APFT measures fitness components twice a year and ensures our Soldiers are prepared to meet the physical demands of the mission and minimize the likelihood of injury.<sup>79,82</sup> The relationship between nutrition and exercise may be bidirectional. Brodney et al<sup>83</sup> studied physically fit and unfit men and women and subsequently reported that those with higher fitness levels consumed diets that were closer to meeting national dietary recommendations than the diets of their lesser fit peers. Of key concern to a military population is sufficient dietary intake that supports energy expenditure of sustained physical activity.

Strong associations between high HES-5 and GAT emotional, social, family, and spiritual dimension scores were found. Those in the top quartiles for these GAT dimensions were significantly more likely to score in the highest HES-5 quartile. These findings highlight the holistic complexity of human performance and are consistent with previous reports suggesting that optimal nutritional fitness can assist in enhancing multiple CSF dimensions.<sup>1,51,52,54-56</sup>

Several limitations exist with this study. First, although the sample size is large, the data are self-reported. The limitations of using self-reported data are well documented: respondents tend to under-report weight and over-report height<sup>84</sup> and waist circumference,<sup>85</sup> and they also misreport their physical activity.<sup>86</sup> Secondly, individuals who chose to have their data used for research purposes may have different characteristics than those who did not, which may affect the ability to generalize these results. Next, the relationships between HES-5 and scores on emotional, social, family, and spiritual fitness are not sufficiently granular to characterize specific dimension components. Further research is needed to clarify the contribution of dietary behaviors to emotional, social, family, and spiritual fitness. All of the logistic regression analyses examined the relationship between HES-5 and only one other variable at a time. Future analyses should utilize multivariate modeling to determine the relative importance of these predictors. Finally, due to limited question number, the HES-5 included only 5 components of the diet, unlike the HEI-2005 which encompasses 12 items.<sup>31</sup> Future studies should consider additional dietary patterns.

In summary, the relationship of dietary behaviors and multiple domains of human performance within the context of overall lifestyle habits and psychosocial health in a military population were examined. We found that the HES-5 is a useful index with which to characterize eating behaviors in a military population and that healthy eaters were more likely to engage in a constellation of appropriate dietary and activity behaviors and more likely to score well on the APFT.

### RELEVANCE TO PERFORMANCE TRIAD

The Performance Triad components—nutrition, sleep, and activity—are intricately interrelated. An exquisite interplay exists between them: (1) sleep quality (and duration) affects nutrition through alterations in metabolism, cognitive decrements, and appetite<sup>4,53,87-90</sup>; (2) nutrition affects sleep,<sup>4,91,84,85</sup> physical performance, recovery and fatigue<sup>51-56</sup>; and (3) physical fitness affects appetite mechanisms, social health, sleep, cognitive performance, and mood.<sup>79,92-96</sup> A recent review<sup>96</sup> hypothesized that eating behavior and physical activity may share a common neurocognitive link since active individuals have an improved regulation of hunger and satiety mechanisms. Clearly, these relationships are critical to optimize health and performance and should be investigated and promoted as a holistic system. This study provides data regarding differences in nutrition behaviors and other lifestyle habits that highlight the need to provide education regarding the positive performance

benefits of good dietary behaviors and to provide targeted resources for ensuring optimal nutrition. The HES-5 may be a useful index for characterizing dietary intake behaviors and would be a valuable index with which to measure nutrition behaviors in future Performance Triad interventions.

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## NUTRITION AS A COMPONENT OF THE PERFORMANCE TRIAD: HOW HEALTHY EATING BEHAVIORS CONTRIBUTE TO SOLDIER PERFORMANCE AND MILITARY READINESS

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# The Importance of Leadership in Soldiers' Nutritional Behaviors: Results from the Soldier Fueling Initiative Program Evaluation

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## ABSTRACT

**Introduction:** Improving Soldiers' nutritional habits continues to be a concern of the US Army, especially amidst increasing obesity and high injury rates. This study examines leadership influence on nutritional behaviors within the context of the Soldier Fueling Initiative, a program providing nutrition education and improved dining facility menus to Soldiers in Basic Combat Training (BCT) and Advanced Individual Training (AIT).

**Methods:** A mixed methods design using surveys (N=486) and focus groups (N=112) was used to collect data at Fort Jackson, SC, and Fort Eustis, VA, in 2011.

**Results:** Survey results showed 75% of Soldiers in BCT believed their drill sergeant was helpful in making performance-enhancing food choices, and 86% agreed their drill sergeant believed it is important to eat for performance. Soldiers in AIT perceived their cadre as less helpful than their BCT drill sergeants and agreed less frequently that the AIT cadre believed it was important to eat for performance ( $P<.05$ ). These measures of leader influence were significantly associated with nutritional attitudes and behaviors in both BCT and AIT.

Focus groups revealed 5 key themes related to cadre influence and nutrition behavior (listed in order of most to least frequent): (1) cadre influence food choices through consequences related to selection, (2) cadre teach Soldiers how to eat, (3) cadre rush Soldiers to eat quickly to return to training, (4) cadre influence choice through example but often do not make healthy choices, and (5) cadre have no influence on food choices.

**Comment:** Leaders influence most Soldiers' nutrition practices within the training environment, particularly within BCT. Given that leader influence can impact Soldiers' attitudes and behaviors, it is critical that military leaders become knowledgeable about optimal nutrition practices to disseminate appropriate information to their Soldiers, avoid reprimand associated with trainees' food choices, reinforce key messages associated with nutrition programming, and lead by example in their own food choices.

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## NUTRITIONAL DEFICIENCIES IN THE TRAINING ENVIRONMENT

Unhealthy eating habits and nutritional deficiencies are an increasing concern among Army personnel. Current literature shows that poor nutrition can affect susceptibility to injury and affect the Soldiers' ability to carry out their missions.<sup>1-4</sup> Overweight or obesity status, which may result from poor nutrition, degrades combat readiness because it puts Soldiers at risk for attrition, for other health problems, and has also increased the number of recruits who are ineligible to serve because of their body fat composition.<sup>5</sup>

According to the 2008 Survey of Health Related Behaviors for military personnel, only 17% of women and 14% of men reported consuming the USDA-recommended

servings of fruits and vegetables per day.<sup>6</sup> This mirrors the general population of the United States: fewer than 25% of Americans eat fruits and vegetables 5 or more times per day.<sup>7</sup> This suggests the majority of military personnel are not consuming the recommended nutrients for the average adult.<sup>8</sup>

Furthermore, Soldiers usually require increased dietary energy intake, especially during training as they maintain high levels of physical activity.<sup>1</sup> Soldiers expending more energy than they consume have a negative energy balance which results in chronic undernourishment.<sup>9</sup> This is a concern because a diet lacking critical nutrients has a negative effect on health, injury, physical performance, and recovery from illness.<sup>1,9-11</sup> For example, Wentz et al found that insufficient nutrient intake and

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chronic undernourishment were linked to increased rates of stress fractures in military recruits.<sup>4</sup>

Poor nutrition can also cause Soldiers to become overweight or obese. Approximately 51% to 61% of military personnel are overweight, and 12% are classified as obese.<sup>12</sup> Soldiers are required to maintain weight-for-height standards and to remain below a certain body fat percentage. There are reports of Soldiers using unhealthy means such as laxatives or sauna/rubber suits to meet those weight standards and avoid attrition based on body fat status.<sup>5</sup> Overweight and less fit individuals also take longer to acclimatize to heat and are less tolerant of heat, which can affect mission readiness in hot climates.<sup>13</sup>

### THE SOLDIER FUELING INITIATIVE

The Soldier Fueling Initiative (SFI) was designed to establish a fueling standard in initial military training (IMT) and improve Soldiers' nutritional status. The SFI encompasses Department of Defense nutritional standards, performance nutrition education, menu development, and preparation and serving standards in order to optimize IMT Soldier fitness and performance.<sup>14</sup> The program includes 2 primary areas of implementation: Food Service Operations and Performance Nutrition Education.

The food service operation component of SFI consists of Go for Green labeling, performance-focused dining facility (DFAC) menus, and Fit Pick vending within Advanced Individual Training (AIT). Go for Green labeling is a nutritional recognition tool that provides point-of-decision prompts and allows Soldiers to make quick assessments of the menu options as they move through the food lines. Food items labeled in green are considered to be high performance and should be eaten often; items labeled in amber are moderate performance foods that should be eaten occasionally, and items labeled in red are performance-limiting and should only be consumed on rare occasions.<sup>14</sup>

The performance nutrition education component consists of a one-hour training course within the first 2 weeks of basic combat training (BCT). During this course, Soldiers receive information on the importance of eating for performance, utilizing the Go for Green labels in DFACs, and understanding how their bodies use food for fuel. The course, presented in a lecture format, is typically conducted by a drill sergeant or other cadre member. As a part of nutrition education, leaders receive SFI training on nutrition fundamentals, appropriate nutrition messaging, and instructing the trainees' nutrition education course.

### LEADER AND PEER INFLUENCE ON HEALTH BEHAVIORS

Throughout this article, the term "leader" refers to drill sergeants in BCT and to cadre members in AIT. Leaders are included in the SFI program delivery because leader and peer influence has the potential to play a role in improving the nutritional status of new recruits. The social ecological model (SEM) asserts that multiple levels of influence (individual, interpersonal, organizational, community, and policy) affect health behaviors.<sup>15</sup> Interpersonal relationships, such as those with family, friends, and teachers, play a role in shaping one's health behaviors. Bandura's Social Cognitive Theory (SCT) also proposes that learning and behavior change occur through interactions with an individual's social environment.<sup>16,17</sup> One construct of SCT is observational learning, whereby people observe a behavior and then replicate it. Studies have also shown that this type of modeling is more effective when the observers consider the models to be similar to themselves.<sup>18</sup>

Health promotion programs frequently use opinion leaders to affect behavior change, and programs that use peer opinion leaders are generally more effective than those that do not.<sup>19</sup> This type of influence has been used in church-based health promotion studies in which pastors communicate health messages to their congregants.<sup>20-22</sup> Similarly, in the case of new Army recruits, a drill sergeant or other peers may serve as opinion leaders and role models that influence eating habits. In Glover and colleagues' study, drill sergeant candidates stated that mentorship and role modeling were an important part of training new recruits.<sup>23</sup> These leaders believe they have a strong influence on BCT Soldiers and try to lead by example. With regard to nutrition, drill sergeants stated they avoid eating unhealthy foods in front of Soldiers.<sup>23</sup>

### SOLDIER FUELING INITIATIVE PROGRAM EVALUATION OVERVIEW

In 2011, the Army Institute of Public Health (AIPH), in collaboration with the IMT Center of Excellence (CoE), initiated a program evaluation of the SFI. The purposes of the SFI program evaluation were to better understand influences of Soldiers' nutrition within the training environment, determine effectiveness and reception of program components, provide strategies for program improvement, and inform subsequent phases of the SFI evaluation. The evaluation was guided by 6 primary evaluation questions:

1. What do Soldiers eat in IMT, and what guides their food choices?
2. What is the reach (use and awareness) of the SFI?

3. Is the SFI implemented as intended?
4. What are Soldier perceptions regarding the SFI?
5. What is the SFI's effect on nutrition knowledge, perceptions regarding eating for performance, and eating habits?
6. To what extent might any healthy behaviors obtained in IMT be sustained?

A subelement of evaluation Question 1 included a specific examination of leader influence on trainees' nutrition behaviors. Specifically, the evaluation team assessed the following:

- ▶ To what extent are Army leaders helpful or unhelpful in making performance-enhancing food selections?
- ▶ To what extent do Soldiers perceive that leaders think it is important to eat for performance?
- ▶ What effect do leaders have on Soldiers' food selection?
- ▶ How does leader influence on nutrition practices vary across different phases of Army training?

To date, no studies have specifically examined how trainees' perceptions of their leaders affect their nutritional attitudes and behavior in IMT, either positively or negatively. Given the potential for leaders to serve as an influence on nutrition practices, it is critical to understand how, if at all, training leaders help their Soldiers choose healthy, performance-oriented foods or hinder them from making such choices.

**METHODS**

Prior to data collection, both the US Army Public Health Command Public Health Review Board and the Center for Accessions Research Institutional Review Board (IRB) reviewed and approved this evaluation. The study used both quantitative (survey) and qualitative (focus group) methods among Soldiers in BCT and AIT. A mixed methods design combining both quantitative and qualitative methods is beneficial because it leads to more robust data than a singular method.<sup>24,25</sup>

**Power Analyses**

The IMT CoE Experimentation and Analysis Element identified 6 companies of Soldiers at Fort Jackson, SC, and 2 companies of Soldiers at Fort Eustis, VA, to participate in the evaluation. The IMT CoE established operational orders to facilitate data collection during October thru November 2011. A total of 598 Soldiers (319 BCT Soldiers and 279 AIT Soldiers) participated in the

evaluation. The IRB waived written consent for surveys because consent forms would have been the only record of study participation; however, Soldiers were given a consent briefing prior to data collection and were informed that their participation was completely voluntary. Soldiers within the focus groups provided written informed consent. Table 1 provides an overview of how the sample participated in data collection efforts. All BCT surveys (n=247) were administered to Soldiers at Fort Jackson in October 2011. The AIT surveys were administered at Fort Eustis (November 2011, n=239) where the SFI had recently been implemented. A priori power analyses revealed this sample was of sufficient size to detect small to moderate effects between groups. The AIPH team also conducted focus groups (methodology described below) with a convenience sample of BCT Soldiers (n=72) and AIT Soldiers (n=40) at Fort Jackson in October 2011.

	Data source	
	Surveys (N=486)	Focus Groups (N=112)
Basic Combat Training (N=319)		
All Soldiers from 3 companies at Fort Jackson, SC	n=247	
Sample of Soldiers from 1 company at Fort Jackson, SC		n=72
Advanced Individual Training (N=279)		
All Soldiers from 2 companies at Fort Eustis, VA	n=239	
Sample of Soldiers from 2 companies at Fort Jackson, SC		n=40

**Survey Methods**

The AIPH team distributed anonymous short paper questionnaires to Soldiers in both BCT and AIT. Response rates for the participating companies were nearly 100% (likely because leaders encouraged Soldiers to participate), surveys were short (less than 10 minutes to complete), data collection was anonymous, and the topic was low- to no-risk. The questionnaires asked about a variety of constructs including demographics; use and perceived helpfulness of various SFI program components (eg, Go for Green labels, nutrition education); changes in weight, lean muscle mass, physical performance, and mental performance over time; nutrition behaviors (eg, frequency of eating lean protein, fruits, vegetables, low fat dairy); and general attitudes about nutrition and eating for performance. The surveys also contained questions designed to assess Soldiers' perceived level of leader helpfulness (1=not at all helpful, 5=very helpful) in making performance-enhancing food choices and the extent to which Soldiers agreed that IMT leaders believed it was important to eat for performance (1=strongly disagree, 5=strongly agree).

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### Focus Group Methods

The evaluation team conducted 6 BCT focus groups based on strata by gender (male and female) and performance (high, average, and low performance based on physical fitness test scores). The team conducted 4 AIT focus groups on gender strata only (ie, 2 groups of men, 2 groups of women).

The structured focus groups assessed Soldiers' experiences within the dining facilities, SFI effect on eating behavior, barriers to SFI implementation, and suggestions for program improvement. The BCT and AIT focus group guides consisted of 10 open-ended questions each. To specifically gauge how leaders affected their nutrition behaviors, moderators asked participants, "how do Army cadre influence your eating?"

A trained AIPH facilitator led each focus group, and a note-taker took extensive notes throughout the session. Each focus group was audio-recorded. Before the focus group or interview began, the facilitator explained the purpose and procedure of the focus group, encouraged open discussion within the group, informed the participants that their participation and comments would remain anonymous, and asked for verbal consent to audio-record the session. Subcontractors transcribed the focus groups' audio recordings verbatim and omitted any identifying information.

### Data Analyses

All survey data were managed and analyzed using the IBM SPSS Statistics (V 21.0) application (IBM Corp, Chicago, IL). The analysis team generated frequencies and descriptive statistics on perceived leader helpfulness and Soldiers' level of agreement that leaders believe it is important to eat for performance. Chi square and independent *t* tests were used to examine differences in these measures between BCT and AIT Soldiers. Measures of leader influence were then additionally correlated with other constructs of interest in the evaluation, listed in Table 2, by means of Pearson product-moment correlations. Type I error rates (*P* values) of .05 or lower designated statistically significant relationships for all analyses.

The AIPH qualitative analysis group, which consisted of three, 2-analyst teams, used NVivo 9 qualitative data analysis software (QSR International Proprietary Ltd, Doncaster, Australia) for focus group data management and analysis. The analysis group used a team-based coding and constant-comparison approach, which consists of an iterative process of revising the codebook to reflect emerging themes and applying the codes systematically across teams.<sup>26</sup> In order to achieve coding reliability, the

analysts of each team reviewed, discussed, and established consensus on each code, and each team reviewed the work of another team. The team then summarized results and extracted example quotes to illustrate each theme for reporting.

## RESULTS

### Survey Results

A total of 486 Soldiers completed the survey, of whom 398 (82%) were male, and 87 (18%) were female. The average age of respondents was  $21.3 \pm 4.5$  years. Additional survey sample demographics are included in Table 3.

Perceived helpfulness of leaders in making performance-enhancing food choices was significantly associated with Soldiers' level of agreement that their leader believed it was important to eat for performance in both BCT ( $r=0.343$ ,  $P<.01$ ) and AIT ( $r=0.470$ ,  $P<.01$ ). Although measures are correlated, moderate effect sizes indicate they are measures of two distinct concepts; therefore, results from each construct are reported independently.

### PERCEIVED LEADER HELPFULNESS OF IN MAKING PERFORMANCE-ENHANCING FOOD CHOICES

The majority of BCT Soldiers (75%) responded that their leader was somewhat or very helpful in choosing performance-enhancing foods while the majority of AIT Soldiers (56%) were neutral (Table 4). Observed differences between BCT and AIT were statistically significant ( $\chi^2=125.365$ ,  $df=4$ ,  $P<.0001$ ).

