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Human Performance Enhancement

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ABOUT THIS REPORT

This report, the sixth in the *Super Soldier* series, covers findings of the Center for a New American Security's study on dismounted soldier survivability. This report is in response to a study conducted for the Army Research Laboratory to identify future concepts and technologies to improve soldier survivability and effectiveness over the next 20 to 30 years in order to identify high-payoff science and technology investment areas. While the primary audience for this report is the Army science and technology community, the report's findings and recommendations may be of interest to a broader group of stakeholders, including across the Army, the Joint Force, and the wider defense community. The full series can be found at www.cnas.org/super-soldiers.

Views expressed in this report are of the authors alone. CNAS does not take institutional positions.

Executive Summary

No attributes are more foundational to success in combat than the physical and cognitive performance of warfighters. Technological advantage has always played a central role in war, from the bow and arrow to modern missiles, but technologies are mere tools in the hands of warfighters. People, not widgets, fight wars.

Militaries have long sought to directly enhance the physical and cognitive performance of warfighters, and indeed some human performance enhancement drugs are widely used across the U.S. military today, such as caffeine. Existing technologies have demonstrated the ability to improve individual physical and cognitive performance above baseline levels and in key areas central to military competition: strength, focus, attention, learning, and resistance to fatigue. Many of these technologies are already being used in civilian settings, in licit or illicit contexts.

The U.S. military is not fully capitalizing on the advantages enabled by human performance technology today and is woefully unprepared for some of the potential changes that could come from future advances in biotechnology. War is dangerous, and enhancements that allow soldiers to carry more protective gear, be more alert, or be better trained all have significant payoffs in terms of improving soldier survivability.

Human performance enhancement technologies raise important legal, ethical, and social issues, some of which are unique to military settings. The U.S military must carefully consider these issues and balance any treatment's risk to a service member against the operational risk the treatment is mitigating. Voluntary use is a particularly challenging issue for military personnel, as service members are an inherently vulnerable population susceptible to coercion – real or perceived, implicit or explicit – from commanders. Nevertheless, these concerns can be met with appropriate procedures in place. There are pathways today for safe and ethical military research on pharmaceuticals and other enhancement techniques, such as brain stimulation. Both the Army and Air Force have conducted studies on modafinil, and the Air Force has conducted research on non-invasive brain stimulation. These research efforts to date generally have been small, however, and the Department of Defense does not have a comprehensive research effort underway to capitalize on existing technologies, many of which have demonstrated benefits in civilian settings. At the same time, the reality is that by providing easy access to caffeine while deployed and over-the-counter supplements on military bases, DoD leaders have de facto encouraged widespread, ad hoc, unregulated use of human enhancement technologies by warfighters without robust guidelines in place or physician oversight. This is the least optimal strategy, one that maximizes the risks and minimizes the potential benefit of treatments.

DoD must urgently increase research into the benefits and risks of human performance technologies and begin a cross-disciplinary dialogue on policies surrounding their use in military settings. The United States owes its warfighters the very best advantages on the battlefield to improve their survivability, and DoD leaders have a duty to seriously consider enhancements that could potentially save service members' lives.

Recommendations

The Army should:

Study, evaluate, and approve human enhancement, where appropriate, in accordance with ethical guidelines.

Physical fitness

- Investigate alternative physical fitness training methods to improve strength and operational performance on the battlefield.
- Leverage emerging technologies such as personal fitness trackers, consistent with DoD guidelines, to collect physical training data across the force and systematically evaluate the best methods for improving performance while avoiding injury.

Nutrition and dietary supplements

- Develop nutrition guides and provide the necessary supplements to develop muscle mass and improve performance as a part of nutrition planning, and limit unregulated supplement use.
- Where there is insufficient research with regard to a supplement's effectiveness, sponsor research to determine if the supplement has benefits to soldier performance.

Sleep

- Institute a comprehensive soldier sleep fitness program that implements the guidelines in *A Leader's Guide to Soldier Health and Fitness* (February 2016) and inculcates an attitude of "sleep as a weapon" in the force.
- Leverage personal fitness devices to track sleep patterns among soldiers and provide objective feedback on soldier sleep.

