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Perspectives on resilience for military readiness and preparedness: Report of an international military physiology roundtable

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ABSTRACT

Modern warfare operations often occur in volatile, uncertain, complex, and ambiguous (VUCA) environments accompanied by physical exertion, cognitive overload, sleep restriction and caloric deprivation. The increasingly fast-paced nature of these operations requires military personnel to demonstrate readiness and resiliency in the face of stressful environments to maintain optimal cognitive and physical performance necessary for success. Resiliency, the capacity to overcome the negative effects of setbacks and associated stress on performance, is a complex process involving not only an individual's physiology and psychology, but the influence of factors such as sex, environment, and training. The purpose of this moderated roundtable was to address five key domains of resiliency in a point/counterpoint format: physiological versus psychological resiliency, sex differences, contributions of aerobic and strength training, thermal tolerance, and the role of nature versus nurture. Each speaker was given three minutes to present and the moderator facilitated questions and discussion following the panel's presentation. The interconnectedness of the five domains highlights the need for an interdisciplinary approach to understand and build resilience to enhance military performance.

1. Introduction

Charles Darwin and Leon Megginson showed that the species that is best able to adapt and adjust to a changing environment is the species that will prevail, not the strongest nor most intellectual.[1] The same principle can be applied to Warfighters, as possessing a high level of physical fitness and cognitive ability is simply not enough to succeed and to maintain overmatch superiority against adversaries. Military operations expose servicemen and women to a variety of stressors including demanding workloads, harsh and dangerous environments, and ambiguity that degrade performance.[2,3] The Armies that prevail are the ones composed of resilient individuals who can overcome these challenges and perform with greater agility, tenacity, survivability, and lethality.

Military resilience can be defined as *the capacity to overcome the negative effects of setbacks and associated stress on military performance and combat effectiveness*. Military operational stress can come in many forms via the singular or combined effects of physical exertion, cognitive overload, sleep restriction, energy insufficiency, variations in the operational environments, and emotional and psychological stress. In the volatile, uncertain, complex, and ambiguous (VUCA) contemporary operating environment, both current and future operations demand and place a higher priority on enhancing and sustaining the readiness and resiliency of military service members in order to decisively win in multi-domain battle.

According to Ruiz-Casares et al., resilience is a dynamic process involving the interaction between risk and compensatory factors

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over the lifespan.[4] Despite everyday stressors of poverty, violence, and political instability, a study by Eggerman and Panter-Brick reported that Afghani students and caregivers possess resilience through the belief that adversity can be overcome by adherence to cultural values, life goals, and daily perseverance.[5] Such values are also necessary in the military as Warfighters must maintain daily perseverance throughout intense military training and must share common goals to protect and serve at all costs. However, resilience is more than a mindset. Studies have reported that autonomic regulation, measured by heart rate variability, may be an indicator of resiliency and ability to adapt to changing environments.[6,7] Furthermore, there is growing evidence that genetic, epigenetic, and neurochemical factors also play a key role in the development of resilience through biological responses to stress.[8]

Beyond the inter- and intra-personal interactions between the body and the mind, there are many other factors that contribute to resiliency including sex, environment, and physical training. It is well known that a variety of anatomical, physiological and functional differences exist between men and women, including body composition, cardiovascular and musculoskeletal systems, as well as hormonal secretion, that can influence initial functioning as well as subsequent resilience in stressful environments. The environment alone can also have an adverse effect on stress tolerance, regardless of sex. Cold stress limits the fine motor dexterity and touch sensitivity[9] and has been shown to decrease vigilance, mood and increase tension.[10] Conversely, extreme heat, combined with physical exercise and increased core temperature, can have detrimental effects on cardiovascular and endocrine function that result in decreased performance.[11] In addition to sex and environment, physical training has a direct impact on the body's ability to withstand physical and cognitive stressors. Lower aerobic power has been associated with an increase in musculoskeletal injuries during basic combat training,[12] whereas load carriage and lifting are among the most frequent activities in which musculoskeletal injuries occur during deployment.[13] In both instances, the result is reduced capability. Without adequate rest, physical training can diminish cognitive performance. A study comparing over trained and control athletes demonstrated that over trained athletes made more mistakes when completing the Stroop Color Word Test.[14] Similarly, sleep restriction has been shown to negatively impacts soldiers' reaction times to shoot foe targets during marksmanship tasks.[15]

Therefore, the selection and training of service members must be used to identify those who can maintain normal physiological and psychological functioning under stress. Such factors demonstrate the complexity of resilience and the need to identify the best means to promote resiliency among military service members. The need is so high that implementing human performance optimisation strategies aimed at enhancing military readiness and lethality has been identified as a top priority for the modernization of future military operations.[3,16,17] However, the most effective strategies to enhance resiliency remain unclear.