In both BCT and AIT, this perceived level of helpfulness was significantly associated with several constructs related to nutrition (Table 5). In BCT, as perceived helpfulness increased, frequency of use of Go for Green labels ( $r=0.173$ ,  $P<.001$ ), frequency of selecting performance-oriented food choices ( $r=0.169$ ,  $P<.001$ ), and positive attitude toward eating for performance ( $r=0.131$ ,  $P<.05$ ) also increased. In AIT, as perceived helpfulness increased, frequency of use of Go for Green labels ( $r=0.154$ ,  $P<.05$ ), frequency of selecting "green" items from the DFAC ( $r=0.135$ ,  $P<.05$ ), frequency of selecting performance-oriented food choices ( $r=0.255$ ,  $P<.05$ ), level of perceived knowledge about eating for physical performance ( $r=0.146$ ,  $P<.05$ ), level of perceived knowledge about eating for cognitive performance ( $r=0.178$ ,  $P<.001$ ), and positive attitude toward eating for performance ( $r=0.225$ ,  $P<.001$ ) also increased. Level of leader helpfulness was not associated with frequency of selecting green, amber, or red items from the DFAC in BCT or frequency of selection of amber, red, or performance-limiting foods in AIT.

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Table 2. Key Constructs of Interest Within the Soldier Fueling Initiative Program Evaluation.

Construct of Interest	Operationalization	Characteristics of Construct
Frequency of use of Go for Green labels in the DFAC	How frequently do you use "Go for Green" labeling when considering food choices in the DFAC? Responses: every meal (5); once a day (4); a few times a week (3); about once a week (2); never (1)	Higher score=higher frequency of use. Analyses run independently for BCT and AIT.
Frequency of selection of food with red labels, amber labels, and green labels in the DFAC	How frequently do you select each of the following in the DFAC? Food with green labels; food with amber labels; food with red labels Responses for each variable: 3+ times a day (5); 1-2 times a day (4); a few times per week (3); about once a week (2); rarely/never (1); I don't know (user missing)	Higher score=higher frequency of selection. Analyses run separately for each classification of labels. Analyses run independently for BCT and AIT.
Frequency of selecting performance-oriented food choices in BCT and AIT	Composite measure of the following items: How frequently do you select each of the following in the DFAC? Lean meats and proteins; low fat dairy; fruits (fresh, canned, dried); vegetables (hot line or salad bar) Responses for each variable: 3+ times a day (5); 1-2 times a day (4); a few times per week (3); about once a week (2); rarely/never (1); I don't know (user missing)	Responses summed across the 4 categories of foods (range: 4-20). Higher scores=Higher frequency of selection of performance-oriented choices. Cronbach $\alpha$ =0.572 for BCT and 0.680 for AIT. Analyses run independently for BCT and AIT.
Frequency of selecting performance-limiting food choices in AIT	Composite measure of the following items: How frequently do you select each of the following in the DFAC? Fried foods; sweets; snack foods; sugary drinks; energy drinks Responses for each variable: 3+ times a day (5); 1-2 times a day (4); a few times per week (3); about once a week (2); rarely/never (1); I don't know (user missing)	Responses summed across the 5 categories of foods (range: 5-25). Higher scores=Higher frequency of selection of performance-limiting choices in AIT. Cronbach $\alpha$ =0.689 for AIT. Analysis for AIT only.
Level of perceived knowledge regarding eating for performance	To what extent do you agree or disagree with each of the following statements? <ul style="list-style-type: none"> <li>➤ I know what to eat to optimize my cognitive performance.</li> <li>➤ I know what to eat to optimize my physical performance.</li> </ul> Strongly disagree (1); Disagree (2); Not sure (3); Agree (4); Strongly agree (5)	Analyses run independently for each category of knowledge. Analysis for AIT only.
Positive attitude toward eating for performance in BCT/AIT	Composite measure of the following items: To what extent do you agree or disagree with each of the following statements? <ul style="list-style-type: none"> <li>➤ I made a significant effort to eat for performance in BCT/AIT.</li> <li>➤ Eating quality foods is essential to optimal performance in BCT/AIT.</li> <li>➤ I will strive to eat for performance during my career as a Soldier.</li> <li>➤ In order to perform as a Soldier, I need to think like an athlete.</li> </ul> Strongly disagree (1); Disagree (2); Not sure (3); Agree (4); Strongly agree (5)	Responses summed across the 4 items (range: 5-20). Higher scores = Higher level of agreement with positive attitudes toward eating for performance in BCT or AIT. Cronbach $\alpha$ =0.698 for BCT and 0.804 for AIT.

**SOLDIERS' LEVEL OF AGREEMENT THAT LEADERS BELIEVE IT IS IMPORTANT TO EAT FOR PERFORMANCE**

Eighty-six percent of BCT Soldiers and 45% of AIT Soldiers agreed or strongly agreed with the statement that their leaders believe it is important to eat for performance (Table 4). Observed differences between BCT and AIT were statistically significant ( $\chi^2=146.445$ ,  $df=4$ ,  $P<.0001$ ). As level of agreement with this statement

increased, frequency of using Go for Green labels ( $r=0.276$ ,  $P<.001$ ), frequency of selecting "green" items from the DFAC ( $r=0.179$ ,  $P<.001$ ), frequency of selecting performance-oriented food choices ( $r=0.383$ ,  $P<.001$ ), and positive attitude toward eating for performance ( $r=0.268$ ,  $P<.001$ ) also increased in BCT (Table 5). Within AIT, as agreement with this statement increased, frequency of selecting performance-oriented food choices ( $r=0.235$ ,  $P<.001$ ), level of perceived

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Table 3. Demographic Characteristics of Soldier Fueling Initiative Program Evaluation Survey Sample in Basic Combat Training and Advanced Individual Training.

Characteristic	BCT N=247	AIT N=239	Total N=486
Gender [n(percentage of N)] <sup>a,b</sup>			
Male	170 (69.1%)	228 (95.4%)	398 (82.1%)
Female	76 (30.9%)	11 (4.6%)	87 (17.9%)
Age (mean±SD, year) <sup>c</sup>	21.9±4.92	20.7±3.96	21.3±4.50
Weight category [n(percentage of N)] <sup>b,d</sup>			
Underweight	1 (0.4%)	3 (1.3%)	4 (0.8%)
Normal weight	144 (59.3%)	171 (72.2%)	315 (65.6%)
Overweight	92 (37.9%)	58 (24.5%)	150 (31.3%)
Obese	6 (2.5%)	5 (2.1%)	11 (2.3%)
BMI [mean±SD, kg/m <sup>2</sup> ] <sup>e</sup>	24.4±2.56	23.7±3.00	24.0±2.81

a. Gender distribution differed significantly across BCT and AIT ( $\chi^2=55.15$ ,  $df=1$ ,  $P<.001$ )  
b. All percentages reported are valid percentages.  
c. Mean age differed significantly across BCT and AIT ( $t=2.7963$ ,  $df=479$ ,  $P<.01$ ).  
d. Weight category distribution differed significantly across BCT and AIT ( $\chi^2=11.04$ ,  $df=3$ ,  $P=.0115$ ); Category: underweight (BMI <18.5), normal weight (18.5-24.9), overweight (25.0-29.9), obese (>30.0).<sup>27</sup>  
e. Mean BMI differed significantly across BCT and AIT ( $t=2.7545$ ,  $df=478$ ,  $P<.01$ ).

knowledge about eating for physical performance ( $r=0.254$ ,  $P<.001$ ), level of perceived knowledge about eating for cognitive performance ( $r=0.263$ ,  $P<.001$ ), and positive attitude toward eating for performance ( $r=0.336$ ,  $P<.001$ ) also increased. Level of agreement with this statement was not associated with frequency of selecting amber or red items from the DFAC in BCT or frequency of use of Go for Green labels, frequency of selection of green, amber or red items from the DFAC, or frequency of selection of performance-limiting food choices in AIT.

**Focus Group Results**

Seventy-two Soldiers participated in the BCT focus groups, of whom 37 (51%) were male and 35 (49%) were female. Forty Soldiers participated in the AIT focus groups, and the proportion of men and women was equivalent.

Results of the 10 focus groups revealed 5 key themes related to leader influence on eating behavior within the training environment:

1. Leaders influence food choices through consequences related to selection.

Table 4. Frequency distribution of responses to the statements: "To what extent is your leader helpful or unhelpful in making performance-enhancing food choices?" (1=very unhelpful, 5=very helpful) and "My drill sergeant/cadre members believe(s) it's important to eat for performance." (1=strongly disagree, 5=strongly agree) (N=486).

	BCT (N=247) n (percentage of N) <sup>f</sup>	AIT (N=239) n (percentage of N) <sup>f</sup>	Total (N=486) n (percentage of N) <sup>f</sup>
Please rate the extent to which your leader <sup>a</sup> is helpful or unhelpful in making performance-oriented choices. <sup>b</sup>			
Very unhelpful	5 (2.1%)	28 (11.9%)	33 (6.9%)
Somewhat unhelpful	7 (2.9%)	15 (6.4%)	22 (4.6%)
Neutral	49 (20.2%)	132 (56.2%)	181 (37.9%)
Somewhat helpful	74 (30.5%)	38 (16.2%)	112 (23.4%)
Very helpful	108 (44.4%)	22 (9.4%)	130 (27.2%)
Mean ± SD <sup>c</sup>	4.12±0.967	3.05±1.04	3.59±1.138
Level of agreement or disagreement that leaders believe it is important to eat for performance. <sup>d</sup>			
Strongly disagree	1 (0.4%)	11 (4.6%)	12 (2.5%)
Disagree	6 (2.4%)	22 (9.3%)	28 (5.8%)
Not Sure	27 (11.0%)	98 (41.4%)	125 (25.9%)
Agree	62 (25.3%)	80 (33.8%)	142 (29.5%)
Strongly agree	149 (60.8%)	26 (11.0%)	175 (36.3%)
Mean±SD <sup>e</sup>	4.44±0.815	3.37±0.960	3.91±1.036

a. Leader refers to drill sergeants in the BCT survey and to cadre in the AIT survey.  
b. Level of helpfulness or unhelpfulness response distributions differed significantly across BCT and AIT ( $\chi^2=125.365$ ,  $df=4$ ,  $P<.0001$ ).  
c. Mean level of helpfulness differed significantly between BCT and AIT ( $t=11.6597$ ,  $df=476$ ,  $P<.0001$ ).  
d. Level of agreement or disagreement response distributions differed significantly across BCT and AIT ( $\chi^2=146.445$ ,  $df=4$ ,  $P<.0001$ ).  
e. Mean level of agreement differed significantly between BCT and AIT ( $t=13.2067$ ,  $df=480$ ,  $P<.0001$ ).  
f. All percentages reported are valid percentages.

2. Leaders teach Soldiers how to eat.
3. Leaders rush Soldiers to eat quickly in order to return to training.
4. Leaders influence choice through example but often do not make the healthy choice.
5. Leaders have no influence on food choices.

Table 6 provides an overview of the number of focus groups in which each theme emerged, the total number of times that Soldiers within the 10 groups made a comment consistent with each theme, and direct quotes that exemplify the theme.

When asked how leaders influenced their eating habits, Soldiers within 9 of the 10 focus groups made 25 references to having experienced negative consequences as a result of their food choices, including the amounts of food and the types of food they selected. The consequences included being forced to eat, being punished with physical activity (eg, doing push-ups), and psychological repercussions such as being made to feel guilty or humiliated. In all 10 of the focus groups, Soldiers mentioned their leaders taught them how to eat. Most (n=18) of the 19 references within this theme suggested cadre instructed the Soldiers to select the healthiest food options, except in one BCT group. In this instance the Soldier expressed his drill sergeant instructed him that it did not matter what he ate as long as he could keep up his physical performance. In all 6 of the BCT focus groups and one AIT focus group, Soldiers talked about their leaders rushing them to eat and finish their meals in a minimum amount of time. The Soldiers also discussed not having the time to taste their food or not being able to eat enough food in the allowed time period to keep them full until the next meal. Five of the Soldier focus groups referenced the fact that their leaders led by example but were not always effective role models for eating in the DFACs or eating healthy foods. A number of the Soldiers complained that cadre members would purchase fast food and eat it in front of the AIT and BCT Soldiers. Soldiers perceived this as hypocritical.

Soldiers in 3 groups made a total of 4 references that their leaders did not influence the way the Soldiers ate in

any capacity. These Soldiers stated that they were not concerned with repercussions and that they would eat whatever they wanted to eat regardless of what their cadre told them to do.

COMMENT

Although there were a few references in the focus groups that leaders do not affect eating practices, both survey and focus group results suggest BCT drill sergeants and AIT cadre influence most Soldiers' nutrition practices within IMT to some extent. Overall, two-thirds of the survey sample agreed or strongly agreed that their leaders believed it is important to eat for performance, and more than half reported their leaders were helpful or very helpful in making performance-enhancing food choices. This is consistent with past research in similar populations demonstrating leaders' influence on health behaviors (eg, among college athletes who look to trainers and coaches for nutrition information).<sup>28-30</sup> Focus group results suggest Soldiers find it particularly useful when cadre members teach them how and what to eat to optimize their performance, especially as it relates to the day's activities or the Army Physical Fitness Test (APFT). Various studies have used skill building as part of an intervention to improve dietary habits, and

Table 5. Pearson product-moment correlation coefficients of perceived level of leader<sup>a</sup> helpfulness in making performance-enhancing food choices and level of agreement that leaders believe it is important to eat for performance with various additional constructs of interest to the Soldier Fueling Initiative program evaluation.

	Perceived level of leader helpfulness in making performance-enhancing food choices		Level of agreement that leaders believe it is important to eat for performance	
	BCT N=247	AIT N=239	BCT N=247	AIT N=239
Frequency of using Go for Green labels	0.173 <sup>b</sup>	0.154 <sup>c</sup>	0.276 <sup>c</sup>	0.014
Frequency of selecting "green" items from the DFAC	0.100	0.135 <sup>c</sup>	0.179 <sup>c</sup>	0.115
Frequency of selecting "amber" items from the DFAC	-0.020	0.100	-0.008	0.100
Frequency of selecting "red" items from the DFAC	-0.035	0.096	-0.094	0.096
Frequency of selecting performance-oriented food choices	0.169 <sup>b</sup>	0.255 <sup>c</sup>	0.383 <sup>c</sup>	0.235 <sup>c</sup>
Frequency of selecting performance-limiting food choices		0.056		0.070
Level of perceived knowledge regarding eating for physical performance		0.146 <sup>c</sup>		0.254 <sup>c</sup>
Level of perceived knowledge regarding eating for cognitive performance		0.178 <sup>b</sup>		0.263 <sup>c</sup>
Attitude toward eating for performance in BCT or AIT	0.131 <sup>c</sup>	0.225 <sup>b</sup>	0.268 <sup>c</sup>	0.336 <sup>c</sup>

a. Leader refers to drill sergeants in the BCT survey and to cadre in the AIT survey.  
 b. Correlation is statistically significant at  $P < .001$ .  
 c. Correlation is statistically significant at  $P < .05$ .

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Table 6. Themes emerging from focus groups conducted with Initial Military Training Soldiers when asked, "How do Army cadre members influence your eating?"

Theme	Number of groups in which theme was mentioned (N=10)	Total number of references to the theme within the group	Examples of Soldier quotes for each theme
Leaders influence food choices through consequences related to selection	9	25	<p>... we get yelled at because we don't eat everything on our plate so that makes us eat a whole bunch more and stuff ourselves. BCT participant</p> <p>If they see certain people they'll heckle certain people in the cafeteria... They never tell us we can't eat anything, they're just going to make you feel like dirt. You know, "are you sure you should be eating that, fatty? You failed your PT and do you really need that?" BCT participant</p> <p>[My Drill Sergeant] figured 44 push-ups a person for one piece of cake. BCT participant</p>
Leaders teach Soldiers how to eat	10	19	<p>Even though they had to pay for meals, [the Drill Sergeants] would eat with us, and they would be like, 'You know, I see you getting that cheeseburger right there. You know you got a PT test coming up.' They would, you know, influence us drastically. AIT participant</p> <p>Now, in basic, I had a Drill Sergeant and he was really, really healthy, working out, eating healthy, and so, he told us kidney beans, wheat bread, stuff like that was healthier. AIT participant</p>
Leaders rush Soldiers to eat quickly in order to return to training	7	19	<p>Oh yeah. What they say, 'eat now, taste it later.' AIT participant</p> <p>...we'll go to sit down and even though we just sat down, he'll be like, "Alright you got three minutes to eat everything on your plate" when we just sat down with a full plate of food. BCT participant</p> <p>I believe the Drill Sergeants ... try to rush you out sometimes depending on what we got going so you won't get all of the food we would like to get. BCT participant</p> <p>They tell you, "You don't need to taste it. You can just throw it up and taste it later." BCT participant</p>
Leaders influence choice through example but often do not make the healthy choice	5	14	<p>I was riding with a Drill Sergeant the other day and I was with one of my battle buddies, they had to go somewhere, and the Drill Sergeant stopped by Taco Bell and I'm thinking to myself "What now?" BCT participant</p> <p>... why would you take advice from somebody that's picking on you and then brings you Burger King, orders Pizza Hut... Eating the chocolate cake... you know, it's kind of hypocritical. BCT participant</p> <p>I just hate the fact that they eat the stuff that we're supposedly not allowed to in front of us like Skittles. BCT participant</p>
Leaders have no influence on food choices	3	4	<p>I actually just learned to kind of ignore the Drill Sergeants when it comes to food because honestly they just give you a hard time. BCT participant</p> <p>The Drill Sergeants, they could say something, but unless it's physically something I can't eat, I'm going to eat it anyway. BCT participant</p>

these tangible skills may be more useful than knowledge alone.<sup>28,29</sup> Moreover, Bandura asserts, "Motivation is enhanced by helping people to see how habit changes are in their self-interest and the broader goals they value highly."<sup>17</sup> The IMT leaders are encouraged not only to educate their Soldiers on nutrition, but also to build skills regarding how to eat for performance and use motivational tactics to drive the desired behavior.<sup>31-33</sup>

Significant differences existed in Soldiers' perceptions of leader influence between BCT and AIT. Three times as many BCT Soldiers as AIT Soldiers reported their leaders were helpful or very helpful in making performance-enhancing food choices, and nearly twice as many BCT Soldiers as AIT Soldiers agreed that leaders believe it is important to eat for performance. While there are several potential explanations for this finding,



the disparity warrants additional research. Within BCT, drill sergeants are involved in instructing the Performance Nutrition Education course, which may increase the extent to which Soldiers perceive them as information brokers or resources related to nutrition information. Furthermore, Soldiers within BCT are under more direct supervision and may spend more time with their drill sergeants than Soldiers in AIT spend with their cadre because of the nature of the training type and phase of IMT.<sup>34</sup> The physical demands of BCT may also be higher than those of AIT, possibly influencing the extent to which BCT leaders emphasize the need to eat for performance or to consider the day's duties when making food choices. That said, proper nutrition is essential for cognitive performance in addition to physical performance.<sup>35-38</sup> Although the duties and demands of AIT may differ from those of BCT, it will be important for AIT cadre and military leaders who are responsible for Soldiers in more cognitively demanding roles to showcase the relationship between nutrition and the ability to perform intellectually as well as physically.