Pharmaceuticals and other enhancement techniques

- Institute a high-level policy review of potentially promising methods to enhance soldier physical and cognitive performance.
- Consider potential physical and cognitive enhancements on a case-by-case basis, evaluated based on the risks of the specific treatment and the relative operational advantages to soldier survivability.
- Investigate the efficacy, safety, and operational utility of physical and cognitive enhancement treatments, consistent with DoD medical guidelines.
- Participation in any research or operational use of enhancements should be voluntary, and the Army should institute procedures to ensure that soldiers are free from coercion, real or perceived, to take enhancements.

Introduction

Human enhancement is a broad topic, and attempts by militaries to modify the human body and the environment around it to produce better results have existed throughout time. Initially the changes were to the outside of the body: Shaved heads among service members help prevent the spread of lice, and routinely changing socks prevents foot problems on long marches. Caffeine consumption counteracts disrupted sleep cycles and long missions. But the introduction of more advanced technology enabled further enhancements, such as immunizations to prevent the spread of illness.

The complex nature of warfare requires both strong cognitive and physical performance for success, so improvement in either can increase survivability and mission performance on the battlefield. Earlier sections of this report have established that heavy loads affect both of these factors and have explored a variety of emerging technologies to address this problem. This section presents technologies that can be used to directly enhance warfighters' cognitive and physical performance. *The Army should study, evaluate, and approve human enhancement, where appropriate, in accordance with ethical guidelines.*

Physical Enhancement

Improved training, nutrition, and the use of performance-enhancing drugs can improve physical performance. Soldiers must be prepared for a multitude of possible operations, requiring well-rounded fitness. But there are certain challenges they face that can help focus training attention with overall benefits. Current training standards focus on somewhat arbitrary measures of fitness, including a 2-mile run and the number of push-ups and sit-ups completed in two minutes.[1] These measures do not adequately illustrate which soldiers will or will not perform well on the battlefield. Lighter soldiers reasonably will more easily perform cardio-intensive activities, such as running, as they have less mass to transport. This does not, however, mean these soldiers are better performers on the field. In fact, measured by mass, smaller soldiers are more likely to struggle to carry heavy loads and maintain agility in combat. The Army could modify both testing standards and training to address this issue.

Improved training

Improved forms of training like interval training can be used to improve soldier performance. Periods of rest and activity are alternated; when the intense periods are particularly vigorous, it is known as high-intensity interval training (HIIT), with even more enhanced results. These workouts combine aerobic activity, strength training, and gymnastics/external loading in tandem. Athletes of all types see benefits from HIIT, with rapids gains seen among the untrained and endurance improvement seen even among the highly trained.[2] These types of workouts can produce results to rapidly improve performance and weight carriage.

HIIT's endurance improvements among highly trained athletes[3] are of particular applicability to the military, since military personnel, especially combat soldiers, already undergo regular physical training. Muscular strength and endurance gains were also demonstrated when layering HIIT on top of an existing aerobic training program in U.S. Navy personnel (compared to aerobic and calisthenics training)[4] and among British army recruits.[5] The improvements to dynamic lift movements, endurance, and march performance found in these studies are critical elements for a dismounted soldier. This type of training has been demonstrated to improve the loaded and unloaded performance of highly physically fit Army soldiers.[6] It also was successfully used to bring airmen who were previously below the physical fitness requirements up to standard with fewer hours of training than traditional methods, using 25-minute HIIT sessions three days per week instead of 60-minute standard training sessions four to five days per week.[7] Overall, interval training improves physical performance and does so quickly, which can shorten training duration while improving strength and endurance. Decreased training time also increases the time available for other activities or more specific training.

Finally, pulmonary muscle exercises can improve soldiers' weight carriage capabilities. Carrying heavy weight on the back applies pressure on the muscles that help facilitate breathing, further limiting battlefield effectiveness. There are, however, exercises that can develop these muscles and improve breathing while under heavy loads.

As an organization heavily invested in physical fitness, the Army must continue to stay on top of the latest physical fitness research, constantly improving training techniques. The recent advent of personal fitness trackers provides an opportunity for the Army to track soldier training in a rigorous and systematic way, which may yield benefits in understanding optimal training to improve fitness and avoid injury. (Some geolocating fitness trackers may pose operational security risks and should always be used consistent with DoD guidelines.[8]) *The Army should investigate alternative physical fitness training methods to improve strength and operational performance on the battlefield. The Army also should leverage emerging technologies such as personal fitness trackers, consistent with DoD guidelines, to collect physical training data across the force and systematically evaluate the best methods for improving performance while avoiding injury.*

Improved nutrition and dietary supplements

Nutrition and non-steroid supplements can also improve the health and strength of soldiers. In the mid-20th century, Colonel Albert P. Clark from the Medical Corps asserted that an enhanced vitamin and mineral diet for soldiers would result in an "unbeatable" army within six months.[9] Enhanced food products, such as caffeine-enhanced chewing gum, already exist. This same type of technological enhancement of dining hall meals or MREs, or simply routinized distribution of vitamins, could be pursued with other supplements to improve overall nutrition through better and more regular vitamin intake. This could enhance muscle mass and recovery. Nutritional supplements also can have further benefits in improving cognition in soldiers.