This paper summarizes a roundtable discussion, held at the 4th International Congress on Soldiers' Physical Performance assembled to address five key domains of resiliency relative to arduous military roles in a point/counterpoint format: 1) physiological versus psychological resiliency, 2) sex differences, 3) contributions of aerobic and strength training, 4) thermal tolerance, and 5) the role of nature versus nurture. A panel of ten internationally recognised scientists and practioners was selected to represent each perspective as follows: Hilde Teien, physiological resilience; Sam Marcora, psychological resilience; Dan Billing, male resilience; Tara Reilly, female resilience; Jace Drain, aerobic training; Herbert Groeller, strength training; Andrew Young, cold tolerance; Nigel Taylor, heat tolerance; Anthony Moffitt, nurturing resilience; Karl Friedl, the nature of resilience. Each presenter was allotted three minutes to effectively defend the perspective. Bradley Nindl served as the moderator, facilitating questions and discussion following the panel's presentation.

1.1. Physiological or psychological resilience is most critical for military readiness

1.1.1. Physiological resilience (Hilde K. Teien, Norway)

Employment standards for soldiers primarily evaluate physiological resilience. If you consider a sniper's success to hit the target, the ability to handle stress has a huge impact on the performance. However, this factor, which might be trained, is always a secondary consideration after the sniper's physical performance, which is crucial for success in military operation. In other words, psychological resilience flows from the more fundamental physiological resilience.

Soldier physiology underpins all soldier performance. Even psychological performance is determined by physiological mechanisms and neurochemistry. Soldier resilience is shaped by personal habits such as daily physical exercise. Physical exercise improves musculoskeletal and cardiovascular fitness. It also stimulates trophic factors such as insulin-like growth factor 1 (IGF-I) and brain-derived neurotrophic factor (BDNF) with benefits to sustaining muscle and bone health.[18] The same factors promote brain neurogenesis and synaptogenesis and these effects improve psychological resilience, including mood, cognition, and pain thresholds.[18] Hence, physiological resilience is the basis for psychological resilience rather than the opposite. In this respect an important research gap is to understand the differential effects of exercise mode and intensity on neurobiology with resilience outcomes ranging from motivation and cognition to immune function and disease resistance.[19,20]

Extreme soldier performance, where resilience really counts, generally involves physical and metabolic endurance. In the Norwegian Ranger School, male and female cadets must perform virtually nonstop for one week with no organized sleep, and limited or no food.[21] Metabolic resilience is the determinant of success, where plummeting blood glucose levels for less resilient soldiers can result in physical collapse, and where men may be less resilient than women because of their biology.[21] When the soldiers need to perform extreme physical activity in combination with deprivation of sleep and energy intake, basic components of survival, physiological resilience will be the predominant factor for success.[22,23]

A preponderance of data demonstrates that the ability to adjust to and overcome the effects of military operational stressors such as thermal extremes, high workload, and inadequate rest is influenced by physiological fitness.[24,25] These combined stressors can affect a wide range of outcomes related to the ability to perform the military mission. Susceptibility to disease is one outcome that has been well investigated in Norwegian soldiers, where physiological resilience factors such as the ability to mobilize body energy stores moderates immune function.[21,26] This has also been demonstrated in the U.S. Army Ranger course.[18,27,28]

Thermal tolerance in hot environments is significantly influenced by fitness.[24] Musculoskeletal injury is also significantly predicted by physical fitness.[25] Since musculoskeletal injuries are the leading cause of injury and lost duty time in soldiers, this makes physiological resilience the most important factor in overall soldier readiness. The single major contributor to loss of soldiers from the military is associated with poor physical fitness, including overweight, and psychological resilience is only a subset of this group because of the fundamental importance of a fit body to cognitive readiness.

In conclusion, a physiologically resilient soldier will also be happy, motivated, and capable of good decision making under stress because these are all metabolic functions that depend on physiological resilience.

1.1.2. Psychological resilience (Samuele Marcora, United Kingdom)

Psychological resilience refers to the role of mental processes and behavior in protecting an individual from the potential negative effect of stressors.[29] It is widely accepted that psychological resilience is critical for coping with the cognitive, emotional and social stressors associated with war exposure. Psychological resilience is most critical for military readiness because it also plays an important role for coping with physiological stressors, and because a psychologically stressed soldier (i.e. a soldier that cannot cope with psychological stressors) will not perform well during military operations no matter how physiologically capable he/she is.

With regards to coping with physiological stressors, scientists have focused on the autonomic, endocrine and immune responses, and autoregulation. However, mental processes and behaviour are also critical to maintain bodily homeostasis when exposed to physiological stressors. For example, coping with physical activity in the heat is not just about sweating and the heat flow from the core to the skin via the blood.[30] Education and self-monitoring as well as pacing and appropriate drinking (behavioural thermoregulation) are also extremely important to optimise performance, and prevent exertional heat stroke and hyponatremia.[31] Furthermore, physiological stressors have psychological manifestations (e.g. subjective fatigue and thermal discomfort) that add to the psychological burden the soldier has to cope with.