As levels of perceived helpfulness of leaders in making performance enhancing food choices and agreement that leaders believe it is important to eat for performance increased, so too did a variety of relevant SFI outcomes. For example, Soldiers who reported higher levels of leader helpfulness in making performance-enhancing food choices also reported higher frequency of use of Go for Green labels, higher frequency of selecting performance-oriented food choices, a greater positive attitude and commitment toward eating for performance, and higher levels of self-reported knowledge regarding what to eat for physical and cognitive performance. Correlation coefficients with these outcomes indicated small to moderate effect sizes suggesting that in addition to leader influence, there are other factors that affect nutritional attitudes and behavior. This is consistent with ecological models of health behavior which assert there are numerous influences to behavior.<sup>15</sup> Despite small to moderate effect sizes, these findings suggest if leaders develop strategies to improve their helpfulness in assisting Soldiers to make performance-enhancing choices and communicate to their Soldiers that they believe it is important to eat for performance, it could be expected that Soldiers will experience at least slight improvements in their nutritional attitudes and behaviors. Survey findings suggest leader influence is most relevant for positive behaviors (eg, frequency of use of Go for Green labels, frequency of selecting performance-enhancing choices, positive attitudes toward nutrition) and has no significant association with negative behaviors (eg, selecting "red" foods from the DFAC in BCT or AIT, selecting performance-limiting food selections

in AIT). In other words, data suggest that even as helpfulness and perceptions that eating for performance is important to their leaders increased, Soldiers' consumption of performance-limiting choices did not decrease. This sentiment was echoed in a few focus group quotes stating that Soldiers were going to eat what they wanted despite what their leaders said. Focus groups further revealed that the most common theme associated with cadre effect on nutrition was that military leaders often issue consequences associated with negative food choices within IMT, and BCT in particular. Previous literature suggests punishment in the form of ostracism may lead to negative emotional and psychological reactions which can impair one's ability to self-regulate and self-monitor, which are required elements for controlled eating.<sup>39</sup> Because positive role modelling may be a better method for improving diet than punishment or attempts to control another person's diet, IMT leaders should be cautioned against controlling choices or using punishment to guide Soldiers' food selection and, rather, should be encouraged to model and support desired behaviors.<sup>40</sup> Based on findings from this evaluation, this strategy is receiving increased emphasis within the IMT Drill Sergeants School.

Recent research reports drill sergeant candidates believe they are role models for Soldiers and try to avoid eating certain foods in front of their Soldiers.<sup>23</sup> Our findings suggest Soldiers perceive leaders are examples in the area of nutrition; however, Soldiers indicated that their leaders did not always serve as the most effective role models in this area. This may be further reflected by survey results indicating that nearly a third of Soldiers in IMT did not agree that their leaders believed it was important to eat for performance. There were several references to leaders going to fast food establishments, and some Soldiers commented that leaders were hypocritical regarding nutrition because they would eat the foods they told Soldiers not to eat. The importance of effective role models in observational learning is a key aspect of several health behavior theories, the Social Cognitive Theory in particular.<sup>17</sup> Therefore, leaders are encouraged to demonstrate positive nutrition practices for their Soldiers and to engage in the behaviors they want to see in their Soldiers.

Lastly, focus groups revealed that Soldiers in BCT were frequently rushed to consume as much food as possible in as short a period of time as possible in order to return to physical training. Studies of children and school lunches have shown that eating speed is related to the loss of control with regard to food intake as well as obesity.<sup>41</sup> Insufficient time allocated for meals may lead to overeating. The importance of physical training within

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IMT, and BCT in particular, is indisputable. However, it is equally important for Soldiers to develop positive nutritional practices and habits during training. Initial Military Training leaders must prepare Soldiers for future success by providing them with a reasonable amount of time in which to eat during BCT, as mealtime provides Soldiers with the opportunity to refuel for performance.

Conclusions from this study are limited because it used only self-report data at one point in time. No causal inferences can be made between any constructs of interest. The study used a convenience sample from only 2 locations (one BCT and one AIT) with a relatively small sample size, so results cannot be generalized to the entire training community or the military as a whole. Analyses did not control for demographic differences between BCT and AIT, and some constructs (eg, selection of performance-limiting choices, perceived level of knowledge regarding what to eat for physical and cognitive performance) were only measured on the AIT survey, so no comparisons could be made with BCT Soldiers.

To the best of our knowledge, this is the first study using a mixed-methods design to examine the influence of leadership on nutrition practices within the Army. Findings from this investigation suggest the need for additional study, particularly in the areas of variation in leader influence in different environments (eg, training versus operational), the effect of consequences for performance-limiting choices on food selection within the military, and the effectiveness of strategies designed to increase leaders' helpfulness and improve their attitudes regarding the importance of eating for performance in order to change not only their own behaviors and attitudes but those of their Soldiers as well.

### RELEVANCE TO THE PERFORMANCE TRIAD

The Army Performance Triad is designed to promote activity, nutrition, and sleep within the Army Family. This study suggests Army leaders have the potential to affect Soldiers' nutritional attitudes and behaviors and may be likely to influence activity and sleep behaviors as well. When designing and implementing strategies and tactics as part of the Performance Triad, Army leaders must be included as a target audience for program messaging (ie, an intervention group), and they could also be used as key opinion leaders to disseminate information and model positive behaviors for Soldiers.

### RECOMMENDATIONS

The Army should do the following to ensure leaders are prepared to support positive nutrition practices within the Triad:

- Provide up-to-date information to leaders so they are knowledgeable regarding healthy, performance-oriented nutrition practices. Previous research indicated some leaders are not as knowledgeable as they would like to be about nutrition.<sup>23</sup>
- Emphasize that leaders should demonstrate a personal commitment to positive habits because their Soldiers look to them as role models; it is important that leaders not only tell Soldiers what to do but also model that behavior themselves. Instruct leaders on how to be helpful to Soldiers with regard to nutrition, and provide them with tools and techniques (other than reprimand) to guide Soldiers to desired behaviors.

Leaders should do the following to optimize performance-oriented nutrition choices among their Soldiers:

- Deliver additional education in both AIT and in the operational environment to continue the momentum initiated in BCT, and help AIT and operational Soldiers understand how to eat for performance and sustain energy if their activities are less physically demanding than in BCT.
- Learn, remember, and reinforce key concepts associated with programming to send consistent messages; approach programming with a positive attitude.
- Routinely emphasize the importance of nutrition for both cognitive and physical performance.
- Lead by example by selecting healthy foods and modeling positive nutritional habits.
- Avoid reprimand and punishment associated with selections such as dessert or nutrient-poor foods; reinforce performance-oriented food choices instead.
- Offer specific suggestions to Soldiers about how best to eat for the day's activities.
- Assist Soldiers in making the connection between nutrition and outcomes that are meaningful to them (eg, APFT performance) in order to motivate them to make performance-oriented choices. In addition to APFT performance, previous literature suggests appearance, health, and meeting military weight standards are additional important motivators for healthy eating in the military.<sup>42</sup>
- Serve as a resource to subordinate Soldiers by becoming knowledgeable about nutrition and by identifying additional resources to which Soldiers can be directed for additional information.

Although these recommendations and the findings from this study are focused solely on nutrition, many of them have the potential to translate across activity and sleep. When either reinforcing or changing behavior within a military community is attempted, leadership engagement, role modeling, and commitment are likely to make a positive difference.

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# Assessment of Dietary Intake Using the Healthy Eating Index During Military Training

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## ABSTRACT

**Objective:** The objectives of this study were to use the healthy eating index (HEI) as a tool to characterize diet quality in Soldiers (n=135) during basic combat training (BCT), and to assess the effects of BCT on diet quality by comparing HEI scores before and after the training period.

**Methods:** HEI scores were calculated from a 110-item semiquantitative food frequency questionnaire. Soldiers were then divided into tertiles (high, medium, and low) of diet quality based upon HEI scores at the start of BCT.

**Results:** No relationships between pre-BCT total HEI score and age, sex, racial background, or physical activity were observed. The odds of being a smoker were 4.75 times higher for those in the low HEI tertile and 3.03 times higher for those in the medium HEI tertile when compared to those in the high HEI tertile (95% CI, 1.67, 13.48 and 1.04, 8.82 respectively). Diet quality improved in the medium and low HEI tertiles over the course of BCT, as total HEI scores increased by 22% and 46% respectively ( $P < .05$ ) with time in these groups. Although different at the start of BCT, HEI scores were similar between the medium and high HEI tertiles at the end of BCT.

**Conclusion:** Study findings suggest that the BCT dining environment elicits positive changes in diet quality for Soldiers who enter military training with lower diet quality, and the HEI appears to be a useful tool to identify military personnel with lower diet quality at the start of training. This may provide the opportunity to target interventions such as diet counseling and education in an effort to improve Soldier health and performance.

The Dietary Guidelines for Americans (DGAs) provide comprehensive nutrition recommendations that promote a healthy diet and body weight, thereby reducing the risk for chronic disease. The DGAs, released by the United States Department of Agriculture (USDA) and the Department of Health and Human Services, are revised every 5 years to reflect new scientific findings. The 2010 DGAs<sup>1</sup> focus on choosing foods that are nutrient dense (food that contains the highest concentration of nutrients per unit of energy). The 2010 DGAs specifically recommend limiting the intake of sodium, saturated fat, dietary cholesterol, trans fat, added sugars, refined grains, and alcohol; and increasing the intake of vegetables, fruits, whole grains, low-fat dairy, lean protein, seafood, oils, potassium, dietary fiber, calcium, and vitamin D.

Individual adherence to the DGAs can be quantified using a scoring rubric known as the healthy eating index (HEI). The HEI controls for the energy intake of a diet and measures diet quality.<sup>2-4</sup> The first HEI score was released in 1995 and subsequently updated in 2005

to reflect the revised DGAs. The HEI has been used to evaluate diet quality in the American adult population using data from the National Health and Nutrition Examination Survey (NHANES).<sup>5</sup> For example, one report indicates that individuals in the highest quartile of HEI scores (mean $\pm$ SE of the mean=69.9 $\pm$ 0.13) were less likely to be obese or overweight, have elevated blood pressure, metabolic syndrome, and decreased high-density lipoprotein when compared to those in the lowest quartile of HEI scores (33.6 $\pm$ 0.10).<sup>6</sup> These data suggest that the HEI may be an appropriate tool to identify those with a poor diet who may benefit the most from nutrition interventions. The data also demonstrate that lower HEI scores are associated with chronic disease risk in older adults.

Prior studies that assessed the intake of specific nutrients in military populations have revealed dietary inadequacies that may affect Soldier performance and risk for injury.<sup>7-9</sup> However, comprehensive studies detailing total diet quality of meals consumed by military personnel

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within garrison environments are limiting. As such, the objective of this study was to characterize the diet quality of Soldiers, using the HEI, during basic combat training (BCT), the 9 to 10 week initial Army training course for enlisted personnel. In addition, the effect of BCT on diet quality was assessed by comparing HEI scores before and after the training period.

### METHODS

#### Volunteers

This study was approved by the Human Use Review Committee at the US Army Research Institute of Environmental Medicine and was conducted at Fort Jackson, South Carolina. Human volunteers participated in this study after providing their free and informed voluntary consent. Investigators adhered to *US Army Regulation 70-25*<sup>10</sup> and *US Army Medical Research and Materiel Command Regulation 70-25*,<sup>11</sup> both of which provide guidance on the participation of volunteers in research. The data presented in this manuscript were collected in conjunction with a study that assessed the prevalence of cardiometabolic risk in Army recruits.<sup>12</sup>

A total of 209 US Army recruits (118 male, 91 female) volunteered to participate in this study. Volunteers were excluded if they reported implausible energy intake (<300 or >4,500 kcal/day for women and <800 or >5,000 kcal/day for men), or if they were missing data at the end of BCT due to separation from their unit or withdrawal from the study. In total, 135 volunteers (76 male, 59 female) were included in the final analyses. The baseline demographics of the study population are presented in Table 1. Dietary intake and background information were collected from the volunteers at the beginning and end of BCT. In their studies, Knapik et al<sup>13,14</sup> describe BCT as a 9 to 10 week course consisting of both physical and military-specific training.

#### Healthy Eating Index Score

The HEI is the composite of 12 component scores and ranges from 0 to 100, with a score of 100 indicating perfect compliance with the DGAs. The 9 adequacy components are:

- ◆ Total fruit
- ◆ Whole fruit
- ◆ Total grains
- ◆ Whole grains
- ◆ Total vegetables
- ◆ Dark green and orange vegetables and legumes
- ◆ Meat and beans
- ◆ Milk
- ◆ Oils

The 3 moderation components are:

- ◆ Sodium
- ◆ Saturated fat
- ◆ Calories from solid fats, alcoholic beverages, and added sugars (SoFAAS)

The HEI scores were calculated from a 110-item, semi-quantitative, Block 2005 food frequency questionnaire (FFQ) (NutritionQuest, Berkeley, CA).<sup>15,16</sup> The full-length, 3-month version of the validated FFQ was used, having been adapted from the full-length, 12-month version by the omission of seasonality questions about fruit consumption. During the second administration of the FFQ, volunteers were instructed to provide data regarding dietary intake during the BCT period only.

Volunteers self-reported dietary intake by completing the FFQ at the beginning of BCT, capturing their intake over the 3 months prior to entering the Army, and completing it again at the end of BCT, capturing their dietary intake during BCT. The food list on the FFQ was developed from NHANES 1999-2002 dietary recall data, and volunteers recorded both the quantity of food items consumed and the frequency of their consumption. The total daily energy and nutrient intake and the number of daily servings within food groups were calculated by NutritionQuest (Berkeley, CA) using the USDA's Food and Nutrient Database for Dietary Studies v.1.0<sup>17</sup> and the MyPyramid Equivalents Database 2.0.<sup>18</sup>

Table 1. Demographic Characteristics at Baseline.

	HEI Tertiles		
	High (n=45)	Medium (n=45)	Low (n=45)
HEI Score Pre ( $P<.01$ )	73.1±6.2	60.3±3.4	46.9±4.4
Age (yr) (mean±SD) ( $P=.50$ )	23.8±5.9	23.1±5.1	22.3±5.1
Sex ( $P=.68$ )			
Male	23	26	27
Female	22	19	18
Racial Background ( $P=.55$ )			
White	25	30	27
Black/African-American	8	8	11
Other	12	7	7
Activity ( $P=.19$ )			
Less than 20 minutes per day	14	12	22
More than 20 minutes per day	31	33	22
Smoker* ( $P<.01$ )			
Yes	6	14	19
No	39	30	26

HEI indicates Healthy Eating Index.  
\*Smoker defined as smoking more than every other day over the past 30 days.

Twelve HEI component scores and total HEI scores were determined according to the HEI guidelines.<sup>2-4</sup> Methods for scoring the HEI components appear in Table 2. Higher scores indicate increased consumption of adequacy components (consume more of) and decreased consumption of moderation components (consume less of), indicating a greater level of dietary quality.

Statistical Analysis

Changes in HEI total and component scores were analyzed as secondary outcomes in a trial powered to characterize the prevalence of cardiometabolic risk during BCT.<sup>12</sup> For the present analysis, change in the HEI total score was considered the primary outcome of interest. Post-hoc power calculations were therefore completed using the HEI total score or change in the HEI total score as the dependent variable. For all statistical analyses, volunteers were divided into equal tertiles based on their baseline HEI score. One-way analysis of variance (ANOVA) with Bonferroni corrections was used to determine differences between HEI tertiles for age. The  $\chi^2$  test was used to determine differences in categorical variables across HEI tertiles, and logistic regression was used to determine odds ratios and 95% confidence intervals (CIs). Mixed model ANOVA was used to determine within (time) and between (group) tertile differences in HEI scores. Significance for all analyses was assumed when  $P < .05$ . All statistical analyses were completed after normality was assessed using the IBM SPSS Statistics (V 20.0) application (IBM Corp, Chicago, IL).

RESULTS

Baseline HEI scores, indicative of dietary intake prior to BCT, did not differ according to age, sex, race, or physical activity (Table 1). However, those volunteers with low diet quality were more likely to be smokers than nonsmokers ( $P < .05$ ). Specifically, the odds of being a smoker were 4.75 times higher for those in the low HEI tertile and 3.03 times higher for those in the medium HEI tertile when compared to those in the high HEI tertile (95% CI, 1.67, 13.48, and 1.04, 8.82 respectively).

Diet quality improved in the medium and low HEI tertiles over the course of BCT, as total HEI scores increased ( $P < .05$ ) with time in these groups. In fact, total post-BCT HEI scores were similar between the medium and high HEI tertiles at the end of BCT as shown in Table 3. Total HEI scores did not change over the course of BCT in those volunteers categorized in the high tertile at the start of training.