Many soldiers already use supplements, particularly in the special operations community. One survey of Army Rangers indicated 37 percent used dietary supplements.[10] (Anecdotally, actual numbers may be quite higher.) A 2015 RAND Corporation study documented 32 percent of service members across the joint force using supplements of one kind or another.[11] The current proliferation of GNC stores on military bases means that soldiers have access to and are using supplements in an unregulated fashion, which is not in the Army's best interests. At best, it is suboptimal, but at the worst, it is harmful. Tim Hsia, an Army infantry officer writing in *The New York Times,* indicated that, "When I had to conduct a health and welfare inspection, I was shocked by the profusion and variety of pills and powders I found in the rooms of soldiers. A few rooms could have been confused for mini-pharmacies."[12] Some of the supplements soldiers are currently using (on their own) may have benefits, but more research is needed to ensure these supplements are enhancing and not detracting from soldier performance. For example, among military supplement users, 27 percent already use creatine. While current research on creatine's performance-enhancing effects are mixed, more studies could be done to ensure it is being used in a manner that generates physical gains.[13] It is not considered a doping substance, lacks adverse effects, and may also support cognition, bone health, and neuromuscular function.[14] The Army should study this type of supplement to assess its benefits to the whole of the soldier.

Similarly, soldiers need muscle strength and endurance to perform their tasks, and muscle mass, endurance, and motor skills all benefit from increased protein intake.[15] Many soldiers require more protein than they are provided and rely on outside sources.[16] The Army could easily invest in either increased protein sources or protein-enhanced food to promote strength benefits among high-performing soldiers. Finally, carbohydrate beverages and mouthwashes have resulted in demonstrated improvements during moderate or intense exercise.[17] Providing supplements to soldiers as part of an official program would ensure that the supplements soldiers were receiving were safe and effective and taken under the care of Army medical personnel. Further, safe substances could be provided to more individuals in a standardized manner to enhance the broader force of individuals who may not be using them now. *The*

Army should develop nutrition guides and provide the necessary supplements to develop muscle mass and improve performance as a part of nutrition planning, and limit unregulated supplement use. Where there is insufficient research with regard to a supplement's effectiveness, the Army should sponsor research to determine if the supplement has benefits to soldier performance.

Pharmaceuticals

Physical strength can also be enhanced by pharmaceutical supplements, such as performance-enhancing drugs (PEDs) including anabolic steroids, which derive from testosterone. In 2008, 2.5 percent of Army personnel reported having used steroids.[18] (Doing so without a prescription from a doctor is illegal under the Uniform Code of Military Justice.)[19] Steroids have been shown to increase strength by 5 to 20 percent, and are often used by athletes who require sudden bursts of energy, such as powerlifters or football players.[20] Most sports ban PEDs, which means use occurs in secret, leaving a gap in scientific research about their effects. Nevertheless, the performance advantages can be clearly seen in athletic outcomes. Powerlifting has tested (clean) and non-tested (where lifters are presumably free to use PEDs) competitions, with marked differences in performance. Overall weight records for untested events are approximately 6 to 18 percent higher than tested events.[21] This type of performance improvement is consistent with what most powerlifters today think PEDs provide, which ranges from a 7 to 12 percent strength increase.[22] Other studies have found a roughly 5 to 20 percent increase in strength from using steroids.[23] Steroids also can have long-lasting effects since they help prepare muscle mass and aid muscle recovery.[24]

Increasing muscle strength by 5 to 20 percent, all things being equal, would be a significant improvement in load carriage for dismounted soldiers. This could allow for greater mobility or improved protection if more armor was carried. Steroids can have significant negative side effects, however, including cardiovascular, liver, and tendon damage, increased aggression, and sexual changes.[25] Anabolic steroids are derived from testosterone, a naturally occurring hormone in both men and women (although in different amounts). Because testosterone exists naturally in the body, the magnitude of strength increases and harmful side effects depends on the level of dose above normal physiological (supraphysiological) levels. Medical research on supraphysiological dosage is relatively scarce, however. What few studies have been done generally use doses much lower than used by athletes, for safety reasons.[26] Controlled medical experiments have demonstrated strength improvements, consistent with those seen in non-tested powerlifting events,[27] but in general there is a lack of sufficient medical research on the benefits and risks of testosterone boosting above normal physiological limits in healthy young adults.