With regards to the effects of psychological stressors on physical performance, a good example is provided by our work on mental fatigue.[32] This experimental work has demonstrated that prolonged and demanding cognitive activity reduces performance in subsequent aerobic exercise despite no significant alterations in the physiological factors thought to determine endurance performance, e.g. cardiac output and muscle fatigue. In other words, mental fatigue (via an increase in perceived exertion) reduces endurance performance despite no reduction in the physiological capacity to perform prolonged aerobic exercise. Importantly, we have also produced some evidence that elite endurance athletes are more resilient than amateurs to the negative effects of prolonged and demanding cognitive activity.[33] These findings suggest that being psychologically resilient may help soldiers perform better physically as well as cognitively during stressful military operations.

In summary, there is evidence suggesting that a psychologically resilient soldier would cope better not only with the psychological stressors associated with war exposure, but also with the physiological stressors associated with military operations. Therefore, psychological resilience has implications not only for mental health, but also for the physical health of a soldier. Furthermore, there is now considerable experimental evidence reporting that psychological stressors like mental fatigue can have a negative impact on physical performance and not just on cognitive performance. Therefore, selecting and developing psychologically resilient soldiers would ensure that they can perform optimally during military operations that require both physical and cognitive tasks. For all these reasons, psychological resilience is most critical for military readiness.

1.2. Men or women are more physiologically/psychologically resilient

1.2.1. Men are more resilient (Daniel Billing, Australia)

Women display superior performance in many roles and will continue to be a vital element of an armed force. However, there are certain roles or assignments where the proportion of men likely to have the requisite physiological resilience to safely and efficiently execute the required duties will be higher than that of women. This position can be explained by discussing the pathway from sex differences to mission accomplishment. Firstly, physiological sex differences in dimensions such as stature, body mass, bone structure and geometry, cardiac output, oxygen extraction, cardiopulmonary endurance, muscle strength and anaerobic capacity, and muscle endurance have been well documented.[34–36] Secondly, as a result of these physiological differences, the execution of a physically demanding single task such as load carriage requires less capable personnel to work at a higher percentage of their maximal capacity.[34] Thirdly, when physically demanding tasks are performed in series, which is reflective of contemporary operations, cumulative fatigue ensues resulting in a higher propensity for musculoskeletal injury and or reduced reserve to respond to emergencies.[35] Fourthly, inadequate reserves to respond to emergencies and or the incapacitation of individual team members due to injury have important implications for small team performance and cohesion. Ultimately, a reduction in the capability and or capacity of the team may compromise mission accomplishment.[37]

We know from my co-authors that the two dimensions of resilience (physiological and psychological) are intrinsically linked so to help support this thesis, two specific case examples are discussed. The assignments and tasks performed by some Special Forces personnel demand extremely high physiological and psychological resilience. Less physiologically capable personnel will be unsuitable for these roles as they have a reduced reserve above normal work conditions to respond to emergencies and are less resistant to fatigue and injury. Another case is extreme manual handling assignments which demand high physiological resilience. In many instances, the demands of these tasks are beyond the capacity of many soldiers.

Although operational roles or assignments' will continue to change with the ever-evolving battlefield, at this point in time the high demands of the more extreme case examples cannot be made easier. As a result, there will remain a lower percentage of women than men who are capable of serving in these occupations. However, through research and implementation of female specific best practice training to enhance modifiable characteristic, such as muscular strength, and the introduction of new performance augmentation technologies, such as exoskeletons, the magnitude of the observed sex differences will continue to diminish or potentially become irrelevant and thereby enable more females (and males) to participate fully in these roles.[38] Further, a better understanding on the psychological profile of women who are successful in physically strenuous occupations will also assist in providing targeted support. In conclusion, when it comes to some of the most arduous roles in the military, at this present point in time men have a higher physiological capacity and are more resistant to fatigue and injury and thereby more resilient than women.

1.2.2. Women are more resilient (Tara Reilly, Canada)

History demonstrates that in times of famine and extreme environmental conditions, women are more likely to survive than men. Assuming resilience equates to survival, women demonstrate lower mortality rates than men at all ages, resulting in women outliving men typically by a 10 year margin. Between 15 and 24 years old men are three times more likely to die than women, and most of these male fatalities are self-inflicted, caused by reckless behavior or violence, a finding that is reflected in other male primates as well.[39] As men age, their choices continue to propel them towards higher risk of death. Illnesses related to smoking and alcohol consumption kill more men than women, and in their 40 s cardiovascular disease and cancer kills far more males than females.[39]

Specific to the demands of combat, women are better at making logical decisions under stressful conditions without the negative interactions caused by testosterone which increases activity of brain areas associated with impulse control and distractibility. Research demonstrates that women in combat roles would result in far fewer accidents, assaults, and cases of fratricide.[40] Biomechanically, women have a lower center of gravity, which inherently gives them better balance, useful for hand to hand combat, climbing and traversing difficult terrain.[41]

In terms of mental resilience, after controlling for reports of prior life stressors and sexual harassment during deployment, Vogt et al. reported no gender differences in the association between several types of deployment stressors including combat exposure and PTSD.[42] In fact, men are 5 times more likely to use alcohol as a coping mechanism, and become alcohol dependent or diagnosed with antisocial personality disorder.