Analysis of the 12 components of the HEI indicate that saturated fat, SoFAAS, oils, total fruit, whole fruit, total grain, whole grain, and total vegetable component scores improved ( $P < .05$ ), and sodium scores declined ( $P < .05$ ) during BCT for volunteers in the low tertile. Over the course of BCT, volunteers in the medium tertile demonstrated similar improvements ( $P < .05$ ) in component scores as those in the low tertile, except for a lack of improvement in the oil component. Volunteers beginning BCT in the high tertile demonstrated improvements ( $P < .05$ ) in the whole fruit, total grain, and whole grain components and a decrement ( $P < .05$ ) in the oil component over the course of BCT.

COMMENT

The objectives of this study were to use the HEI as a tool for assessing dietary quality in military personnel and to assess changes in diet quality during training. The major finding was that diet quality improved in Soldiers beginning BCT with the lowest diet quality. These findings indicate that the HEI may be used as a tool for identifying military personnel with low diet quality for nutrition interventions, and that dietary quality may improve during the course of initial military training for Soldiers who come into the military with poor eating habits.

Consistent with previous findings in US adults, we report diminished diet quality in smokers as compared to nonsmokers.<sup>3</sup> However, unlike previous studies in civilian populations using NHANES data,<sup>19</sup> we did not observe better diet quality in women than men. This may be due to the limited sample size of the current study or

Table 2. HEI Component Scoring Rubric.

Component <sup>a</sup>	Score Range	Standard for the Maximum Score <sup>b</sup>	Standard for the Minimum Score <sup>b</sup>
Total fruit	0-5	≥0.8 cup equiv.	0 cup equiv.
Whole fruit	0-5	≥0.4 cup equiv.	0 cup equiv.
Total vegetables	0-5	≥1.1 cup equiv	0 cup equiv.
Dark green and orange vegetables and legumes	0-5	≥0.4 cup equiv.	0 cup equiv.
Total grains	0-5	≥3.0 oz equiv.	0 oz equiv.
Whole grains	0-5	≥1.5 oz equiv.	0 oz equiv.
Milk	0-10	≥1.3 cup equiv.	0 cup equiv.
Meat and beans	0-10	≥2.5 oz equiv.	0 oz equiv.
Oils	0-10	≥12 grams	0 grams
Saturated fat <sup>c</sup>	0-10	≤7% of total energy	≥15% of total energy
Sodium <sup>c</sup>	0-10	≤0.7 grams	≥2.0 grams
Calories from solid fats, alcoholic beverages, and added sugars	0-20	≤20% of total energy	≥50% of total energy

HEI indicates Healthy Eating Index.

a. Defined per HEI guidelines.<sup>2</sup>

b. Per 1000 kcal, unless percentage of energy.

c. Receive scores of 8 for intakes that reflect Dietary Guidelines for Americans recommendations.

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Table 3: HEI Total and Component Score (mean±SD) Before and After BCT.

	HEI Tertiles			Effect
	High (n=45)	Medium (n=45)	Low (n=45)	
HEI Score				T,G,TxG
Pre-BCT	73.1±6.2	60.3±3.4 <sup>a</sup>	46.9±4.4 <sup>a,b</sup>	
Post-BCT	75.5±8.8	73.8±8.2 <sup>c</sup>	68.6±7.4 <sup>a,b,c</sup>	
Sodium				T,G,TxG
Pre-BCT	3.2±1.9	3.3±2.3	4.1±2.5	
Post-BCT	2.8±2.0	2.4±1.6 <sup>c</sup>	2.2±1.7 <sup>c</sup>	
Saturated Fat				T,G,TxG
Pre-BCT	7.1±2.2	5.1±2.9 <sup>a</sup>	4.1±3.3 <sup>a</sup>	
Post-BCT	7.6±2.3	7.2±2.3 <sup>c</sup>	6.9±2.2 <sup>c</sup>	
Calories from Solid Fats, Alcoholic Beverages, and Added Sugars				T,G,TxG
Pre-BCT	15.9±3.1	9.5±4.6 <sup>a</sup>	4.1±3.8 <sup>a,b</sup>	
Post-BCT	14.9±3.3	14.6±3.1 <sup>c</sup>	13.3±2.2 <sup>a,c</sup>	
Oils				G,TxG
Pre-BCT	7.8±2.4	7.0±2.2	5.6±2.5 <sup>a,b</sup>	
Post-BCT	6.7±2.2 <sup>c</sup>	7.0±2.5	6.6±2.3 <sup>c</sup>	
Milk				
Pre-BCT	6.4±3.0	6.2±2.7	5.7±2.9	
Post-BCT	5.9±2.9	5.5±2.6	5.4±2.8	
Total Fruit				T,G,TxG
Pre-BCT	4.4±1.0	3.8±1.5	2.6±1.3 <sup>a,b</sup>	
Post-BCT	4.5±0.9	4.3±1.1 <sup>c</sup>	3.9±1.4 <sup>c</sup>	
Whole Fruit				T,G,TxG
Pre BCT	4.3±1.0	3.5±1.5 <sup>a</sup>	2.3±1.2 <sup>a,b</sup>	
Post BCT	4.8±0.5 <sup>c</sup>	4.5±1.1 <sup>c</sup>	4.4±1.1 <sup>c</sup>	
Total Grain				T,TxG
Pre-BCT	4.0±1.0	4.1±1.0	3.7±1.1	
Post-BCT	4.5±0.7 <sup>c</sup>	4.5±0.9 <sup>c</sup>	4.7±0.5 <sup>c</sup>	
Whole Grain				T,G,TxG
Pre-BCT	2.3±1.5	1.7±1.2	1.0±1.0 <sup>a,b</sup>	
Post-BCT	3.1±1.4 <sup>c</sup>	3.2±1.4 <sup>c</sup>	2.8±1.3 <sup>c</sup>	
Meat and Beans				
Pre-BCT	9.7±1.1	9.9±0.4	9.7±1.0	
Post-BCT	9.8±0.7	9.8±0.7	9.7±0.9	
Dark Green and Orange Vegetables and Legumes				T,G
Pre-BCT	3.6±1.6	2.5±1.6	1.4±1.2	
Post-BCT	4.2±2.4	4.0±2.4	2.7±1.7	
Total Vegetables				T,G,TxG
Pre-BCT	3.9±1.2	3.3±1.1 <sup>a</sup>	2.4±1.0 <sup>a,b</sup>	
Post-BCT	3.8±1.2	3.9±1.2 <sup>c</sup>	3.6±1.1 <sup>c</sup>	

HEI indicates Healthy Eating Index.  
 BCT indicates basic combat training.  
 Effects: T - main effect of time  
 G - main effect of group  
 TxG - time by group interaction

Notes:  
 a. Different (*P*<.05) from High  
 b. Different (*P*<.05) from Medium  
 c. Different (*P*<.05) from Pre-BCT

to differences between military personnel and civilians in terms of diet quality in the demographic included in the population sampled.

The HEI scores improved during BCT for those who began their military service with lower scores. This may indicate that when exposed to a military dining environment with a variety of food choices, Soldiers are inclined to choose and may prefer healthier food options. In support of this hypothesis, we observed improvements in saturated fat, whole fruit, total and whole grain, and total vegetable intake in both the medium and low tertiles of volunteers throughout the course of BCT. Similarly, previous studies have demonstrated that when military dining facility services were altered to promote healthy diet options, such as healthy food options at the beginning of service lines and implementing the Go for Green method of rating the nutritional composition of food items, caloric and total fat intake were reduced and customer satisfaction improved as compared to the control dining facilities.<sup>20</sup>

Nutrition education strategies may also underlie improvements in diet quality. The Soldier Fueling Initiative, which provides nutrition education during BCT and highlights the consumption of nutrient dense foods in garrison dining facilities, was implemented prior to this study and may have contributed to the observed improvement in diet quality. Given the findings of the current study, it is possible that the HEI can be used as a tool for the evaluation of initiatives aimed at improving the nutrient quality of dining options within military environments.

Pasiakos et al<sup>12</sup> previously reported improvements in lipid profiles, fasting glucose, and insulin sensitivity during BCT in this cohort. These favorable effects may be partially attributable to the improved diet quality during BCT observed in this study, as well as the physical activity encountered during BCT. Previous studies in older cohorts have demonstrated that if those with low HEI scores continue to consume poor diets, unfavorable outcomes such as overweight, obesity, and an unhealthy lipid profile may result.<sup>6</sup> Future studies should focus on possible relationships between HEI scores and biomarkers of chronic disease risk in military populations, which may be predictive of longer-term health outcomes. Similarly, identifying areas of the diet with the lowest component scores may add focus to nutrition education programs aimed at improving overall diet quality in young people, including military personnel, thereby establishing positive dietary habits and preventing the negative effects of poor diet later in life.



Strengths of this study include the longitudinal design and the use of a validated FFQ to collect dietary intake data. Weaknesses include the small sample size in comparison to larger studies, such as NHANES, conducted in civilian populations. Further, dietary intake was not collected for a full year; therefore, seasonal variation in nutritional intake may not have been captured. Future studies should include larger populations of military personnel in both training and permanent duty assignments and should follow Soldiers for longer periods to determine if improvements in their diet quality are sustained. Similarly, biomarker data may be used in conjunction with the HEI to demonstrate the effects of diet quality on indicators of nutritional status and disease risk.

#### RELEVANCE TO THE PERFORMANCE TRIAD

This study suggests that the BCT dining environment elicits positive changes in diet quality for Soldiers entering military training with lower diet quality. The HEI appears to be a useful tool to identify military personnel with low diet quality at the start of training and may be a valuable tool for evaluating nutrition initiatives within the Performance Triad Program, The US Army Surgeon General's strategy to improve the wellness, individual performance, and resilience of the Army community through proper activity, nutrition, and sleep. The identification of military personnel with low diet quality early in their careers may provide the opportunity to target interventions such as diet counseling and education in an effort to improve Soldier health and performance over the course of a military career and beyond.

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## Cut back on sodium and empty calories from solid fats and added sugars



Look out for salt (sodium) in foods you buy. Compare sodium in foods and choose those with a lower number.

Drink water instead of sugary drinks. Eat sugary desserts less often.

Make foods that are high in solid fats—such as cakes, cookies, ice cream, pizza, cheese, sausages, and hot dogs—occasional choices, not every day foods.

Limit empty calories to less than 260 per day, based on a 2,000 calorie diet.

## Be physically active your way

Pick activities you like and do each for at least 10 minutes at a time. Every bit adds up, and health benefits increase as you spend more time being active.

**Children and adolescents:** get 60 minutes or more a day.

**Adults:** get 2 hours and 30 minutes or more a week of activity that requires moderate effort, such as brisk walking.

Vegetables	Fruits	Grains	Dairy	Protein Foods
<p>Eat more red, orange, and dark-green vegetables like tomatoes, sweet potatoes, and broccoli in main dishes.</p> <p>Add beans or peas to salads (kidney or chickpeas), soups (split peas or lentils), and side dishes (pinto or baked beans), or serve as a main dish.</p> <p>Fresh, frozen, and canned vegetables all count. Choose "reduced sodium" or "no-salt-added" canned veggies.</p>	<p>Use fruits as snacks, salads, and desserts. At breakfast, top your cereal with bananas or strawberries; add blueberries to pancakes.</p> <p>Buy fruits that are dried, frozen, and canned (in water or 100% juice), as well as fresh fruits.</p> <p>Select 100% fruit juice when choosing juices.</p>	<p>Substitute whole-grain choices for refined-grain breads, bagels, rolls, breakfast cereals, crackers, rice, and pasta.</p> <p>Check the ingredients list on product labels for the words "whole" or "whole grain" before the grain ingredient name.</p> <p>Choose products that name a whole grain first on the ingredients list.</p>	<p>Choose skim (fat-free) or 1% (low-fat) milk. They have the same amount of calcium and other essential nutrients as whole milk, but less fat and calories.</p> <p>Top fruit salads and baked potatoes with low-fat yogurt.</p> <p>If you are lactose intolerant, try lactose-free milk or fortified soy milk (soy beverage).</p>	<p>Eat a variety of foods from the protein food group each week, such as seafood, beans and peas, and nuts as well as lean meats, poultry, and eggs.</p> <p>Twice a week, make seafood the protein on your plate.</p> <p>Choose lean meats and ground beef that are at least 90% lean.</p> <p>Trim or drain fat from meat and remove skin from poultry to cut fat and calories.</p>

**For a 2,000-calorie daily food plan, you need the amounts below from each food group.**  
To find amounts personalized for you, go to [ChooseMyPlate.gov](http://ChooseMyPlate.gov).

<p><b>Eat 2½ cups every day</b></p> <p><b>What counts as a cup?</b> 1 cup of raw or cooked vegetables or vegetable juice; 2 cups of leafy salad greens</p>	<p><b>Eat 2 cups every day</b></p> <p><b>What counts as a cup?</b> 1 cup of raw or cooked fruit or 100% fruit juice; ½ cup dried fruit</p>	<p><b>Eat 6 ounces every day</b></p> <p><b>What counts as an ounce?</b> 1 slice of bread; ½ cup of cooked rice, cereal, or pasta; 1 ounce of ready-to-eat cereal</p>	<p><b>Get 3 cups every day</b></p> <p><b>What counts as a cup?</b> 1 cup of milk, yogurt, or fortified soy milk; 1½ ounces natural or 2 ounces processed cheese</p>	<p><b>Eat 5½ ounces every day</b></p> <p><b>What counts as an ounce?</b> 1 ounce of lean meat, poultry, or fish; 1 egg; 1 Tbsp peanut butter; ½ ounce nuts or seeds; ¼ cup beans or peas</p>
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# Sleep as a Component of the Performance Triad: The Importance of Sleep in a Military Population

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## ABSTRACT

**Objective:** Sleep habits among military populations are problematic. Poor sleep hygiene occurs in parallel with the global increase in obesity and metabolic syndrome and contributes to a decrease in performance. The extent of sleep issues needs to be quantified to provide feedback for optimizing warfighter performance and readiness. This study assessed various health behaviors and habits of US Army Soldiers and their relationship with poor sleep quality by introducing a set of new questions into the Comprehensive Soldier and Family Fitness (CSF2) Global Assessment Tool (GAT).

**Methods:** Subjects included 14,148 US Army Active, Reserve, and National Guard members (83.4% male) who completed the GAT, a self-report questionnaire that measures 4 fitness dimensions: social, family, emotional, and spiritual. Approximately 60 new questions, including ones on sleep quality, within the fifth CSF2 dimension (physical) were also answered. A sleep score was calculated from 2 questions validated in the Pittsburgh Insomnia Rating Scale (0 to 6).

**Results:** Poor sleepers (5-6) were significantly ( $P < .001$ ) more likely than good sleepers (0-1) to consider themselves in fair or poor health, be overweight or obese, and score in the lowest quartile of the emotional, social, family, and spiritual fitness dimensions. Additionally, poor sleepers were significantly ( $P < .001$ ) less likely to have a healthy body mass index and waist circumference, eat breakfast 6 or more times a week, meet aerobic exercise and resistance training recommendations, and pass their Army Physical Fitness Test in the top quartile.

**Conclusion:** This study examined sleep quality in a group of military personnel and indicated significant associations between quality of sleep and physical performance, nutritional habits, measures of obesity, lifestyle behaviors and measures of psychosocial status. Targeted educational interventions and resources are needed to improve sleep patterns based on behaviors that can be most easily modified.

Sleep, in addition to nutrition and physical activity, is a component of the Performance Triad because sleep habits among the military are problematic,<sup>1-5</sup> and inadequate sleep is prevalent in the Army.<sup>6-8</sup> With regard to the Performance Triad, sleep is perhaps more difficult to control than activity and nutrition. Soldiers are at a heightened risk for diminished sleep quality as a result of dangerous working environments, loud noise exposure, and unpredictable hours.<sup>9,10</sup> Effective sleep practices and habits that contribute to quality nighttime sleep and daytime alertness, is essential for high quality sleep.<sup>11</sup> The phenomenon of poor sleep is occurring in parallel with the global increase in obesity and metabolic syndrome,<sup>12,13</sup> as well as increases in depression, anxiety, and other mental health issues.<sup>8,14-19</sup> Interestingly, poor sleep behaviors have also been associated with a pro-inflammatory state.<sup>20-24</sup>

Many epidemiological and meta-analytic studies suggest these observed relationships may be bidirectional and possibly confounded by other issues.<sup>13,20,25</sup> For example, psychological state is influenced by and directly influences sleep quality.<sup>26-29</sup> Moreover, sleep-induced disturbances in circadian rhythms have been shown to affect selected endocrine parameters<sup>13,30,31</sup> and metabolic pathways.<sup>12,13,32</sup> Importantly, compromised sleep habits, in terms of duration and quality, may lead to insulin resistance and immunologic alterations; whereas, depression, anxiety, and life stressors can interfere with sleep duration and quality to create a vicious cycle.<sup>12,13,30-32</sup> Finally, exercise and nutritional habits can directly influence sleep quality and duration,<sup>5,20,33-38</sup> in either negative or positive directions. Exercise and sleep interact bidirectionally as well. Military trainees who experienced lack of sleep due to night missions, coupled with early

morning wake-up calls, reported a diminished ability to perform daily physical training and a decline in physical fitness and marksmanship testing scores.<sup>3</sup> Weekly, moderate physical activity improves self-reported sleep quality and can result in shortened sleep latency, fewer awakenings after sleep onset, longer sleep duration, and better overall sleep efficiency.<sup>31,39</sup>

The concerns about insufficient sleep in the military have led researchers to quantify the extent of the sleep issues in order to target educational and behavioral practices to improve sleep patterns. Thus, we conducted an investigation, in collaboration with the Army's Comprehensive Soldier and Family Fitness program (CSF2), to assess various health behaviors and habits of US Army Soldiers. New questions were incorporated into the on-line Global Assessment Tool (GAT), which all nondeployed Soldiers are required to complete once per year. Family members of Soldiers and all Department of Defense (DoD) civilians may also take the GAT. The intent of the questions was to determine gaps in Soldier knowledge and behaviors relating to physical fitness, nutritional habits, and sleep quality, then provide feedback to help them modify health behaviors and access resources to do so. The study examined sleep quality in Soldiers who completed the pilot launch of new GAT questions. Specifically, we asked about sleep quality and examined how it was related to overall emotional, spiritual, social, family, physical, and nutritional fitness.