Testosterone replacement is used as a therapeutic treatment in aging men as testosterone levels naturally decline. Military personnel similarly show decreased testosterone levels as a result of intense training.[28] One lower-risk treatment option would be to measure testosterone levels among soldiers, particularly when engaged in high-intensity training, and restore testosterone to normal levels when necessary.

In addition to strength, sustained aerobic capacity is an important factor for dismounted soldiers. Blood doping, a performance-enhancing technique used in competitive cycling, increases red blood cells, improving oxygen transport to muscles for better aerobic performance. A series of Army studies in the 1980s demonstrated that blood doping increased red blood cell counts and improved oxygen intakes by 10 percent in soldiers.[29] Blood doping has significant risks, however. It can thicken the blood to the point of creating clots or causing a stroke or heart attack,[30] and has been implicated in a number of deaths in competitive cycling.[31]

Cognitive Enhancement

In addition to physical strength and endurance, combat requires mental agility and focus. Situational awareness, sound decision-making, and rapid responses all depend on strong cognition, which is fueled by good rest and mental preparedness. On the battlefield, these are valuable commodities. Better sleep, common supplements such as caffeine, pharmaceuticals, and techniques such as non-invasive brain stimulation can all help improve cognition. While improved cognition will not increase soldier load carriage, it can increase vigilance, alertness, situational awareness, and reaction time, improving soldier survivability.

Sleep

Sleep deprivation is a significant problem for soldiers, even when not deployed, and a major detriment to their cognitive functioning. Service members report poorer sleep quality compared to their civilian counterparts; one-third report feelings of fatigue three to four days per week.[32] Only one-third of troops get seven or more hours of sleep, while the other two-thirds are split equally between getting six hours or five or fewer.[33] (By comparison, only 8 percent of civilian adults get five or fewer hours).[34] Poor sleeping conditions and irregular hours exacerbate this problem. The consequences to soldier performance are significant. Sleep is a critical part of overall health and proper cognitive functioning. Numerous military studies have demonstrated the detrimental effects of sleep deprivation, with some showing as much as a 70 percent decrease in cognitive performance when service members are deprived of sleep.[35]

Military operations will inevitability disrupt sleep and require soldiers to go long periods without sleep. Military training should prepare soldiers for this reality to the maximum extent possible, while inculcating healthy sleep habits overall. However, sleep problems are prevalent in non-deployed military personnel, suggesting broader institutional dynamics at work. Post-combat stress is likely a factor among recently deployed personnel,[36] as are long-term effects of disrupted sleep patterns and habitual caffeine and alcohol use.[37] Head injuries such as traumatic brain injury can also disrupt sleep.[38] Cultural factors undoubtedly also play a role. Units often do not incorporate best practices for shift work,[39] and cultural attitudes within the Army too often treat sleep as a weakness, not a weapon.[40] As one researcher studying military sleep put it, “Sleep is viewed as a luxury, rather than a necessity.”[41]

Soldiers’ attitudes toward sleep can be contrasted with how the Army views hydration. Soldiers are not encouraged to “be hard” and avoid drinking water. Rather, regular hydration is seen as essential to soldier performance. Sleep is similarly a necessary input for the human body to properly function. One of the U.S. Army’s decisive advantages over adversaries is better motivated, educated, and trained soldiers, resulting in superior performance on the battlefield. These advantages are undermined if soldiers are exhausted and unable to cognitively perform at their best.