In summary, with lower levels of oxygen free radicals, higher body fat, lower need for caloric intake, and better lipid utilization for energy metabolism while sparing muscle protein and glycogen,[43] women have a higher average survival rate than men in times of great metabolic stress, like severe famine. Additionally, the greater the severity of the stress, the greater the difference in survival numbers between men and women.[44] Women, are designed to have children, and evolutionary adaptations to bear children have enabled women to deal better with deprivation.[44] These physiological advantages that women have over men for survival in adverse environments remain, and this advantage is further supported by the rapid reduction in the male to female gap in athletic performance, a result of the scale up of athletic programs targeting girls and women.[45]

1.3. *Aerobic or strength training best builds military physiologically resilience*

1.3.1. *Aerobic training best builds military physiological resilience (Jace Drain, Australia)*

It is well understood that many military occupational tasks involve prolonged and/or repeated performance, e.g. pack marches, digging, sand-bagging, fire and movement, material manual handling. Typically, cardiovascular endurance underpins the performance of these tasks. An individual with a higher aerobic capacity (VO_{2max}) will therefore be working at a lower relative intensity ($\%VO_{2max}$), when compared to less aerobically fit individuals. A reduced relative task intensity will in turn allow for longer task performance and/or a greater capacity for repeated efforts.[46] Beyond occupational performance, aerobic fitness is also strongly correlated with injury rates and attrition during military training.[47] In fact, aerobic fitness is one of the most common risk factors for musculoskeletal injury during military training.[12]

Aerobic training can also help military personnel buffer the allostatic stress associated with military training. Specifically, aerobic fitness has been associated with attenuated hormonal and subjective stress reactivity in response to military training.[48,49] Importantly in a military context, aerobic training helps to moderate reactivity to psychological stressors, in the absence of physical stress. Furthermore, evidence indicates that aerobic training can help to attenuate age-related increases in the hypothalamic-pituitary-adrenal axis reactivity to psychological stress.[50] Improved aerobic fitness is also associated with reduced cardiometabolic risk factors and importantly, can help to attenuate stress-related increases in cardiovascular risk factors.[51]

In summary, aerobic training can confer an array of benefits to military personnel including increased physical and physiological ability to tolerate occupational task demands, decreased injury risk, improved overall health (including psychological), and enhanced ability to buffer stress. These benefits are realized in both the short-term (e.g. improved ability to execute a task/mission) and the longer-term (e.g. improved injury resistance and stress buffering during sustained training/deployment, and decreased disease risk). Whilst the requirement for physical conditioning is overt for military personnel in physically demanding roles/occupations (e.g. infantry, artillery), physical fitness should also be considered a tool to manage capability (and resilience) across an ageing and diverse workforce. It is suggested that there can be little doubt that aerobic training is essential to building military physiological resilience. On this basis, the establishment and maintenance of aerobic fitness should be an imperative for military organizations.

1.3.2. *Strength training best builds military physiological resilience (Herbert Groeller, Australia)*

Physical fitness clearly influences the ability of individuals to manage and adapt well to stressors.[52] Higher levels of physical fitness (cardiorespiratory fitness and local muscle endurance) prior to entry into basic combat and severe military training was associated with a lowered stress response and improved psychological outcomes in soldiers.[53,54] However, the optimal type and amount of exercise to facilitate the protective benefits of physical fitness has not as yet been established.[54] Furthermore, of the range of physical regimen investigated, more is known of the effect of aerobic exercise training and responsiveness to physical and psychological stress. Therefore what role might strength training have upon the physiological resilience of soldiers?

The characteristics of the stressor are an important consideration, as intermittent exposure to stress with sufficient recovery is known to facilitate toughness, mastery that can provided a protection function for the soldier. Given the carriage and lifting of external loads is associated with the highest incidence of injury during deployment,[13] intermittent and functional exposure to physical stressors to improve performance in this area would appear to have the greatest utility with respect to physiological resilience. Indeed, the modern day battlefield requires high intensity and explosive movement, often with soldiers burdened by the carriage of an external mass; physical performance characteristics that benefit from increased muscular strength and power.[55,56] Yet, cardiorespiratory endurance training is still a significant bias within modern military training regimen.[55]

However, the incorporation of resistance training to improve physiological resilience in soldiers should be carefully considered. A focus upon physical gains to increase force production capacity or skeletal muscle mass that has poor utility with the essential physical demands of deployment and combat may serve to decrease the physiological resilience of the soldier. Thus, a critical evaluation of the end state requirements of the soldier should be acknowledged and used to inform the application of resistance training regimen, to improve not only muscular strength and power for functionally relevant tasks, but also enhance endurance performance and movement competency and quality. Nonetheless, this strategy in isolation is likely to have limited efficacy with respect to the development of physiological resilience. The totality of the physical stress should be considered; where paradoxically increased absolute physical training loads when progressively applied load, can increase resilience to musculoskeletal injury.[57]