## METHODS

This pilot study was conducted using a sample population of 14,850 Soldiers and DoD civilians during a 2-week period in July 2012. Currently, the annual GAT measures health in 4 psychosocial dimensions: emotional, social, family, and spiritual. Approximately 60 pilot questions were added to the GAT to assess lifestyle behaviors in the physical dimension. After completion of the GAT, respondents were informed that the physical dimension questions were for validation purposes and would not be scored. Respondents were then given the option to consent for use of their GAT responses for research purposes. Per an established data use agreement, personal identifying information was removed from the CSF2 data (thus waiving the requirement for Institutional Review Board approval), which was then provided to researchers for analysis.

### Population

The total number of participants was 14,850. The following were excluded from analyses: 599 DoD civilians, 3 family members, and 100 with missing sleep data. Therefore, the analyses presented herein are for 14,148 Active, Reserve, and National Guard members.

## Measures

Measures included the GAT, which was developed in part by Seligman et al<sup>40</sup> and others.<sup>41</sup> The details of its evaluation and reliability were previously described.<sup>41,42</sup> The GAT's overall purpose is to assess a Soldier's emotional, social, spiritual, and family fitness with 105 questions. Each dimension yields an overall score based on responses to the questions, and the scores are aggregated into quartiles. For the purposes of this study, the fifth dimension (physical fitness) was added, and pilot questions were incorporated to represent this new dimension assessment. Questions for the physical fitness dimension included items related to nutritional habits and behaviors, physical activity patterns, sleep quality, and other lifestyle behaviors.

Participants were asked to report their height and weight, and the body mass index (BMI) (weight [kg]/[height (m)]<sup>2</sup>) was calculated from their self-reported data. The cutoff was 27.5 kg/m<sup>2</sup> as specified by *Army Regulation 600-9*.<sup>43</sup> A healthy waist circumference was defined as 35 inches or less for females and 40 inches or less for males.<sup>44</sup>

Sleep quality was subjectively assessed by self-report, and an overall score was calculated from responses to the short version of the Pittsburgh Insomnia Rating Scale, which had previously been validated.<sup>45,46</sup> The 2 questions and responses were:

1. In the past week, how much were you bothered by lack of energy because of poor sleep? (not at all bothered, slightly bothered, moderately bothered, severely bothered)
2. Over the past week, how would you rate your satisfaction with your sleep? (excellent, good, fair, poor)

Each answer choice was assigned a score of 0 to 3. Hence, the sum total score ranged from 0 to 6; we considered scores of 0 or 1 as good sleep, 2 to 4 as moderate sleep, and 5 or 6 as poor sleep quality. Although the author of the Pittsburgh Insomnia Rating Score indicated that a total score of 2 or more would identify someone with presumed problems, we further divided the group to look at those with self-reported sleep issues.

In addition to calculating a sleep-quality score, a Healthy Eating Score (HES-5) was developed based on the US Department of Agriculture's (USDA) Healthy Eating Index,<sup>47-50</sup> but modified by using 5 questions assessing daily intake of fruit, vegetable, whole grain, dairy, and fish.<sup>51</sup> Other nutrition questions included the number of days per week breakfast is consumed and the inclusion of recovery snacking, whether or not a snack is consumed within 60 minutes of strenuous exercise.

## SLEEP AS A COMPONENT OF THE PERFORMANCE TRIAD: THE IMPORTANCE OF SLEEP IN A MILITARY POPULATION

Physical activity information was captured by asking Soldiers the number of times per week they participated in aerobic activity for at least 20 minutes and strength or resistance exercise, based on the American College of Sports Medicine (ACSM) and Centers for Disease Control and Prevention (CDC) exercise recommendations.<sup>52</sup> Additionally, participants provided their most recent Army Physical Fitness Test (APFT) score, which included number of push-ups, sit-ups, and run time.

Finally, participants were asked to respond to several questions relating to health, perceived body image, and alcohol habits. Specifically, they were asked to answer the following 3 questions:

1. How do you consider your general health? (excellent, good, fair, poor, don't know)
2. In thinking about your weight, do you consider yourself to be: underweight, about the right weight, overweight, obese, don't know?
3. Have you exceeded 5 alcoholic drinks on any single occasion during the past 3 months? (yes or no)

Internal consistency for the subsets of questions was measured using Cronbach  $\alpha$ .<sup>53</sup> The values were the following: HES-5=0.810; sleep=0.807; and physical activity=0.793. The GAT dimensions had Cronbach  $\alpha$  results of 0.724, 0.802 and 0.860 for the social, family, and emotional dimensions respectively, based on the current data. A Cronbach  $\alpha$  greater than 0.80 is regarded as good, above 0.70 is acceptable, and below 0.60 is unacceptable.<sup>53</sup> The pilot questions will be validated through a collaborative study between CSF2 and the Consortium for Health and Military Performance at the Uniformed Services University of the Health Sciences.

### Statistical Analysis

The IBM SPSS (V 20.0) for Windows (IBM Corp, Chicago, IL) application was used to perform all statistical analyses. Frequency tables and descriptive statistics were reviewed to remove outliers and confirm assumptions for parametric tests. Binary logistic regression was used to obtain odds ratios (OR) and 95% confidence intervals (CI) to compare the relationships between sleep quality and nutrition, exercise, and lifestyle behaviors. For this purpose, poor sleepers were considered the reference group, and independent variables were either categorical (gender, active duty status, enlistment status, marital status) or categorized into groups (age, dietary behaviors, physical activity, APFT scores, BMI, waist circumference) based on quartiles or other appropriate classifications and/or dichotomized; as noted above, responses to the 4 psychosocial GAT dimensions were grouped into quartiles.

A separate multiple linear-regression model was also used to predict poor sleep, with demographic variables, HES-5, APFT total score, and the 4 dimensions of the GAT. Due to the high number of statistical analyses, the *P* value was set at the .0025 significance level. This was based on dividing the *P* value of .05 by the 25 logistic regressions conducted.

## RESULTS

### General Characteristics and Sleep Status

The overall characteristics of the sample are presented in Table 1. The distribution of poor, moderate, and good sleepers did not differ as a function of age (OR 1.0; 95% CI, 0.92-1.10; *P*=.93). However, women were 1.4 times more likely to be poor sleepers than men (OR 1.40; 95% CI, 1.24-1.57; *P*<.001). Additionally, those on active duty were 1.69 times more likely to be poor sleepers than those in the National Guard or Army Reserve (OR 1.69; 95% CI, 1.55-1.85; *P*<.001). Moreover, enlisted personnel were 1.74 times more likely to be poor sleepers than officers (OR 1.74; 95% CI, 1.53-1.99; *P*<.001).

### Dietary Patterns and Sleep Status

On average, poor sleepers were 50% less likely to meet the USDA dietary recommendations for the following: fruit (OR 0.48; 95% CI, 0.43-0.52; *P*<.001); vegetables (OR 0.53; 95% CI, 0.47-0.59; *P*<.001); whole grains (OR 0.45; 95% CI, 0.43-0.52; *P*<.001); dairy (OR 0.48; 95% CI, 0.42-0.54; *P*<.001); and fish (OR 0.58; 95% CI, 0.53-0.63; *P*<.001). Each of the dietary recommendations was used to create a HES-5 score. Figure 1 indicates that only 17.4% of the poor sleepers were also healthy eaters as defined by the HES-5 (a score of 20 out of 25). Overall, poor sleepers were 77.2% less likely to be a healthy eater (OR 0.23; 95% CI, 0.14-0.38; *P*<.001) than good sleepers. Table 2 captures additional dietary behaviors showing that poor sleepers were more likely to drink soda and less likely to eat breakfast regularly, or consume a snack within 60 minutes after a strenuous exercise session.

### Physical Fitness and Sleep

Frequency of physical activity was assessed and respondents met recommendations if they engaged in at least 20 minutes of aerobic exercise 5 days per week (71.5%), and at least 2 days per week of resistance training (66.8%). Figure 2 illustrates the percentages of each sleep group who met the recommendations and how many passed their APFT in the top quartile. Soldiers were less likely to be poor sleepers if they met aerobic exercise recommendations (OR 0.54; 95% CI, 0.49-0.60; *P*<.001), participated in regular resistance training (OR 0.52; 95% CI, 0.47-0.57; *P*<.001), or passed their APFT in the top quartile (OR 0.53; 95% CI, 0.45-0.64; *P*<.001).

Table 1. Demographic characteristics of the study sample population (N=14,148).

Frequencies	Sleep Score Mean±SD	
Age mean±SD, years	27.7±8.3	
Years range (min-max)	17-61	
Age Group		
17 to 29	66.9%	2.4±1.7
30 and over	33.1%	2.5±1.6
Gender		
Female	16.6%	2.6±1.6
Male	83.4%	2.4±1.6
Army Status		
Active Duty	52.6%	2.6±1.7
National Guard/Reserve	47.4%	2.3±1.6
Enlisted Status		
Enlisted	85.3%	2.5±1.7
Officers	14.7%	2.1±1.5
Marital Status		
Married	49.0%	2.5±1.7
Single/divorced/legally separated	50.9%	2.4±1.6
Army Physical Fitness Test	n=10,054	
Failed	13.7%	2.6±1.7
Passed	86.3%	2.3±1.6
BMI Categories	n=11,545	
Underweight (<18.4 kg/m <sup>2</sup> )	0.5%	2.4±1.6
Normal/healthy (18.5-27.5 kg/m <sup>2</sup> )	65.3%	2.4±1.6
Overweight (27.6-29.9 kg/m <sup>2</sup> )	16.9%	2.5±1.6
Obese (>30 kg/m <sup>2</sup> )	17.3%	2.7±1.7
BMI Mean±SD, kg/m <sup>2</sup>	26.6±4.03	
Range	13.4-56.3	
Waist Circumference	n=6,012	
Healthy	90.9%	2.4±1.6
Unhealthy	9.1%	2.8±1.7
Sleep Categories		
Good sleepers	32.9%	0.6±0.5
Moderate sleepers	41.8%	2.5±0.5
Poor sleepers*	25.3%	4.7±0.78

Note: Data are represented as mean±SD for continuous variables and as a percentage for categorical variables. Percentages within characteristic groups may not add up to 100% due to missing data.  
\*Poor sleepers are defined by a total score of 5 or 6 on the Pittsburgh Insomnia Rating Scale-2.  
BMI indicates body mass index.

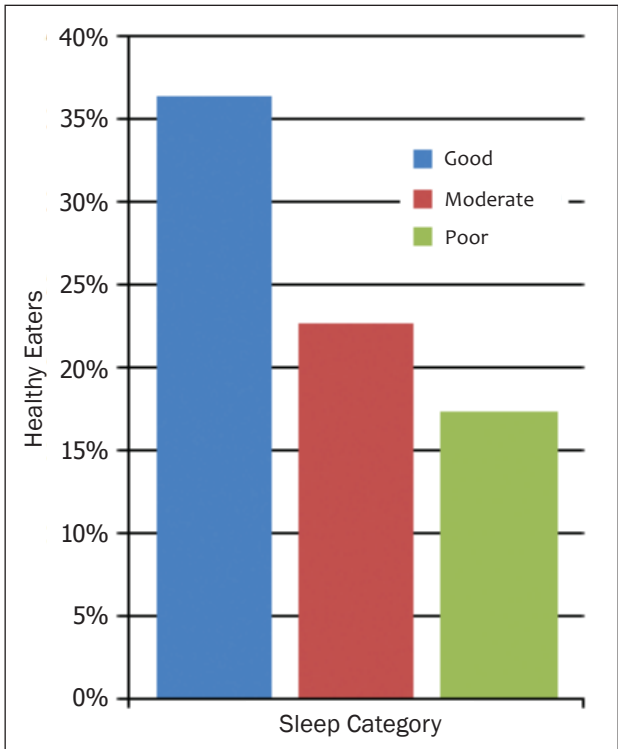


Figure 1. Percentage of healthy eaters in each sleep category. A healthy eater received a score of 20 out of 25 on the Healthy Eating Scale-5. Poor sleepers are defined by a total Pittsburgh Insomnia Rating Scale-2 score of 5 or 6; a moderate sleeper scored a 2, 3, or 4; and a good sleeper received a score of 0 or 1.

Health Self-Assessments and Sleep

Approximately 42% of respondents provided their waist circumference. The mean (±SD) waist circumference for women was 30.2±3.7 inches and 34.4±3.6 inches for men. Odds ratios to predict healthy anthropomorphic measurements are included in Table 3. Although self-reported, the correlation between waist circumference and BMI was 0.673 (P<.001). Answers to the health self-assessments are also presented in Table 3. Remarkably, poor sleepers were 25.7% less likely to have a healthy BMI, 50.0% less likely to have a healthy waist circumference, and 17 times more likely to consider themselves to be in fair or poor health.

GAT Dimensions

Figure 3 presents sleep quality category by the 4 GAT psychosocial dimensions. As noted, those who were poor sleepers were significantly more likely to score in the lowest quartile relative to the other sleep categories. A dose-related response was clearly noted, such that 19% to 35% in the good sleep group, 54% to 59% in the moderate, and 72% to 85% of the poor sleep group scored in the lowest quartiles. Table 4 documents the

Table 2. Logistic Regression of Poor Sleepers and Dietary Behaviors.

	Good Sleepers (n=4,658)	Moderate Sleepers (n=5,915)	Poor Sleepers* (n=3,575)	OR (P<.001)	95% CI
Drinks either diet soda or regular soda (%n)	54.7%	59.1%	61.7%	1.35	1.24-1.48
Breakfast at least 6 times per week (%n)	52.9%	40.8%	31.2%	0.40	0.37-0.44
Consumes 2 or more snacks per day (%n)	45.6%	44.4%	41.1%	0.83	0.76-0.91
Recovery snack (%n)	54.4%	49.3%	43.9%	0.66	0.6-0.72

Note. Data are represented as percentages for the categorical variables.  
\*Poor sleepers are defined by a total Pittsburgh Insomnia Rating Scale-2 score of 5 or 6 and used as the reference group; a moderate sleeper scored a 2, 3, or 4; a good sleeper received a score of 0 or 1.  
OR indicates odds ratio between poor and good sleepers.  
CI indicates confidence intervals.

## SLEEP AS A COMPONENT OF THE PERFORMANCE TRIAD: THE IMPORTANCE OF SLEEP IN A MILITARY POPULATION

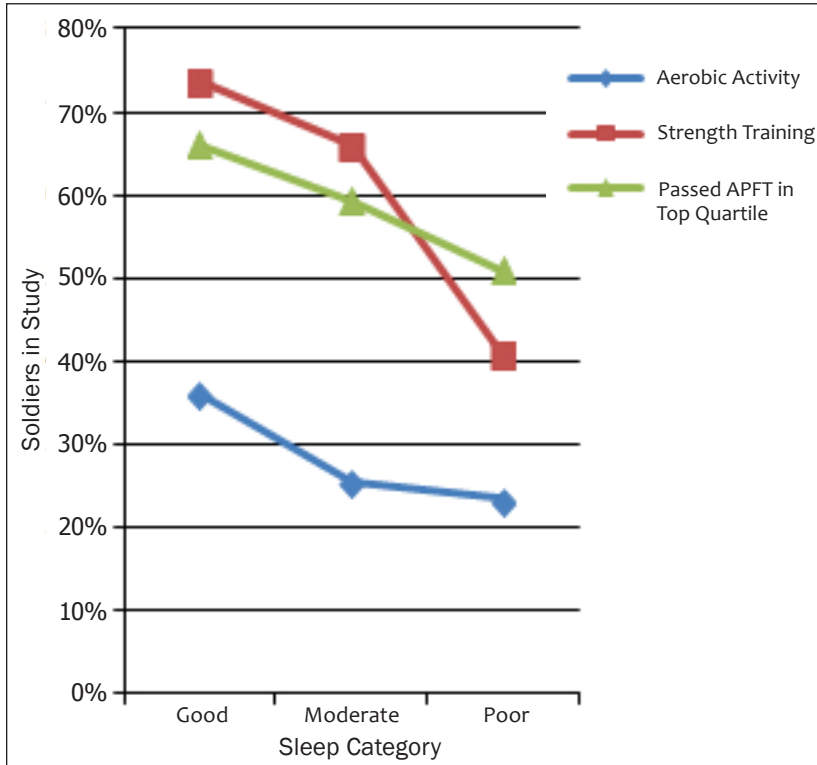


Figure 2. Percentage of Soldiers in each sleep category who met the Centers for Disease Control and Prevention and the American College of Sports Medicine recommendations for aerobic exercise (at least 20 minutes, 5 days per week) and resistance training (2 days per week), or passed the Army Physical Fitness Test in the top quartile. Poor sleepers are defined by a total Pittsburgh Insomnia Rating Scale-2 score of 5 or 6; a moderate sleeper scored a 2, 3, or 4; and a good sleeper received a score of 0 or 1.

Table 3. Logistic Regression of Poor Sleepers and Health Self-assessment.

	Good Sleepers	Moderate Sleepers	Poor Sleepers*	OR (P<.001)	95% CI
Healthy BMI (18.5 to 27.5 kg/m <sup>2</sup> )	(n=3,782) 68.0%	(n=4,839) 65.7%	(n=2,924) 61.2%	0.74	0.67-0.82
Healthy waist circumference†	n=2,022 93.2%	n=2,484 91.3%	n=1,506 87.2%	0.50	0.40-0.63
Consider their health to be "fair" or "poor"	n=4,650 4.8%	n=5,896 18.7%	n=3,506 46.0%	17.0	14.64-19.77
Consider themselves to be "overweight" or "obese"	n=4,337 23.8%	n=5,438 34.1%	n=3,200 45.1%	2.60	2.38-2.90
Exceeded 5 alcoholic drinks on any single occasion during the past 3 months	n=4,658 16.7%	n=5,915 24%	n=3,575 29.7%	2.10	1.89-2.34

Note: Data are represented as percentages of n for the categorical variables.

\*Poor sleepers are defined by a total Pittsburgh Insomnia Rating Scale-2 score of 5 or 6 and used as the reference group; a moderate sleeper scored a 2, 3, or 4; a good sleeper received a score of 0 or 1.

†Healthy waist circumference is defined as 35 inches or less for women and 40 inches or less for men.