First and foremost, to improve soldier cognitive performance the Army must improve its cultural attitude toward sleep. Army leaders have begun to take steps toward changing this culture. The Army recently published *A Leader’s Guide to Soldier Health and Fitness*, which has an extensive section on sleep that outlines clear guidance to military leaders about the need for adequate, regular sleep,[42] as well as *A Leader’s Guide to Soldier and Crew Endurance,* which explores the causes of fatigue, its implications, and ways to mitigate it.[43] Some technologies, such as blue light filters, may help facilitate good sleep practices.[44] *The Army should institute a comprehensive soldier sleep fitness program that implements the guidelines in* A Leader’s Guide to Soldier Health and Fitness (February 2016) *and* A Leader’s Guide to Soldier and Crew Endurance (January 2015) *to inculcate an attitude of “sleep as a weapon” in the force. The Army should also leverage personal fitness devices to track sleep patterns among soldiers and provide objective feedback on soldier sleep.*

In addition to better or more sleep, pharmaceuticals can induce sleepiness or alertness, as appropriate. Melatonin, for example, can be used to decrease the effects of jet lag and has been shown useful to help

adjust the sleep cycles for Army aircrews deployed rapidly.[45] The effectiveness of sleep treatments depends on many factors: the baseline cognitive performance and type of thinking required by a task, degree of sleep deprivation, and duration of the stimulant's effect (either pharmacological or natural forms such as sleep banking or napping). In rested individuals, some drugs can enhance cognitive performance above baseline levels.[46]

Caffeine

Caffeine, the most widely used drug in the world, is commonly used by service members as a performance-enhancing stimulant. Caffeine improves situational awareness, reaction time, and mood and reduces fatigue and sleepiness, with the greatest effects after one hour but some advantages persisting for eight hours.[47] While this can aid operational performance, such as sighting time and firing on targets, it does not improve the technique involved in performing tasks, such as marksmanship.[48] Caffeine also does not, however, negatively affect technique; in a study on Navy SEALs, there was no degradation in marksmanship after the use of caffeine.[49] Caffeine is regularly used within the Army and is endorsed for use in countering fatigue.[50] *A Leader's Guide to Soldier Health and Fitness* lays out guidance for caffeine use under operational conditions.[51] Actual caffeine use by soldiers is often uncontrolled, however, a factor that may contribute to sleep disorders among service members.

Cognitive-enhancing drugs

Caffeine is only one of many stimulants that have cognitive-enhancing effects. Amphetamine use in war dates back to World War II,[52] and the U.S. Air Force has used dextroamphetamine (Dexedrine) since at least the late 1980s to sustain alertness in aircrews on long missions.[53] All three military services approve the use of dextroamphetamine by aviators for sustaining performance.[54] Additionally, the U.S. Air Force authorizes the use of modafinil (Provigil), a newer stimulant that is commonly used to treat narcolepsy and promote alertness in shift workers, for use in multi-seat fighter and bomber crews.[55] Modafinil is currently under review by the Army for approval and, according to the *Leaders Guide to Soldier Crew and Endurance* updated in January 2015, will soon be approved for use in the Army and Navy.[56]

A meta-analysis done by the Army Aeromedical Research Lab on modafinil and dextroamphetamine found that both improved cognition, alertness, and judgment with fewer side effects than caffeine.[57] These stimulants not only reduce fatigue, they also can heighten alertness and cognitive performance in rested individuals.[58] While these stimulants, as well as caffeine, improve psychomotor speed, the effects on higher-level thinking are more difficult to assess and vary by stimulant.[59] Some studies have indicated negative cognitive side effects pertaining to overconfidence, risk-taking, or poor judgment, although study results are more mixed on this front.[60] The effects of each of these stimulants also vary by individual, with the possibility that some could actually diminish mental performance among high-performing individuals.[61] Safety is another important factor. Modafinil is not generally considered to be addictive and is deemed safer than other psychostimulants such as amphetamines.[62] (Modafinil is a schedule IV drug under the Food and Drug Administration [FDA], while dextroamphetamine is a Schedule II drug due to its high abuse potential.[63])

Other cognitive performance-enhancing drugs include those used to treat attention-deficit/hyperactivity disorder (ADHD), such as methylphenidate (Ritalin) or mixed amphetamine and dextroamphetamine (Adderall). These drugs help enhance cognition in the pre-frontal cortex[64] to improve focus and concentration.[65] They are also reported to be widely used in colleges as a "study drug" in healthy individuals to enhance focus, with some studies suggesting on the order of 30 percent of college students use them on some campuses.[66] Similar to other stimulants such as caffeine and dextroamphetamine, many of these drugs can have side effects such as agitation, nervousness, sleeplessness, irritability, or nausea.