1.4. *Thermal resilience is essential for military preparedness*

1.4.1. *Cold environmental resilience is most essential for military preparedness (Andrew Young, United States)*

Preparations to improve Warfighter tolerance/resilience to cold exposure during military operations are probably more important to undertake than preparations to enhance tolerance of heat stress. For one thing, the likelihood that military forces will be deployed in the cold, northern latitudes for peacekeeping and national security operations is increasing as global warming causes sea lanes in the Arctic Ocean to open, and nations compete for the natural resources in that region.[58] Also, the incidence rate of cold injuries[59] is much higher than the incidence of heat injuries.[60] Most Warfighters and their leaders have prior experience coping with heat-stress conditions during military missions, whereas far fewer have experience with cold-weather operations. Further, it is widely appreciated by military leaders that physiological mechanisms underlying human heat tolerance can be optimized in their Warfighters relatively easily, simply by having them perform increasingly strenuous bouts of physical work in the hot-weather conditions for progressively longer periods of time over five to ten consecutive days (i.e., induction of heat acclimatization), and ensuring that they consume adequate amounts of water to maintain homeostasis. In contrast, the primary human physiological responses to cold exposure, shivering and peripheral vasoconstriction, provide little meaningful protection even after induction of cold acclimatization, which is slower to develop and less effective for improving thermal tolerance than heat acclimatization.[61] Optimizing behavioral responses to cold is more effective for enhancing cold tolerance/resilience than optimizing physiological responses. Developing optimal behavioral responses to operate effectively in cold conditions without suffering cold injuries will entail learning and practice by the individual Warfighter, as well as specialized clothing and equipment, and will therefore require more time and resources than needed to optimize heat tolerance.

Key behavioral responses that must be learned and practiced during cold-weather operations to improve Warfighter tolerance/resilience include understanding how to wear, use and maintain cold-weather protective clothing, shelters, tools, and mobility equipment. Proper wear of cold-weather protective clothing, will be highly variable between and within individuals, depending on weather conditions, physical activity levels and individual anthropometric characteristics.[62] Individual Warfighters should be allowed to choose their own clothing combinations to achieve optimal environmental protection. This skill cannot be mastered in a classroom, and requires training in different cold-weather conditions at different activity levels so Warfighters learn to appreciate their own individual requirements.[63] Similarly, Warfighters must train to perform their duties wearing their cold-weather clothing using their weapons and equipment during different cold-weather conditions, so they can appreciate how that clothing and the cold weather conditions affect their dexterity and ability to function in the environment. Compared to optimizing heat tolerance/resilience, it is essential that Warfighters complete much more extensive experiential learning to develop behavioral responses to cold exposure that optimize environmental tolerance/resilience.

1.4.2. Heat tolerance is an essential part of military preparation (Nigel Taylor, Australia)

Homoeothermic species are vulnerable to climatic extremes that challenge temperature regulation and elicit significant changes in tissue temperatures. Humans are no exception, with those in military and emergency-service occupations facing regular thermal challenges. From a military perspective, operations in both hot and cold extremes are likely, with the probability dictated by national priorities and international obligations. For instance, Asia–Pacific countries routinely prepare for deployment into tropical and equatorial regions. Since humans evolved in hot-dry climates, it may be argued that we are more prone to cold-related injuries, and the evidence supports that proposition.[64–66]

Cold per se does not exist; it is merely a subjective description assigned to states of lower thermal energy (heat). Since energy constantly moves from higher to lower energetic states, then some solutions to these thermal challenges come in the form of protective barriers. Designers, manufacturers and procurers of personal protective clothing and equipment for the military and first responders face significant challenges. In the cold, thermal protective clothing must resist heat loss, whilst the influx of thermal energy must be minimised when external temperatures exceed body temperature. Furthermore, protective clothing should enhance heat dissipation during states of high metabolic heat production, regardless of environmental temperature. Thermal problems also challenge physiologists seeking to identify strategies to enhance the tolerance and resilience of warfighters and emergency personnel.

With the exception of extreme radiant-heat exposures, it is the deep tissues that are most susceptible during heat stress, giving rise to illnesses ranging from cramps to heat stroke. For the military and first responders, those disorders are associated as much, if not more so, with physical exertion and metabolically derived heat, largely due to occupational requirements mandating the wearing of protective clothing, equipment and body armour. Such ensembles can encapsulate the wearer, particularly during chemical and biological threats, isolating that person from the ambient medium. In that state, limited exchange occurs between the body and the external environment.[67] Thus, heat produced within, and fluid lost into, that closed system remains within the protective ensemble, and the microclimate approximates body temperature and rapidly becomes saturated with water vapor. That state, when combined with elevated heat production, is not conducive to prolonged survival, regardless of prior physical and thermal conditioning.