OR indicates odds ratio between poor and good sleepers.

CI indicates confidence intervals.

BMI indicates body mass index.

the good sleep quality group, poor sleepers were 23.0 times more likely to score in the lowest quartile of emotional fitness.

### Sleep Prediction Model

A step-wise multiple linear regression model was used to predict poor sleep. The following variables were allowed to be incorporated: age, gender, active duty, enlisted, and married Soldiers, HES-5, APFT total score, and 4 GAT dimensions. Although age and spiritual fitness were initially included in the model, no statistically significant associations were found. Table 5 shows the final model and the contribution of each variable entered. Overall, 22.7% of the variance in predicting sleep quality could be explained by this model. Emotional fitness contributed the most with 13.8%, and HES-5 accounted for 5.1% of the total explained variance.

### COMMENT

The adverse health consequences of poor sleep quality and inadequate quantity are receiving increasing attention. Both are strongly affected by lifestyle behaviors and daily nutrition and fitness habits. In particular, poor sleep quality has been associated with disturbed or dysfunctional neuroendocrine<sup>13,30,31</sup> and metabolic<sup>12,13,32</sup> pathways, depression, anxiety, obesity, cardiovascular risk, and multiple life stressors.<sup>12,13,30-32</sup> Although these health issues are well recognized, few have examined the relationship between sleep quality and the combination of multiple health components in a single sample. This study examined subjective sleep quality in a group of military personnel and indicated significant associations between quality of sleep and physical performance, nutritional habits, measures of obesity, lifestyle behaviors, and, importantly, measures of psychosocial status. In particular, poor sleepers by self-report were significantly more

likely to score in the lowest quartile for emotional, social, and family fitness; have poorer performance on the APFT; and participate less frequently in healthy exercise



and dietary behaviors than good sleepers. Additionally, poor sleepers were significantly more likely to have larger waist circumferences and higher BMI than good sleepers.

The current data support several consistent associations between poor sleep quality and health in a large sample of military persons. A key finding was the dose-related relationship between sleep quality and emotional, social, and family health. Importantly, emotional health, as measured by the Army GAT, was highly dependent on sleep quality, with poor sleepers being 23 times more likely to have scored in the lowest quartile for emotional health. Ribeiro et al<sup>54</sup> evaluated the severity of depressive symptoms, hopelessness, posttraumatic stress disorder diagnoses, anxiety disorders, and drug and alcohol abuse symptoms in a sample of military personnel. Their results suggested that after controlling for all other symptoms, insomnia may possibly predict suicide risk. In other military specific populations, sleep problems proved to be an important mediator for developing posttraumatic stress disorder or depression.<sup>3,6</sup> A strong association between sleep quality and perception of stress has also been demonstrated.<sup>8</sup> In addition, Collen et al<sup>1</sup> found that hypersomnia, sleep fragmentation, obstructive sleep apnea syndrome, and insomnia were common among persons with mild traumatic brain injury from blast and blunt trauma injuries. Minkel et al<sup>29</sup> noted that the psychological threshold for perceiving stress was lowered by poor sleep quality, and Eliasson et al<sup>18</sup> reported that perception of stress was inversely related to sleep quality. Of note is the finding of Mauss et al<sup>55</sup> that the ability to regulate negative emotions is impaired in persons with poor sleep quality. In addition to perception of stress, sleep quality appears to significantly affect cognitive performance.<sup>26,56,57</sup> Whether this performance decrement in association with sleep quality is confounded by perceived stress remains to be determined.

The strong association between sleep quality and emotional health observed in this study was coupled with comparable associations for both social and family

health: self-reported poor sleepers were 14.5 and 6.7 times more likely to have scored in the lowest quartile for social and family health respectively. These findings are supported by previous work.<sup>58,59</sup> In particular, Ailshire et al<sup>58</sup> demonstrated that strained family relationships were associated with troubled sleep; whereas, supportive family relationships were related to high-quality sleep. Although not directly related to sleep,

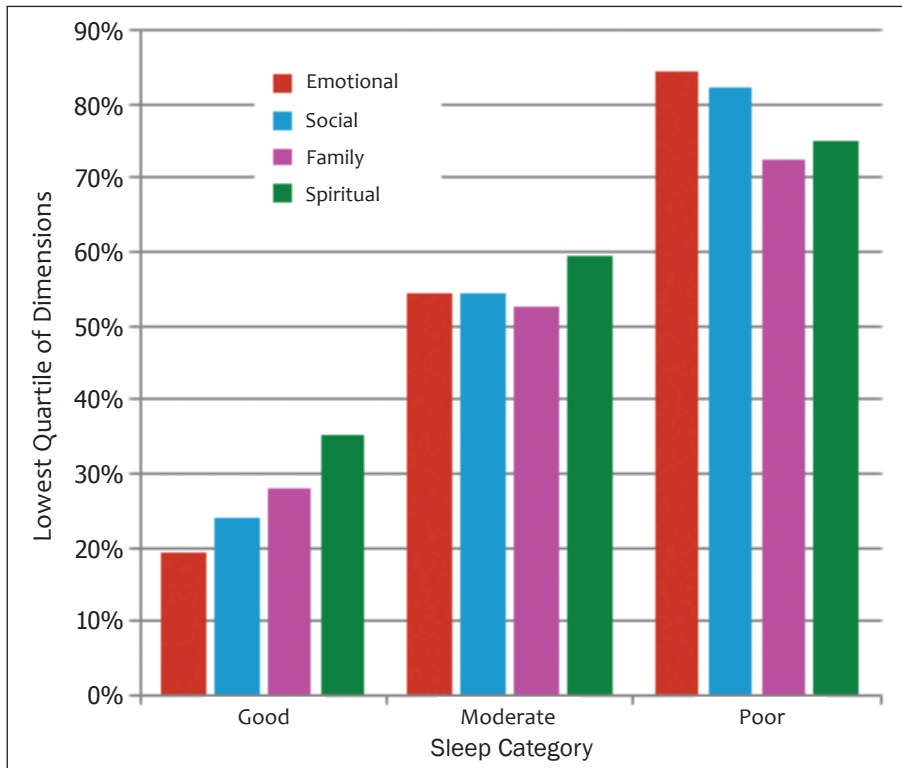


Figure 3. Percentage of each sleep category scoring in the lowest quartile for the Global Assessment Tool psychological dimensions. Poor sleepers are defined by a total Pittsburgh Insomnia Rating Scale-2 score of 5 or 6; a moderate sleeper scored a 2, 3, or 4; a good sleeper received a score of 0 or 1.

Table 4. Logistic Regression Predicting Likelihood of Poor Sleepers Scoring in the Bottom Quartile of Global Assessment Tool (GAT) Dimensions

GAT Fitness Dimensions	Good Sleepers (n=2,575)	Moderate Sleepers (n=2,475)	Poor Sleepers* (n=1,984)	OR (P<.001)	95% CI
Emotional	19.3%	54.5%	84.6%	23.00	19.64-26.85
Social	24.1%	54.4%	82.2%	14.47	12.47-16.79
Family	28.1%	52.6%	72.4%	6.71	5.83-7.72
Spiritual	35.1%	59.5%	74.9%	5.52	4.86-6.26

Note: Data are represented as percentages of n for the categorical variables.  
 \*Poor sleepers are defined by a total Pittsburgh Insomnia Rating Scale-2 score of 5 or 6 and used as the reference group; a moderate sleeper scored a 2, 3, or 4; a good sleeper received a score of 0 or 1.  
 †Healthy waist circumference is defined as 35 inches or less for women and 40 inches or less for men.  
 OR indicates odds ratio between poor and good sleepers.  
 CI indicates confidence intervals.  
 BMI indicates body mass index.

## SLEEP AS A COMPONENT OF THE PERFORMANCE TRIAD: THE IMPORTANCE OF SLEEP IN A MILITARY POPULATION

Table 5. Stepwise Multiple Regression Analysis-Predicting Poor Sleep.

Final Variables in Model	R	R <sup>2</sup>	R <sup>2</sup> Change	Standardized $\beta$ Coefficient	P Value
1 Active Duty	0.107	0.011	0.011	0.063	.00
2 Enlisted Status	0.127	0.016	0.005	0.020	.03
3 Gender	0.132	0.017	0.001	0.040	.00
4 Married	0.136	0.018	0.001	0.029	.01
5 HES-5	0.262	0.068	0.051	-0.104	.00
6 APFT Total Score	0.273	0.074	0.006	-0.086	.00
7 Emotional Fitness	0.461	0.212	0.138	-0.277	.00
8 Social Fitness	0.473	0.223	0.011	-0.121	.00
9 Family Fitness	0.477	0.226	0.004	-0.073	.00

Note: A stepwise multiple linear regression model was used to predict poor sleep using the following variables:  
 Age                      Active duty                      Married                      APFT total score  
 Gender                    Enlisted                              HES-5                        4 GAT dimensions

Pollock et al<sup>60</sup> found that close and flexible family relationships are linked to low individual perceived stress levels. Together these data clearly show the remarkable interplay among sleep quality, stress, relationships, and overall psychosocial functioning.

Sleep impacts other daily activities in addition to psychological and social functioning. This study found a strong association between sleep quality and dietary and physical activity habits. In particular, poor sleep quality was related to larger waist circumferences and higher BMIs, greater participation in adverse alcohol-related behaviors, and poorer performance on military-related tasks. Specifically, poor sleepers were less likely to meet the USDA dietary guidelines and CDC and ACSM exercise guidelines, eat breakfast on a regular basis, engage in positive eating habits, and more likely to drink sugar-laden sodas. These findings are also consistent with the literature.<sup>36,38,61-63</sup> For example, Gerber et al found that participants who reported higher fitness levels exhibited lower insomnia scores and had a higher perceived sleep quality.<sup>52</sup> Golley et al<sup>36</sup> reported that both late bedtime and late wakeup times were related to poor diet quality, independent of sleep duration. Cheng et al<sup>64</sup> noted a significant association between poor sleep quality and skipping breakfast in undergraduate female students, which is indicated in our finding that poor sleepers were more likely to skip breakfast. Although the research to date on breakfast and performance is derived primarily from young, school-age children, it is apparent that consuming breakfast is associated with enhanced attention and cognitive performance relative to not eating breakfast.<sup>65-69</sup> Of particular interest are the recent findings of Deshmukh-Taskar et al<sup>70</sup> showing that consumption of breakfast was associated with more favorable cardiometabolic risk profiles in adults 20 to 39 years of age when compared to skipping breakfast. Likewise, Naring et al<sup>71</sup> have indicated that adolescents who scored the

highest on measures of sleep disturbances were significantly more likely to have cardiovascular risk factors and hypertension than those who scored the lowest.

Studies have also shown a relationship between sleep and successful weight loss. For example, Chaput et al<sup>72</sup> found that more fat mass was lost over the course of a weight-reduction program by those who reported good sleep quality prior to starting the program. Consistent with that work, Thomson et al<sup>73</sup> found that participants who reported better subjective sleep quality were more likely to be successful with weight loss. This is not unexpected as Kim et al<sup>62</sup> examined dietary patterns in association with sleep duration and concluded that both habitual short sleepers and very long sleepers typically did not eat during conventional eating hours—they had disrupted eating patterns with snacks being dominant over meals. Of note, both unconventional eating hours and snack dominance were reflective of a low quality diet, that is, lower intakes of fruits and vegetables and higher intakes of sweets and fat as a percentage of energy.<sup>62</sup> Together these reports demonstrate the close interrelationship between sleep and dietary habits and the influence on overall health.

The limitations of this study must be acknowledged. First, only 2 sleep questions were used, unlike the Pittsburgh Sleep Quality Index which has 20 questions.<sup>12,74,75</sup> However, the 2 questions were global and reflective of perceived sleep quality. Moreover, the percent of persons self-reporting poor sleep was what had been anticipated. Thus, the results are most likely accurate given the large sample size. Secondly, the relationships between sleep and scores on emotional and social health do not allow any determination of the key components of either specific dimension. However, the strength of the relationships demonstrates a clear interaction between sleep quality and emotional and social health. Further research will be necessary to refine the relative contribution of the factors discussed herein. Finally, the information on dietary patterns is not as granular as might be desired, but again the trends were quite strong, so these data will allow for further examination of specific patterns in the future.

### RELEVANCE TO PERFORMANCE TRIAD

In summary, this study is one of the first to examine self-reported sleep quality within the context of overall lifestyle patterns and self-reported psychosocial health in a military population. Poor sleepers were more likely to be poor eaters, engage in less healthy dietary and

lifestyle behaviors, and score in the lowest quartiles with respect to emotional and social health. It further validates the central and essential relationships among physical activity, nutrition, and sleep—they fully support the concept of the Performance Triad. The results underscore the need to provide education on the health consequences of poor sleep habits and supportive resources for ensuring sufficient high quality sleep. However, this should be done in an integrative fashion so as to include information on nutrition and physical fitness, as they are intertwined and must be considered as a whole.

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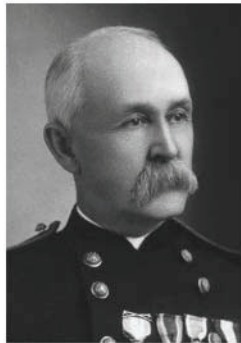
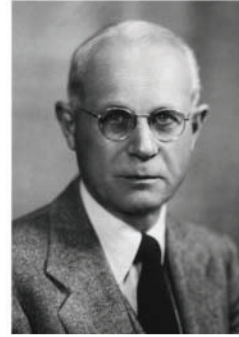
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## "GOOD TUBERCULOSIS MEN" THE ARMY MEDICAL DEPARTMENT'S STRUGGLE WITH TUBERCULOSIS

As the United States prepared for war in Europe, Army Medical Officer George E. Bushnell recognized the threat of *Mycobacterium tuberculosis* to American troops, and noted, what the Army needed was some "good tuberculosis men." Despite the efforts of the nation's best "tuberculosis men," the disease would become a leading cause of World War I disability discharges and veterans' benefits. This book tracks the impact of tuberculosis on the U.S. Army from the late 1890s, when it was a ubiquitous presence in society, to the 1960s when it became a curable and controllable disease.



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# The Challenge of Sleep Management in Military Operations

Nancy J. Wessenden, PhD  
Thomas J. Balkin, PhD

## ABSTRACT

It has long been known that short-term (days) insufficient sleep causes decrements in mental effectiveness that put individuals at increased risk of committing errors and causing accidents. More recently, it has been discovered that chronic poor sleep (over years) is associated with a variety of negative health outcomes (metabolic syndrome, obesity, degraded behavioral health). Implementing an effective sleep health program is, therefore, in the best interests of active duty personnel and their families both in the short- and long-term. Like managing physical activity or nutrition, effectively managing sleep health comes with its unique set of challenges arising from the fact that individuals who routinely do not obtain sufficient sleep are generally desensitized to feeling sleepy and are poor at judging their own performance capabilities—and individuals cannot be compelled to sleep. For these reasons, an optimally effective sleep health program requires 3 components: (1) a rigorous, evidence-based sleep education component to impart actionable knowledge about optimal sleep amounts, healthy sleep behaviors, the known benefits of sleep, the short- and long-term consequences of insufficient sleep, and to dispel myths about sleep; (2) a nonintrusive device that objectively and accurately measures sleep to empower the individual to track his/her own sleep/wake habits; and (3) a meaningful, actionable metric reflecting sleep/wake impact on daily effectiveness so that the individual sees the consequences of his/her sleep behavior and, therefore, can make informed sleep health choices.

## SLEEP IS A PHYSIOLOGICAL REQUIREMENT

Like the need for food, water, and air, the need for sleep is physiologically based. However, sleep differs from other basic physiological needs in several key respects. The most salient of these is the fact that sleep is not actually necessary to sustain human life. Although there are limits to the duration of time that life can be sustained in the absence of food, water, or air, there is no known limit to the number of hours/days/weeks that humans can go without sleep. In a series of studies conducted at the University of Chicago in the early 1980s, Retschaffen and colleagues<sup>1</sup> reported that rats that were totally deprived of sleep died within 2-3 weeks. At the time those studies were published, the mechanism by which total sleep loss effected death in the rats was not clear. It was subsequently shown that preceding death, sleep-deprived rats display transmigration of bacteria from the gut that results in widespread extraintestinal infection/septic load.<sup>2</sup> Similar effects of sleep loss have not been observed in any other species, including humans (and notably, neither humans nor rats can volitionally go without sleep for more than a few days, meaning that nonvolitional behavioral methods or pharmacological methods must then be used to maintain wakefulness).

Accordingly, there are no known instances in which a human death has been *directly* attributed to sleep

deprivation. Of course, there are numerous instances in which insufficient sleep has indirectly resulted in death: for example, the Automobile Association of America estimates that between 1999 and 2008 sleepiness was a contributing factor in 16.5% of traffic fatalities (approximately 69,300 deaths) in the United States.<sup>3</sup> And it is clear that insufficient sleep exacts an enormous economic toll as well, with yearly costs resulting from home and industrial accidents, errors, and inefficiencies estimated to cost the US economy hundreds of billions of dollars per year.<sup>4</sup> But there is no evidence that sleep subserves any physiological function that is *directly* necessary for sustaining life. Patients with a rare prion disease called fatal familial insomnia experience total insomnia for several months before eventually succumbing; however, it is likely that these deaths are the result of other aspects of the disorder (for example, the large thalamic lesions that also characterize the disorder).<sup>5</sup> Also, patients can be kept alive in a coma for decades, and coma is *not* sleep. In fact, some patients with a diagnosis of vegetative state/unresponsive wakefulness syndrome show no discernible evidence of sleep.<sup>6</sup>

This is not to say that sleep plays no role in the maintenance of health. Over the past 2 decades, evidence that chronic sleep disturbance is associated with mood disorder,<sup>7</sup> impaired immune function,<sup>8</sup> age-related cognitive decline,<sup>9</sup> metabolic syndrome/obesity/diabetes,<sup>10</sup> heart

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disease,<sup>11</sup> and even cancer<sup>12</sup> has steadily accrued. The exact mechanism(s) by which sleep exerts its influence on these disorders is not known. Also unknown is whether sleep disturbance exerts a direct causal or indirect influence. Compared to food, air, or water—resources obtained from the environment that when removed lead to death in a relatively quick and straightforward manner—sleep (a wholly internal phenomenon that depends on the presence of no particular environmental resources) is less critical for actual survival. For example, sleep is not critical for vegetative processes needed to maintain viability of individual brain cells.