An Army Aeromedical Research Lab meta-analysis of cognitive-enhancing drugs concluded that "modafinil (at both low and high doses) shows promise as an enhancement agent," although further research is needed on its use in rested individuals. Despite the widespread use of ADHD drugs for cognitive performance enhancement in college students, the Army meta-analysis found that there were insufficient medical studies on its efficacy to draw conclusions. (However, it seems reasonable to assume that college students find some benefit in using the drugs, with relatively manageable short-term side effects.) While there have been some studies on modafinil in rested individuals, in general there have been few studies on cognitive-enhancing drugs in healthy individuals.[67] One such study, however, indicated that modafinil and methylphenidate increased high-performing chess players' wins by 8 to 15 percent and 6 to 15 percent, respectively. The drugs did not make the players think better, but they increased the time players were willing to spend analyzing possible choices (from 437 to 550 seconds on average), so players took better moves.[68]

One limiting factor in medical research is that the FDA does not have a mechanism for approving drugs purely for enhancement in otherwise healthy individuals. Many drugs, such as modafinil, are commonly often used "off label" – prescribed by a doctor but to treat a condition other than that for which the drug was approved by the FDA. As an Army report on cognition-enhancing drugs pointed out, "This practice is common and legal." An estimated 20 to 60 percent of prescriptions are written for off-label use, a figure that may be even higher for certain drugs.[69] Some have estimated as many as 90 percent of modafinil prescriptions are off label.[70] The Trump administration has signaled willingness to allow drugs to be marketed for off-label purposes more easily.[71] The FDA regulates drugs, but does not regulate the practice of medicine. In fact, some cases of off-label use may be considered "state of the art" treatment, where physicians are using drugs to respond to emerging scientific evidence ahead of slower regulatory processes.[72] Whether or not off-label use is appropriate depends on the specific drug, condition, patient, and a relative assessment of the various risks of treatment or other alternatives, as with any drug. Making this determination can be challenging when there is limited research on a particular off-label use, as is the case for many cognitive-enhancing drugs in healthy individuals, demonstrating the necessity of further research.

Brain stimulation

Other non-pharmacological tactics can be used to improve cognitive performance. Stimulation of parts of the brain through non-invasive measures is advancing. Repetitive transcranial magnetic stimulation actually causes neurons in the brain to fire. Transcranial electrical stimulation, such as transcranial direct current stimulation (tDCS), increases energy in the brain, making it easier for neurons to fire. This can alter connections in the brain and modify synapses, improving motor performance and cognition.[73] Transcranial direct current stimulation is already being used by Olympic athletes and at-home users alike and is currently being tested at the Air Force Research Laboratory. In controlled experiments, tDCS has been demonstrated to increase vigilance and cognition under fatigue. Air Force studies have demonstrated it improves reaction times and decreases false alarms when targeting, enhancing performance in a battlefield task.[74] In one study, the Air Force found that tDCS improved imagery analysts' visual search accuracy by approximately 25 percent. It also has been shown to improve multitasking performance, an increasingly relevant component of military operations.[75] In one test, sleep-deprived soldiers who had received brain stimulation performed better overall than those who consumed caffeinated chewing gum, due to improvements in mood and fatigue beyond solely cognitive testing.[76] TDCS also shortens training time, making training more efficient and causing lasting effects weeks beyond immediate use. The commercial company Halo's product research page cites improved pilot and sniper training among the U.S. armed forces by 50 percent, and Navy special operators reportedly have begun using the product to shorten training.[77] Members of the Naval Special Warfare community reportedly have begun testing Halo's product to streamline training. Immediate side effects are relatively modest. Some tDCS users report a mild tingling sensation or metallic taste in their mouth.[78] The long-term risks of habitual use are essentially unknown, however.

Ethical, Legal, and Social Issues

Human enhancement raises a number of ethical, legal, and social issues. Use of controlled substances without a doctor's prescription is not legal. Service member use of steroids to increase physical strength without a prescription is illegal, and if service members were to use so-called study drugs to enhance their cognitive performance without a prescription, it also would be illegal. This is an argument against self-medication by service members who are not under the care of a doctor, however. It is not necessarily an argument against the treatment itself, which might be appropriate in some circumstances if administered by a physician. There is nothing inherently illegal about human enhancement. Indeed, medical treatments such as vaccines are specifically intended to enhance humans above their baseline physical condition.