Three approaches have been used to minimise the risk of exertional heat illness: heat adapting personnel,[68] developing fabrics that facilitate heat and moisture removal[67] and supplemental cooling. The first two are beneficial to minimally clothed athletes. However, heat adaptation elevates sweat secretion, at least in the short term, most of which remains unevaporated, and provides negligible cooling for those wearing protective clothing. Such sweat losses accelerate dehydration and compromise thermal insulation of the protective clothing. Smart fabrics, if worn beneath protective clothing and equipment, offer no respite.[67] The less exotic solution must, just like in the cold, center around sound educational and managerial practices, in combination with ample experiential opportunities.

1.5. The military can (nurture) or cannot (nature) build and instill physiological/psychological resilience

1.5.1. The military can build and instill physiological and psychological resilience (Anthony Moffitt, Australia)

“Man can (nurture) only on external and visible characters: nature cares nothing for appearances, except in so far as they may be useful.” If Darwin’s allusion to the futility of influencing eons of random variations and infinitesimal ‘nature’ adaptations is correct, “which as far as our ignorance permits” it is, should we consume ourselves with the ‘nurture’ of man at all?

How many citizens would need to be trained to counter a potentially catastrophic threat to Australia – hundreds of thousands? If so, our military will essentially ‘get what we get’. We can no longer take for granted the ‘hardiness’ of past generations given the profound biopsychosocial developmental challenges that the emerging digital native generation are experiencing.[69] Certainly, the brutality of combat is profoundly divorced from a contemporary young westerner’s reality. So, how prepared is the current fighting aged generation?[70] Building and instilling resilience (nurture) in ‘what we get’ (nature) is not so much a question as it is a critical vulnerability.

A military’s first object is to defend its people and territories. We have successfully made soldiers of our citizens forever. During WW1&2 pressure for boots on the ground ultimately meant that genetics mattered little. Since this time, Australia’s commitment to warfare has been modest and safe in comparison and we have been able to build enviable military capability.

In the face of a potentially catastrophic threat, 'nature' will again be largely irrelevant. In the context of a softening modern Australian society, building resilience in a sustainable lethal capability will be more important than ever. However, the challenge to build resilient combat effective soldiers to operate in VUCA battlefield environments appears to be unprecedented. For example, more sedentary lifestyles and the increase in 'knowledge work' may be conspiring against us in terms of a worst case national defense perspective. Further, there appears to be an over emphasis on what we put *on* our soldiers rather than what we put *in* them.[71]

The nature/nurture debate has outlasted its usefulness. Technology and developments in pedagogy, psychology and physiology have revolutionized how we 'build' humans. Developments we may well leverage deliberately to influence epigenetic factors[72] and the biopsychosocial plasticity of our soldiers to assist in the build. Many things we considered fixed in humans, are not. For example, our understanding of how social stimuli are translated into physical characteristics in the brain[73]; or, the significant psychological (cognitive) benefits of physiological training.[74–76] Interestingly, both raise questions around the maintenance of resilience.

This can be achieved by immersing the scientists with our soldiers in what must be reality based training environments. We must resist the risk adversity of the bureaucratic policy makers that predominate modern training serials. Indeed, many senior soldiers would agree that this risk adversity is a threat to our soldier's resilience. It is time to return the ancients' approach[77] of a locally coordinated, multidisciplinary, multifaceted 'Human Performance' programs that are well resourced and founded in practitioner-academia alliances.

We have successfully built resilience in our military forever, with few exceptions. Through training and by organizing them into groupings and indoctrinations we have also built social and national resilience. However, in less determinable times we must modernize deliberately and rapidly. Rather than policy our soldiers need adaptive human performance programs supported by local academic alliances. Our soldiers', and indeed our nation's, resilience profoundly defines us all, and therefore we 'must' build on what we get.

1.5.2. The military cannot build and instill physiological and psychological resilience (Karl Friedl, United States)

Everyone can do their part for national defense, but not everyone is born to be a soldier. Soldier resilience is determined by genetics and early childhood experiences; building resilience rather than selecting individuals who already possess it is generally not feasible. By the time 17 or 18 year old recruits report for duty, the die has been cast and there are practical limits to how much biology can be modified to best meet soldier performance needs.

Early influences have been well entrained by the time young men and women report to military training and the resulting resilience attributes are not easily modifiable. In 1946, the U.S. Congress enacted the school lunch program because of national security concerns. Too many chronically malnourished conscripts had been unsuitable for military service in World War II, and the Army could not build or instill resilience in these individuals after the fact. Today, reversing the first two decades of nutrition and exercise habits has also been unsuccessful for obese young men and women; obese recruits who successfully lose weight during basic training are still likely to be eliminated as fitness failures before the end of their first enlistment.[78] During basic training additional selection occurs because trainability genes determine who can achieve minimum physical training standards and continue as a soldier.[79]

Genetic and epigenetic influences determine resilience factors such as hardiness and metabolic flexibility. In a study of the U.S. Army Ranger course, the two leanest individuals out of 50 young soldiers who completed the full eight weeks involving high workload and hypocaloria illustrated opposite extremes of metabolic response. One of these soldiers lost the least amount of weight (only 9% of body weight) and relatively little lean mass, while the other lost the largest amount of weight (23%) and consumed an estimated 40% of muscle mass (and was not awarded the Ranger tab, based on patrol leadership performance).[80] U.S. Army Rangers are selected on the basis of demonstrated resilience.