Nevertheless, sleep does play a crucial role in day-to-day functioning: it promotes and sustains waking brain (specifically, neocortical) processes that constitute and/or facilitate mass action-potential-dependent functions ranging from basic consciousness/alertness to higher-order mental abilities including situation awareness, problem-solving, memory, and creativity.<sup>13-15</sup> The importance of sleep to higher-order mental abilities is illustrated in Figure 1, which depicts the effects of 24 hours of total sleep deprivation on regional brain metabolic activity. Among the cortical regions most metabolically degraded by sleep loss is the prefrontal cortex (blue areas located in the frontal portion of the brain), the brain region responsible for mediating the highest-order cognitive functions.<sup>17</sup> A translation of such higher-order mental abilities into operationally relevant capabilities is presented in the Table. In short, sleep is a process that not only occurs in the brain, it is also a process that undoubtedly confers unique benefits to the brain itself.

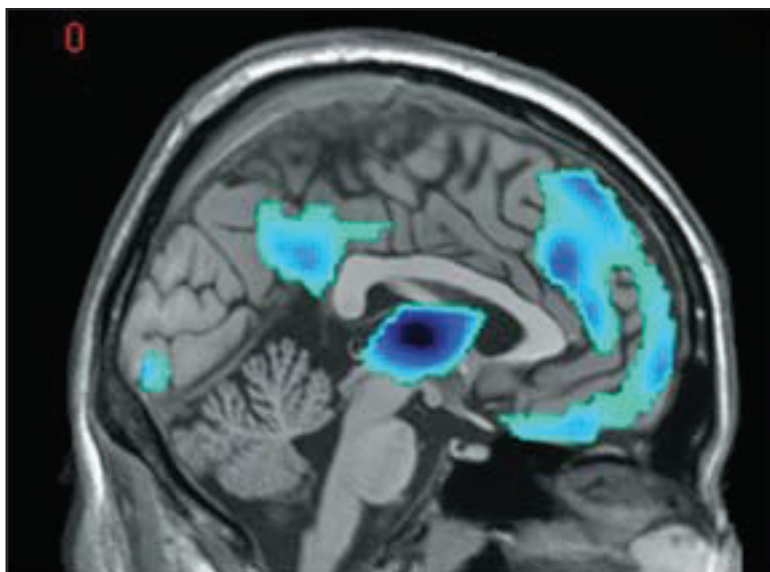


Figure 1. Characterization of brain metabolic activity after 24 hours of total sleep deprivation. Darkest shades of blue indicate areas of greatest metabolic deactivation compared to baseline (normal alertness). Adapted from Thomas et al.<sup>16</sup>

### PUBLIC AWARENESS OF THE IMPORTANCE OF SLEEP

Partly as a result of concerted efforts by organizations such as the National Institutes of Health,<sup>19,20</sup> the Centers for Disease Control and Prevention,<sup>21</sup> and the National Sleep Foundation,<sup>22</sup> and partly as a result of the discovery that sleep disorders (most notably obstructive sleep apnea) are prevalent in United States, awareness of the importance of sleep has rapidly expanded within the general population over the past several decades. In fact, the term sleep apnea, first coined in the scientific medical literature in 1976,<sup>23</sup> is now a widely used and understood part of the American lexicon. Also, the possible role of insufficient sleep in highly publicized incidents including the nuclear reactor near-meltdown at Three Mile Island on March 28, 1979 (for which the causal human error occurred in the early morning hours<sup>24</sup>), the explosion of the space shuttle *Challenger* on January 28, 1986 (for which the serious flaw in decision-making also occurred during early morning hours, prior to launch<sup>25</sup>), the nuclear reactor meltdown at Chernobyl on April 26, 1986 (for which standard opinion is that operator error was the root cause of the disaster<sup>26</sup>), and more recently the 2009 Colgan Air Flight 3407 crash near Buffalo, NY (for which the sequence of errors that ultimately led to the crash are consistent with deficits in higher-order cognitive abilities degraded by insufficient sleep, perhaps most notably a degraded ability to rapidly recognize a failed course of action and adjust accordingly<sup>27</sup>) have heightened awareness of the importance of adequate sleep, particularly for those engaged in occupations for which lapses in attention or judgment can have disastrous consequences.

### HOW MUCH SLEEP?

Sleep experts are often asked by leaders, “What is the minimum amount of sleep that my Soldiers need to remain effective?” This question reflects the tacit calculation that Soldier productivity during all hours spent asleep is zero, and productivity for all hours spent awake is greater than zero. Viewed this way, it makes sense to maximize the number of hours that troops spend awake and minimize the number of hours that they spend asleep each day.

However, the problem with this calculation becomes clear if one substitutes “mental agility” or “situational awareness” for sleep. The question then becomes “what is the minimum amount of mental agility/situational awareness that my Soldiers need to remain effective?” From both a physiological and practical standpoint, the answer is “more is always better.” There are 2 reasons for this. First, as discussed



Operationally Relevant Capability Impacted by Sleep.		
MOST IMPACTED	ALSO IMPACTED	LESS IMPACTED
Acquiring, assigning priorities, allocating, and using resources	Establishing position Requesting fire	Loading magazines
Anticipating and solving problems	Coordinating squad tactics	Lifting
Managing and exploiting change	Monitoring environment (vigilance)	Digging, etc.
Acting decisively under pressure	Attending to preventive maintenance	

Adapted from Chapter 4, *Field Manual 6-22.5*.<sup>18</sup>

previously, sleep promotes waking mental acuity: the more sleep that is obtained, the better the individual is able to maintain situational awareness, anticipate and solve problems, generate creative and appropriate solutions, etc. In battlefield situations, even the smallest “edge” in reaction time, situation awareness, and problem solving could be critical to mission success. Second, more sleep is always better because it ensures not only that sleep debt is not incurred acutely, but it also helps ensure that more long-term, subtle sleep debt, which becomes apparent under conditions of chronic insufficient sleep, does not accrue. It is this latter situation which is less appreciated but far more insidious

and potentially problematic. Stated another way, the more sleep a Soldier obtains on a regular basis, the more resilient that Soldier becomes to the effects of subsequent sleep loss. In effect, the Soldier establishes a “sleep reserve”<sup>28</sup> that can be tapped days (and perhaps even weeks) later to better sustain alertness and performance when subsequently faced with the challenge of sleep loss resulting from high tempo of operations (OPTEMPO), continuous operations, etc. For example, Rupp et al<sup>29</sup> showed that volunteers who were allowed 10 hours time in bed per night (TIB) for 7 nights performed better during a subsequent sleep restriction challenge of 3 hours TIB than volunteers who were allowed 7 hours TIB for 7 nights prior to the same 3-hour TIB challenge. The data is presented in Figure 2. Critically, the difference between the groups grew as the sleep restriction challenge continued across days, and recovery was faster in the 10-hour prior TIB group (that is, less recovery sleep was needed to restore alertness and performance to baseline levels). These findings reveal the long time constant associated with sleep’s beneficial effects. It may be that these enduring, slowly accumulating beneficial (or, in the case of insufficient sleep, deleterious) effects underlie the relationship between sleep and general health, relationships that

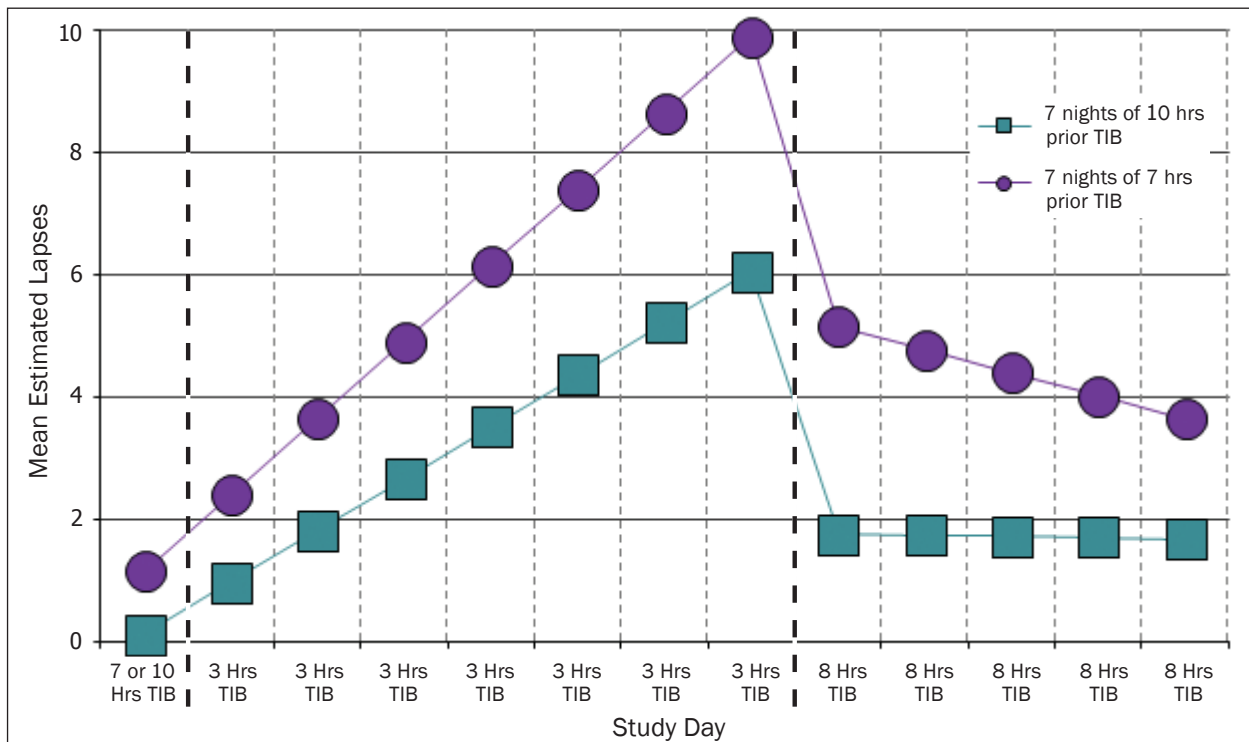


Figure 2. Objective performance during a sleep restriction challenge of 3 hours time in bed (TIB) for 7 nights. For the 7 nights immediately preceding the 3-hour TIB challenge, one group was allowed 10-hours TIB per night and the other was allowed approximately 7-hours TIB per night. Although performance in both groups deteriorated across the 3-hour TIB challenge, the rate of performance deterioration was slower, and recovery was faster, in the 10-hour TIB group. Adapted from Rupp et al.<sup>29</sup>

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may only become apparent over years. Little is known about the influence of prior sleep history. In controlled laboratory studies published to date, prior sleep history has been recorded only for approximately a week. Also, our study was the only one in which prior sleep history was manipulated. The influence of sleep history may be greater than the magnitude shown in results from cross-sectional studies,<sup>30</sup> that is, the extent to which sleep can be banked may be greater than that shown in our relatively short-term (7 days of banking) study. Ideally, future longitudinal studies will be conducted in which volunteers' daily sleep amounts are tracked over weeks, months, and/or years, and compared against sensitive and relevant metrics of neurobehavioral performance, physical health, behavioral health, etc.

Although more sleep is always better in terms of alertness and performance, it is not invariably the case that sleep opportunity should *always* be maximized during military operations. Because recuperative benefits do not accrue linearly during sleep,<sup>32</sup> within every operational situation there is a point at which extra sleep provides diminishing returns: an inflection point at which the amount of recuperation (mental acuity/resilience) that is gained by extending sleep duration is outweighed by the short-term benefits (in terms of work/productivity) that can be realized by having the Soldier remain awake performing his or her duties. Thus, just as carrying too much fuel, food, and ammunition for a particular mission can exact costs in terms of efficiency or effectiveness, it is possible that too much time allocated for sleep could cut into military effectiveness by inefficiently cutting into the number of hours of productive wakefulness.

In reality, the likelihood of a scenario in which too much time is allotted for sleep during a military operation is low. With the generally high OPTEMPO of military operations, the problem has been (and will likely remain) ensuring that nominally adequate time is allotted for sleep. In practice, this not only means allotting adequate time for sleep itself, but additionally allotting adequate time for other activities (calling home, for example) for which military personnel will invariably sacrifice sleep, if forced to choose between the two.

Therefore, the primary target of opportunity, the lynchpin of success for a sleep/alertness management program, will be a change in behavior in which each person conscientiously and voluntarily optimizes sleep during whatever time(s) he has available. In order to achieve this, it will first be necessary to get "buy-in" (through reeducation) to the simple truth that in the operational environment, Soldiers not only put themselves at risk, but also potentially endanger their fellow Soldiers by

foregoing sleep for nonessential waking activities. It will also be necessary to educate the larger Army family regarding the relationship between optimal sleep and everyday functioning, including but not limited to better on-the-job performance, better motivation to maintain a fitness program, better school performance, and improved mood.

### WHAT DRIVES OUR SLEEP BEHAVIOR?

This change in behavior and attitude is neither simple nor straightforward because when left to our own devices, we as individuals and as a society rarely opt to maximize sleep duration, and thus optimize next-day alertness and performance. Instead, we seem to choose sleep durations that strike an implicitly self-selected balance between engagement in competing waking activities (both work-related activities and recreational pastimes such as watching television, playing video games, etc) and the physiological need/desire to sleep, resulting in an objectively less-than-optimal (but subjectively tolerable and sustainable) level of chronic, mild sleep restriction.

There is a good explanation for why we do not obtain more sleep: over days/weeks (and also months and years) of insufficient sleep, individuals become inured to the feeling of sleepiness, the primary mechanism by which the brain communicates the need for sleep. When asked how they feel, individuals with untreated obstructive sleep apnea will often reply that they feel normally alert, even though they cannot maintain wakefulness under nonstimulating situations such as sitting in meetings, watching television, and sometimes even while driving a vehicle under monotonous conditions. By all objective criteria, these individuals are pathologically sleepy (unable to maintain wakefulness for more than a few minutes when subjected to a nonstimulating environment), yet they do not consider themselves to be excessively sleepy. It is as though over months or years of insufficient sleep, their set-point or threshold for subjective sleepiness has substantially increased. Similarly, in one study, Belenky et al<sup>33</sup> showed that this habituation to subjective sleepiness occurs within a few days of switching from an 8-hour TIB schedule to a 3-hour TIB schedule. Notably, subjective sleepiness did not track objective performance, which continued to degrade across sleep restriction (Figure 3). The abrupt transition from 8 hours TIB to 3 hours TIB may not mimic real-world conditions in which individuals may volitionally increase total recuperative sleep time (TrST) over time, but a similar lack of correspondence between performance and subjective alertness was evident in both the 5-hour and 7-hour TIB groups in which the TIB decrement was not so drastic.

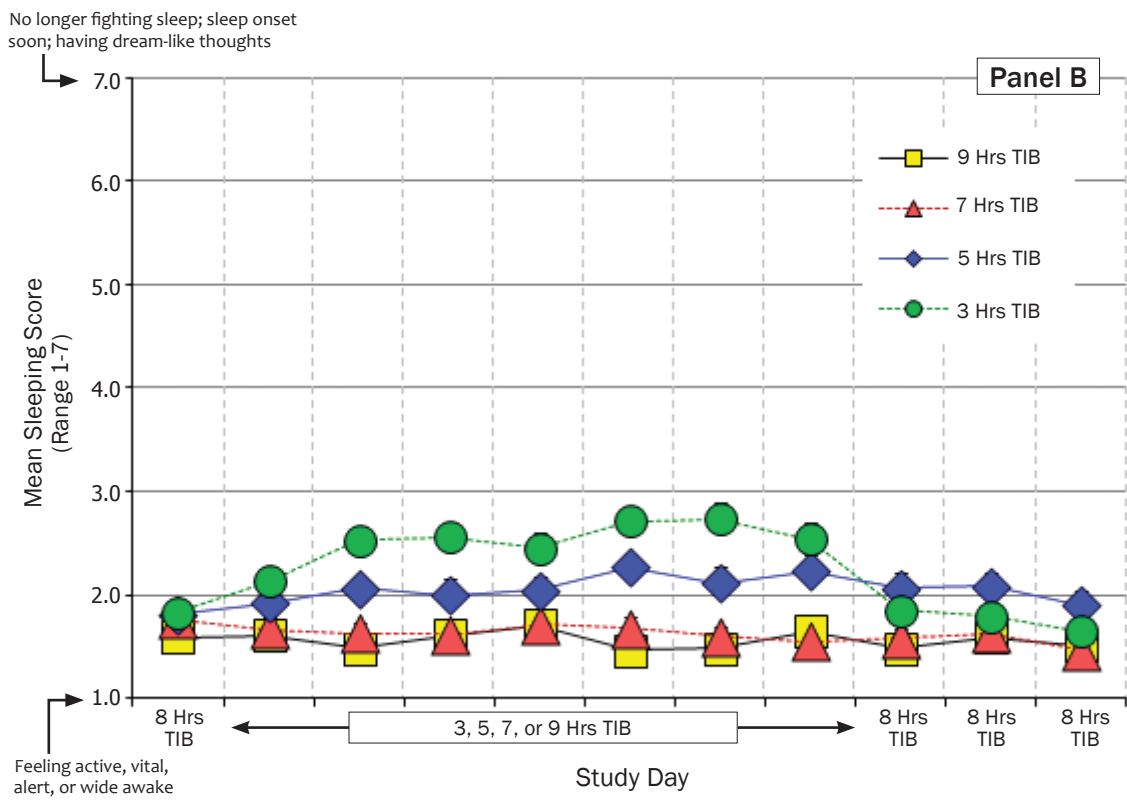
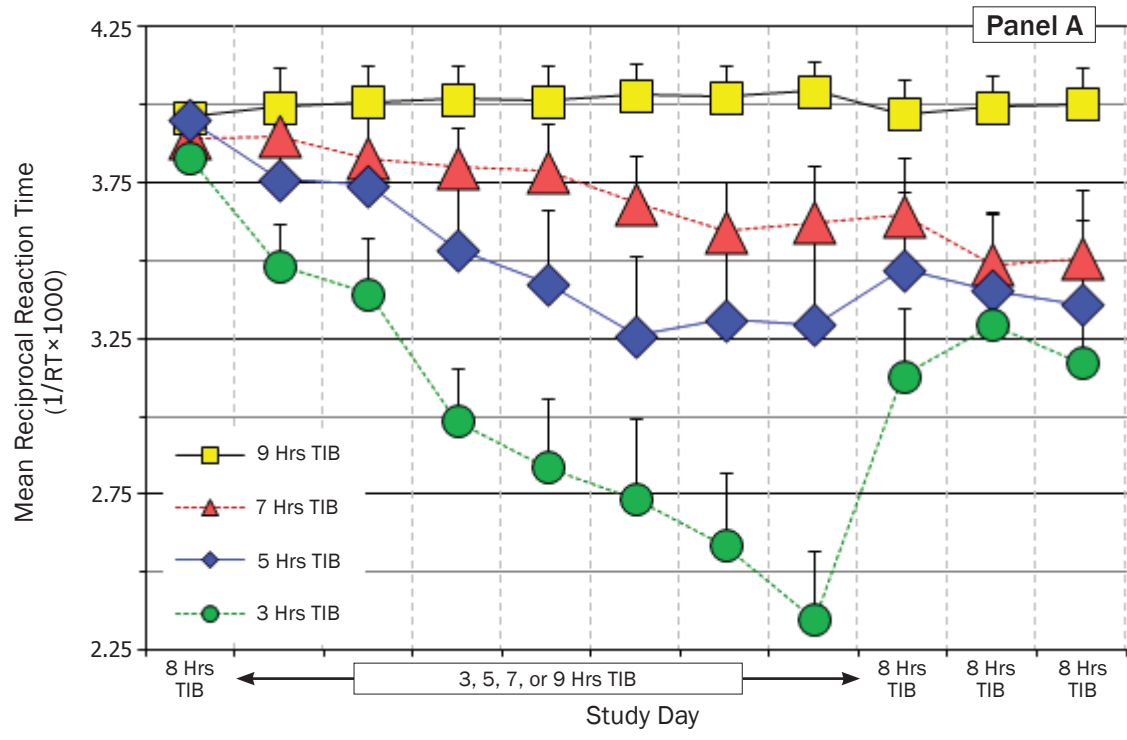