From an ethical standpoint, most of the concerns with human enhancement revolve around fairness and equal access. In sporting, doping is illegal because it is considered to offer competitors an unfair advantage. These concerns do not apply in war. The entire purpose of military technology and training is to gain an unfair advantage over the adversary. War is not a sport. It is a life and death struggle, and tiny advantages can result in dramatically different outcomes on the battlefield.

A principal concern in the military context is therefore safety and the balance of risk. Are the relative risks of a treatment worth the military operational value? The risk to a service member of receiving a treatment must be balanced against the operational risk the treatment is mitigating. War is dangerous, and enhancements that allow soldiers to carry more protective gear, be more alert, or be better trained all have significant payoffs in terms of improving soldier survivability. Enhancements that could potentially save soldiers' lives should be seriously considered.

One factor that complicates balancing the relative risks of treatment vs. non-treatment is the lack of adequate research on many potential enhancements on healthy individuals. This means that unlike vaccines or caffeine, both of which are commonly used forms of enhancement, many treatments may be relatively new with risks that are poorly understood. Given this uncertainty, informed voluntary consent from soldiers for treatment is critical.

Colonel Michael Russo of the Army Aeromedical Research Laboratory has outlined a four-part criteria that should inform decisions regarding the use of cognitive enhancement drugs in a military context:

1. Use is voluntary – the soldier has given informed consent;
2. The treatment is safe for the intended operational use;
3. Dosage and use are consistent with its intended function; and
4. Non-pharmacological agents have been fully explored.

While Russo intended this criteria for cognitive-enhancing drugs, the same criteria could equally apply to physical enhancements or non-pharmacological interventions, such as brain stimulation.

Voluntary use is a particularly difficult problem for military personnel. Soldiers are an inherently vulnerable population susceptible to coercion – real or perceived, implicit or explicit – from commanders. Nevertheless, these concerns can be met with appropriate procedures in place. There is a pathway today for safe and ethical military research on pharmaceuticals and other enhancement techniques, such as brain stimulation. Both the Army and Air Force have conducted studies on modafinil, and the Air Force has conducted research on non-invasive brain stimulation.[79] The Army has been hesitant to consider human enhancement more generally, however. While there are valid legal and ethical concerns that must be addressed, much of the hesitancy comes from a social squeamishness about the concept of enhancement being seen as unfair or illegitimate in other contexts. The military context is unique.[80] Just as the military trains soldiers to do other actions that are legitimate in war but would not be in civilian settings – such as killing – fairness is not a consideration in war.

Conclusion

It is normal for military organizations to pursue advantages over their adversaries, including methods to enhance soldiers' abilities. The Army currently uses two cognitive performance-enhancing drugs: caffeine and dextroamphetamine. Dextroamphetamine is used in limited settings under the control of Army physicians, but caffeine use is officially endorsed by Army policy, which establishes guidelines on dosage. In practice, however, caffeine use is often unmonitored and may be a contributing factor in widespread sleep disorders within the force. Army studies indicate that for combating fatigue and restoring performance, modafinil may be a preferable alternative to caffeine and dextroamphetamine with fewer side effects. The Army also effectively tacitly endorses dietary supplement use by virtue of allowing GNC stores on military bases. While dietary supplements may have some benefits, current unsupervised use may be harmful to service members. A military symposium on steroid use concluded, "Policies and practices should support evidence based, responsible, and effective supplement use."[81] This is not the case today.

A number of treatments show potentially advantageous effects for physical and cognitive enhancement. If properly used, these could significantly improve soldier survivability and performance. The chief limiting factor in applying these treatments in a military context is the lack of sufficient research on their benefits and risks. Unfortunately, with the exception of modafinil for Army aviators, the Army has not generally conducted much research on the military value of these enhancements.

The Army's current approach to human enhancement is ad hoc, allowing unregulated use of over-the-counter supplements but forgoing research on a number of potentially promising enhancements. This is the least optimal strategy, one that maximizes the risks and minimizes the potential benefit of treatments. *The Army should institute a high-level policy review of potentially promising methods to enhance soldier physical and cognitive performance. The Army should consider potential physical and cognitive enhancements on a case-by-case basis, evaluated based on the risks of the specific treatment and the relative operational advantages to soldier survivability. Because many potential treatments are under-studied, the Army should investigate the efficacy, safety, and operational utility of physical and cognitive enhancement treatments, consistent with DoD medical guidelines. Participation in any research or operational use of enhancements should be voluntary, and the Army should institute procedures to ensure that soldiers are free from coercion, real or perceived, to take enhancements.*

NOTES

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