Epigenetics can determine psychological resilience. Trauma-induced stress responsivity can be passed to offspring, putting these individuals at increased risk for PTSD and other maladaptive responses to future traumatic exposures.[81] Other recent findings show that mindful control of anxiety is moderated by the strength of the connection between prefrontal cortex and the amygdala. Trait anxiety is lower in individuals with a thicker fiber tract connection to frontal cortex, the center of psychological resilience.[82] Gut microbiota also play an important role in stress and anxiety.[83] Until there is a program to reverse epigenetic effects or successfully reconfigure the gut microbiome of recruits, these factors affect key resilience traits that should be part of soldier selection.

Artificial attempts to enhance soldier performance may actually reduce resilience. For example, pharmaceutical enhancement of alertness removes the flexibility for restorative sleep opportunities, and drug manipulation of myostatin action to create massively muscled hulks reduces the opportunity to run fast and tolerate hot environments. Armies should select individuals with high resilience genes from the most promising pools of recruits; warrior cultures such as Sikhs, Gurkhas, New Zealand Māori, and Highland Scots are examples of such individuals who are purposely overrepresented in military service. Selection is preferable to extraordinary training, drug, and genetic enhancement of average individuals.

2. Discussion

Resilience is the ability to maintain normal psychological and physiological functioning in the presence of high stress and trauma.[8,84] As demonstrated in this roundtable, there are many co-dependent layers to resilience that build upon one another to ultimately enhance military readiness and preparedness (Fig. 1). Resilience is initially instilled within soldiers through training and preparation aimed to enhance physiological tolerance to stress. Aerobic training has long been the cornerstone of military training due to the physiological adaptations including increased cardiac output, decreased peripheral vascular resistance, and increased number of mitochondria in muscle cells that are vital to optimal performance of many military tasks.[85] Certainly these adaptations are advantageous in the presence of high physiological stress. However, the modern battlefield requires higher levels of anaerobic fitness, involving high force and quick explosive movements, and failure to prepare for such demands can lead to increase in injury or death.[85]

As more combat roles become open to women, the importance of anaerobic and strength training become increasingly essential for women to develop the adaptations necessary to meet the demands of the battlefield. The discernable physiological differences between men and women can promote and hinder resiliency for either sex. Though men have several physiological advantages over women, including higher average cardiac output and muscle strength, testosterone can negatively affect impulse control and decision making in combat.[40] In contrast, despite the physiological shortcomings requiring women to perform at a higher level of their maximum capacity during some military-specific tasks,