Figure 3. Objective performance (panel A—mean reciprocal reaction time on a simple one-choice reaction time task) and subjective alertness (panel B—responses on the Stanford Sleepiness Scale) across days on different nightly sleep schedules. Adapted from Belenky et al.<sup>33</sup>

TIB indicates time in bed per night. RT indicates reaction time.

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Stated another way, we generally fail to appreciate the deleterious effect of insufficient sleep on our own performance. We suffer few (if any) identifiable day-to-day negative consequences of insufficient sleep. We may nod off during an afternoon briefing, not appreciating that this is a cardinal sign of insufficient sleep, but most of us have no objective marker (such as productivity at work) against which the effect of insufficient sleep can be quantified and tracked. Serious consequences of day-to-day, commonly experienced levels of sleepiness, such as fatal automobile crashes, are relatively infrequent even among young adults, for whom traffic accidents are a leading cause of death. News stories on high-profile, sleepiness-related accidents may fail to resonate because they typically focus on workers in high-risk professions, such as transportation workers. Likewise, news stories and emerging information about the long-term health consequences of inadequate sleep may not resonate with young adults, simply because the potential for such problems seems too remote.

Consequently, a campaign to improve sleep health in the military family requires 3 components: (1) an aggressive education component, (2) an accurate, objective personal sleep assessment tool, and (3) the means to translate the objectively-measured sleep data into a relevant effectiveness prediction.

### EDUCATION COMPONENT

Myths, misinterpretations/misrepresentations of fact and old wives' tales regarding sleep are common. This situation is magnified by nearly universal access to the internet, where misinformation can be rapidly disbursed among and perpetuated by millions of people. Self-identified "experts" who appear on television and radio talk shows and sensationalize research findings or disseminate misinformation unwittingly compound the problem.

Therefore, a campaign to change sleep behavior starts with education to ensure that our active duty military personnel and their families receive accurate (nonsensationalized) and timely information about the currently known benefits of sleep and consequences of insufficient sleep. Education is required to dispel beliefs based in myth, misinformation, and/or outdated information. For example, it is widely held, even among some sleep experts, that naps should be curtailed or limited in duration to avoid "sleep inertia" (degraded alertness and performance upon awakening). This myth appears to be rooted in a non-peer-reviewed report in which the authors incorrectly extrapolated the transition through sleep stages that occurs within the confines of a well-controlled laboratory environment to real-world conditions. It also appears to be based on a publication in

which the duration of sleep inertia was estimated to be up to 4 hours, an overestimation based on the known improvement in performance, even in totally sleep-deprived individuals, that occurs across the day as a result of the circadian alertness signal.\*

The desired outcome of an educational effort is that military leaders appreciate the role of sleep in mission success and consequently prioritize sleep in the mission-planning process, and individual Soldiers and their family members likewise understand the importance of sleep and also choose to prioritize it: they voluntarily devote maximum free time to sleep and voluntarily minimize sleep-stealing activities such as video games.

### ACCURATE, OBJECTIVE SLEEP ASSESSMENT

The second component for behavior change is an objective and accurate sleep assessment tool to quantify and track the behavior of interest, in this case, sleep. For the vast majority of individuals (nonclinical settings), the key sleep parameter is TrST per 24 hours. The timing of sleep within the 24-hour period affects TrST in a predictable way: during a daytime sleep period, individuals awaken frequently, although they may not remember these awakenings, which may last only a few seconds to a few minutes. Daytime "sleep fragmentation" or degraded "sleep quality" is caused by the brain's circadian alertness signal\* and/or from light, noise, or other environmental disruptions. Time spent awake, no matter how brief, reduces TrST within a given period allocated for sleep. That is, sleep quality and sleep quantity are actually the same.<sup>34</sup> It was previously thought that sleep "continuity" or "fragmentation" was a parameter of sleep that was independent of other sleep metrics such as amount of time spent in the various sleep stages, which sum to total sleep time. However, results of numerous studies aimed at determining the basis of sleep continuity led to the same conclusion: there is no evidence that sleep continuity or sleep fragmentation are measurable factors contributing independently to recuperation during sleep.<sup>34</sup>

Currently, the technology best suited for objectively tracking relevant sleep parameters in the operational environment is wrist actigraphy. This mature and well-validated technology<sup>35</sup> is based on the observable fact that normal, healthy humans move their wrists more frequently during wakefulness (even when in engaged in sedentary activities like watching television) than during sleep. Wrist movement data are detected by an

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\*The circadian alertness signal is the alertness-enhancing output from the suprachiasmatic nucleus that increases from morning to peak in the late evening, and then decreases across the night to trough near the normal wake time.

accelerometer contained within the actigraph and then scored for sleep or wake using a sleep/wake scoring algorithm. Modern wrist actigraphs are “wear-and-forget” wristwatch-like devices that contain sufficient memory to record wrist movement activity continuously for 4-6 weeks at a time. For some actigraphs, the sleep/wake-scoring algorithm resides on a microprocessor in the actigraph and sleep/wake is automatically scored. Real-time information regarding amount of time spent sleeping over the last few hours or days can be displayed on the actigraph face.

A limitation of actigraphy is that sleep stages cannot be distinguished from one another. In particular, the lightest stage of sleep (N1) which appears to have no recuperative value is indistinguishable from deeper stages of sleep that have been clearly linked to recuperation. In normal sleepers, this limitation is almost inconsequential since normal individuals do not spend appreciable amounts of time in stage N1 (and almost none at all if they carry a sleep debt). However, in certain patient populations who experience numerous awakenings (and consequently more stage N1), their total recuperative sleep may be overestimated, and less sensitive actigraphs will overestimate recuperative sleep to a greater extent than more sensitive devices.<sup>36,37</sup> However, for purposes of improving sleep health by increasing time spent asleep (which is the primary issue), actigraphy provides a useful, objective, and cost-effective means of measuring the amount of sleep obtained over days/weeks/months in a large number of individuals. That is, it provides individuals with a means to gauge the benefits of implementing behaviors and habits that promote healthy sleep (see “Ten Effective Sleep Habits” on the facing page).

#### ESTIMATED MENTAL EFFECTIVENESS: AN ACTIONABLE METRIC

Accurately measuring TrST is important. Translating this TrST into an actionable metric is of far greater practical value (for example, knowing how much gas is in your vehicle’s tank is useful, but not as useful as knowing how far you can drive on that amount of gas). In this respect, the effects of insufficient sleep are akin to those of blood pressure, difficult to self-assess and thus appropriately manage without an external, objective, quantifiable measure against which the success or failure of management efforts can be gauged.

In terms of “sleep miles per gallon,” mental effectiveness is a key actionable metric because, as discussed above, the main function of sleep is to support mental effectiveness, which in turn underlies success in military operations and in daily living. At the group (squad,

platoon, etc) level, such information is valuable to planners for immediate and future resource allocation. At the individual Soldier level, effectiveness feedback is valuable for providing the individual with an objective estimate of the extent to which his or her sleep/wake schedule is affecting mental performance, an estimate that may deviate substantially from what the wearer perceives to be his or her current mental effectiveness.

Commercial entities (most notably the airline industry) currently use effectiveness prediction models as part of prospective fatigue risk management programs. The most widely used model was developed by the Department of Defense (DoD).<sup>38-45</sup> The Federal Aviation Administration recently determined that effectiveness models (and specifically the DoD model) have undergone sufficient evaluation to be used in aviation fatigue risk management decisions. The US Naval Safety Center uses the DoD effectiveness model to retrospectively analyze the potential role of fatigue (insufficient sleep and circadian factors) in mishap investigations, and the USAF Air Mobility Command uses model predictions as a component of its aviation operational risk management matrix. For these types of applications, sleep/wake is not measured directly but is estimated based on flight schedule, travel across time zones, etc. Fatigue mitigation strategies also can be modeled. For example, the effectiveness benefit realized by obtaining a 30-minute in-flight nap (for operations in which in-flight napping is allowed) can be modeled, and the resulting effectiveness used as the basis for informed decision-making.

#### SLEEP, MENTAL EFFECTIVENESS, AND LONG-TERM PERFORMANCE TRIAD GOALS

In the short term, the goal of the Performance Triad is to “improve individual performance and resilience through improved sleep, activity, and nutrition discipline.”<sup>46</sup> As outlined above, mental effectiveness serves as the objective marker of sleep health.

But what is the long-term goal that can be subserved by improved sleep (and thereby improved mental effectiveness)? As Army Surgeon General LTG Patricia Horoho stated,

We will continue to encourage members of the Army Family to incorporate health-promoting behaviors and decisions into their everyday lives. The success will be measured by the improvement in health and the reduction of disease and injury among Army team members.<sup>47</sup>

As noted earlier, although the exact mechanism(s) by which sleep promotes long-term health are not yet clear, mounting evidence indicates a link between chronic poor sleep and a myriad of behavioral and physical

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health ailments. Regardless of mechanism, the implication is clear: improving sleep health is a “win-win,” both in the short-term and the long-term.

### SUMMARY AND CONCLUSIONS

One goal of an effective sleep education effort is to ensure that leaders understand the importance of sleep and, as a consequence of this understanding, provide adequate daily sleep opportunities for their personnel during military operations, to the extent possible within

the constraints of mission requirements and exigencies. Also, it is critical that Soldiers and their families appreciate the importance of sleep for overall health so that they are motivated to actually *use their time wisely* to optimize the amount of sleep obtained on a daily basis. With respect to the latter, the use of technologies such as wrist actigraphy and effectiveness prediction models will prove invaluable for tracking and maintaining the desired behaviors, ultimately resulting in a healthier, more effective, and more productive military.

<b>Ten Effective Sleep Habits</b>	
1.	Create a quiet, dark, comfortable sleeping environment. Cover windows with darkening drapes or shades (dark trash bags work as well), or wear a sleep mask to block light. Minimize disturbance from environmental noises with foam earplugs or use a room fan to muffle noise. If you can, adjust the room temperature to suit you. If you cannot, use extra blankets to stay warm. Use a room fan both to muffle noise and keep you cool.
2.	Use the bedroom only for sleep and intimacy. Remove the TV, computer, laptop, and other electronic distractions from your bedroom. Do not eat or drink in bed. Keep discussions or arguments out of the bedroom.
3.	Stop caffeine consumption at least 6 hours before bedtime. Caffeine promotes wakefulness and disrupts sleep.
4.	Do not drink alcohol before bed. Alcohol initially makes you feel sleepy, but disrupts and lightens your sleep several hours later. In short, alcohol reduces the recuperative value of sleep. Nicotine, and withdrawal from nicotine in the middle of the night, also disrupts sleep. If you need help quitting drinking or using nicotine products, see your healthcare provider for options.
5.	Complete your exercise by early evening. Exercising is great, just be sure to finish at least 3 hours before bedtime so that you have plenty of time to wind down.
6.	Do not go to bed hungry. A light bedtime snack (eg, milk and crackers) can be helpful, but do not eat a large meal close to bedtime. And empty your bladder just before you go to bed so that the urge to urinate does not disrupt your sleep.
7.	Maintain a consistent, regular routine that starts with a fixed wakeup time. Start by setting a fixed time to wake up, get out of bed, and get exposure to light each day. Pick a time that you can maintain during the week and on weekends, then adjust your bedtime to target 7-8 hours of sleep.
8.	Get out of bed if you cannot sleep. Only go to bed (and stay in bed) when you feel sleepy. Do not try to force yourself to fall asleep; it will tend to make you more awake, making the problem worse. If you wake in the middle of the night, give yourself about 20 minutes to return to sleep. If you do not return to sleep within 20 minutes, get out of bed and do something relaxing. Do not return to bed until you feel sleepy.
9.	Nap wisely. Napping can be a good way to make up for poor or reduced nighttime sleep, but too much napping can cause problems falling asleep or staying asleep at night. If you need to nap for safety reasons such as driving, try to do so in the late morning or early afternoon, perhaps right after lunch, to take the edge off your sleepiness.
10.	Move the clock from your bedside. If you tend to check the clock two or more times during the night, and if you worry that you are not getting enough sleep, cover the clock face or turn it around so that you cannot see it (or remove the clock from the bedroom entirely).
<p>The Ten Effective Sleep Habits were assembled by the Army Surgeon General's Performance Triad Sleep Working Group.</p>	

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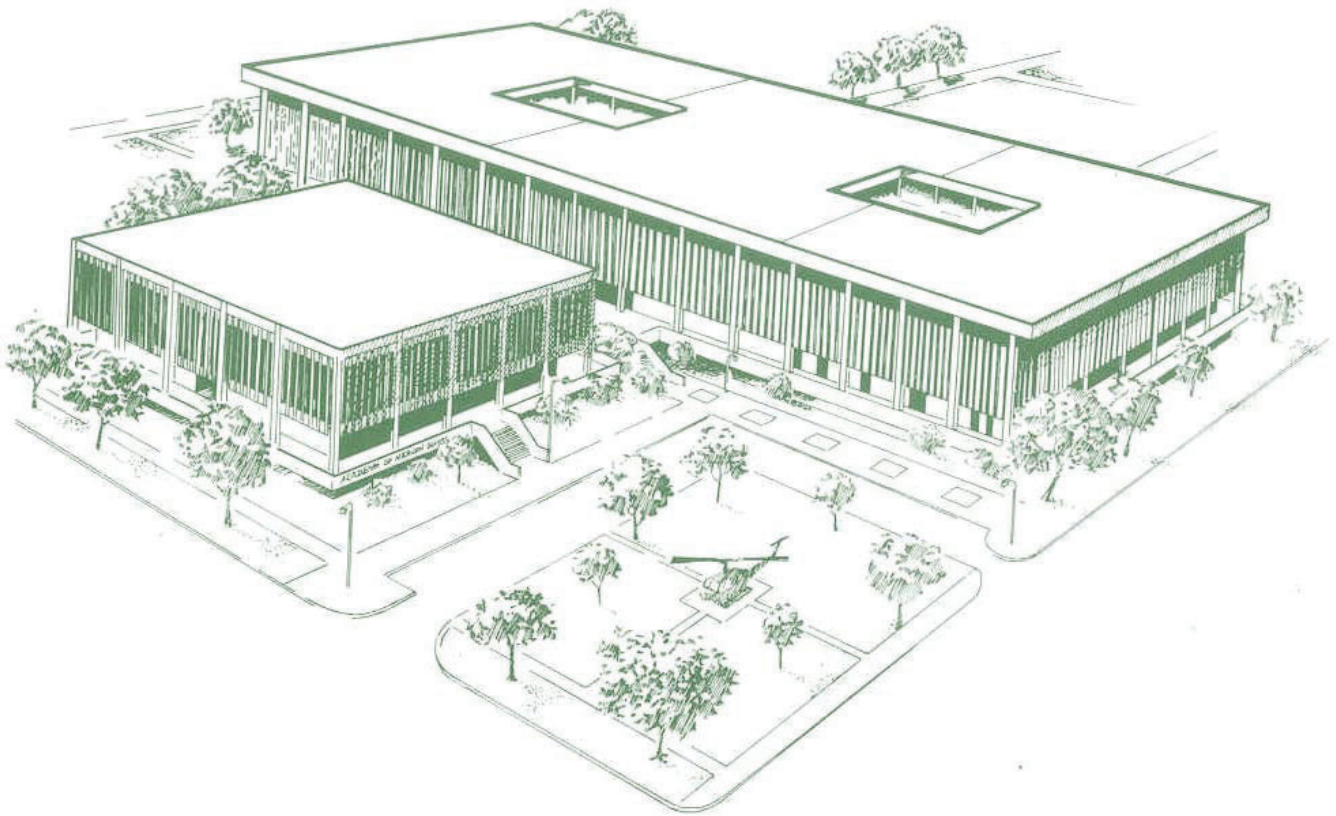
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