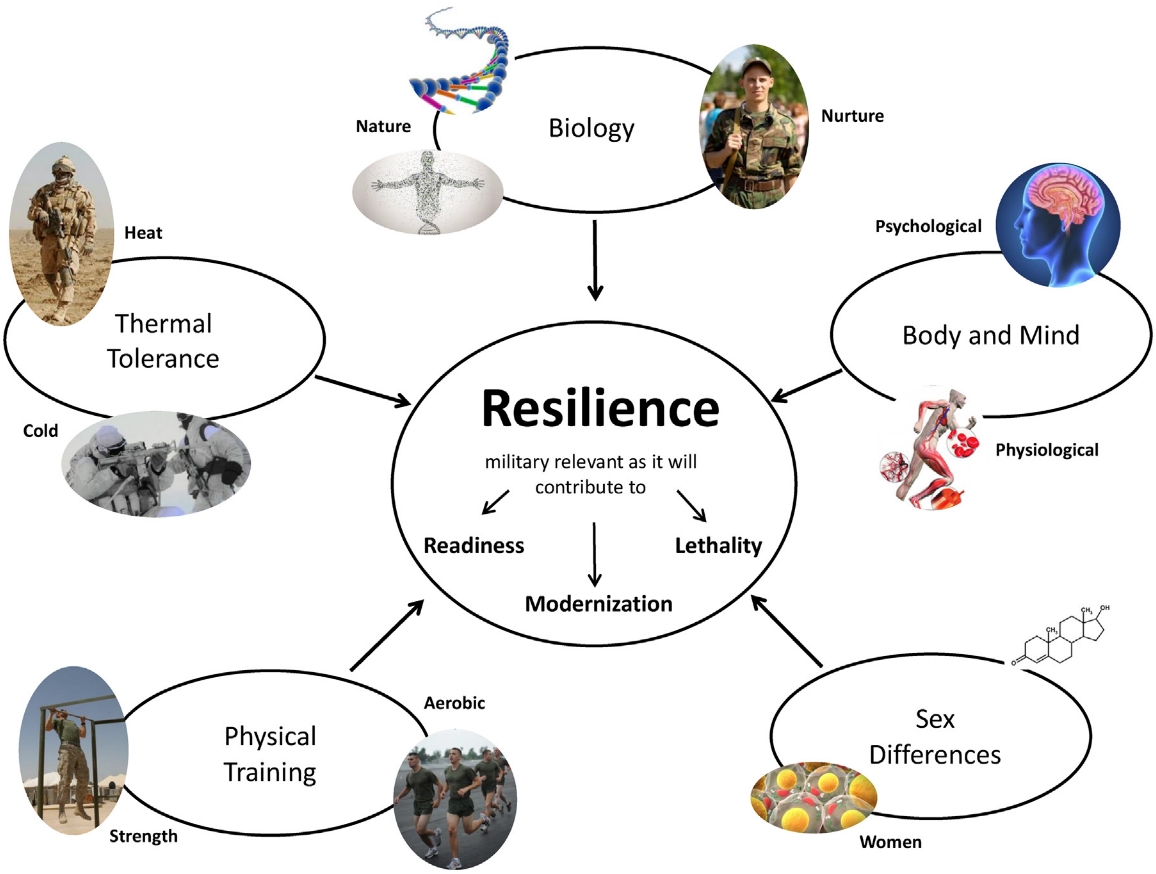

Fig. 1. Five key domains of resiliency resilience can be promoted through a variety of domains to enhance the readiness, lethality, and modernization of armed forces. While performance is ultimately grounded in cellular biology and physiology, it is enhanced through developing psychological coping mechanisms that nurture soldiers to tolerate discomfort and stress. For years aerobic training has been the cornerstone of military training due to the advantageous physiological adaptations. However, the modern battlefield requires higher levels of strength and anaerobic fitness. Though men have several physiological advantages over women, better lipid utilization provides women a resilient advantage over men in adverse environments. Regardless of sex, soldiers can prepare for extreme heat and cold by training in protective clothing while exposed to the elements.

their decreased caloric requirements and better lipid utilization[43] provide a resilient advantage over men in adverse environments.

While the capability of a soldier's performance is ultimately grounded at the cellular level, performance will be suboptimal if the soldier is unable to develop coping mechanisms to handle a changing operational environment. Therefore, building adaptive resilience in soldiers is the next layer necessary to promote military readiness. Considering the response to the same psychological stressor can vary immensely from person to person, resilience is considered an individual trait.[86] However, humans have proven to be a highly adaptable species. Through behavioral adaptations and reality based training environments, resilience has the potential to be instilled in soldiers, just as it has been historically during wartime with minimal selection criteria for soldiers, i.e. conscription. The Comprehensive Soldier Fitness (CSF) program is one example of how the US Army is taking a proactive approach to building resiliency in soldiers.[87] Based on positive psychology, the CSF program takes a similar approach to the Army's physical fitness training. Adaptive resilience is not solely based in psychology as a soldier must also be physically prepared to adapt to extreme climates. A combination of physiological training using specialized equipment for extreme environments, performing tasks while wearing appropriate protective clothing, and exposure to the elements, in conjunction with psychological training such as pacing, self-monitoring, and managing discomfort, are necessary to build resilience in the presence of extreme heat or cold.

Natures versus nurture tradeoffs are completely dependent on the needs of the military. Though some aspects surrounding resilience are solely grounded in nature, such as biological sex, genetic predisposition, and environmental conditions, resilience has the potential to be nurtured through physical and psychological training combined with the use of specialized equipment for extreme conditions. In times of national emergency, every able bodied individual may be called to serve in defense of their country and selection standards are eased or eliminated. In conscript armies around the world, individuals are prepared in basic training to do their part for national defense. Professional armies and specialized elite performers are more likely to be selected for their performance, including demonstrated resilience traits.

Once the layers of foundational and adaptive resilience have been established, the final layer should aim to reduce the demands for resilience in the modern battlefield to enhance readiness and preparedness. For instance, the application of new technologies, such as the use of exoskeletons for carrying heavy combat loads,[88] or innovative approaches to determine readiness, such as biomarker analysis,[16] can further enhance the level of preparedness. Furthermore, forecasting the operational environment and building appropriate techniques and countermeasures will optimize the readiness of our soldiers.

Ultimately, the interrelations of the layers of resilience indicate there is no singular or even binary approach that is most advantageous for building resilience to enhance military preparedness. Rather, a hybrid approach may be superior. Combining strategies may promote optimal readiness in the face of unanticipated, adverse stressors allowing service members to be equipped for a variety of scenarios. In doing so, the military can optimize performance in soldiers that are both mentally and physically resilient and equipped with behavioral adaptations to overcome the forces of nature, including physiological predispositions and extreme environmental conditions. While this roundtable focused on the individual soldier, future concern should also be provided for team resilience as military operations are generally executed in small and large units.

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