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Soldier Protection Today

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Center for a New American Security

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ABOUT THIS REPORT

This report, the second in the *Super Soldiers* series, covers findings from the Center for a New American Security's study on dismounted soldier survivability. This study was 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.

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

Introduction

The *Super Soldiers* series examines opportunities to improve dismounted soldier survivability in the near-, mid-, and far-term through changes to policies, improvements in equipment, and by harnessing emerging technologies. The first report in this series, "A Strategy for Enhancing Warfighter Survivability," provided an overview of the limitations of current armor systems and a strategy for improving soldier survivability.

This second report is an in-depth examination of the state of soldier protection today – both its value and limitations. Subsequent reports will build on this background material to examine the three main lines of effort outlined in "A Strategy for Enhancing Warfighter Survivability": (1) mitigate blast effects to the brain; (2) optimize body armor design and use; and (3) capitalize on emerging technologies.

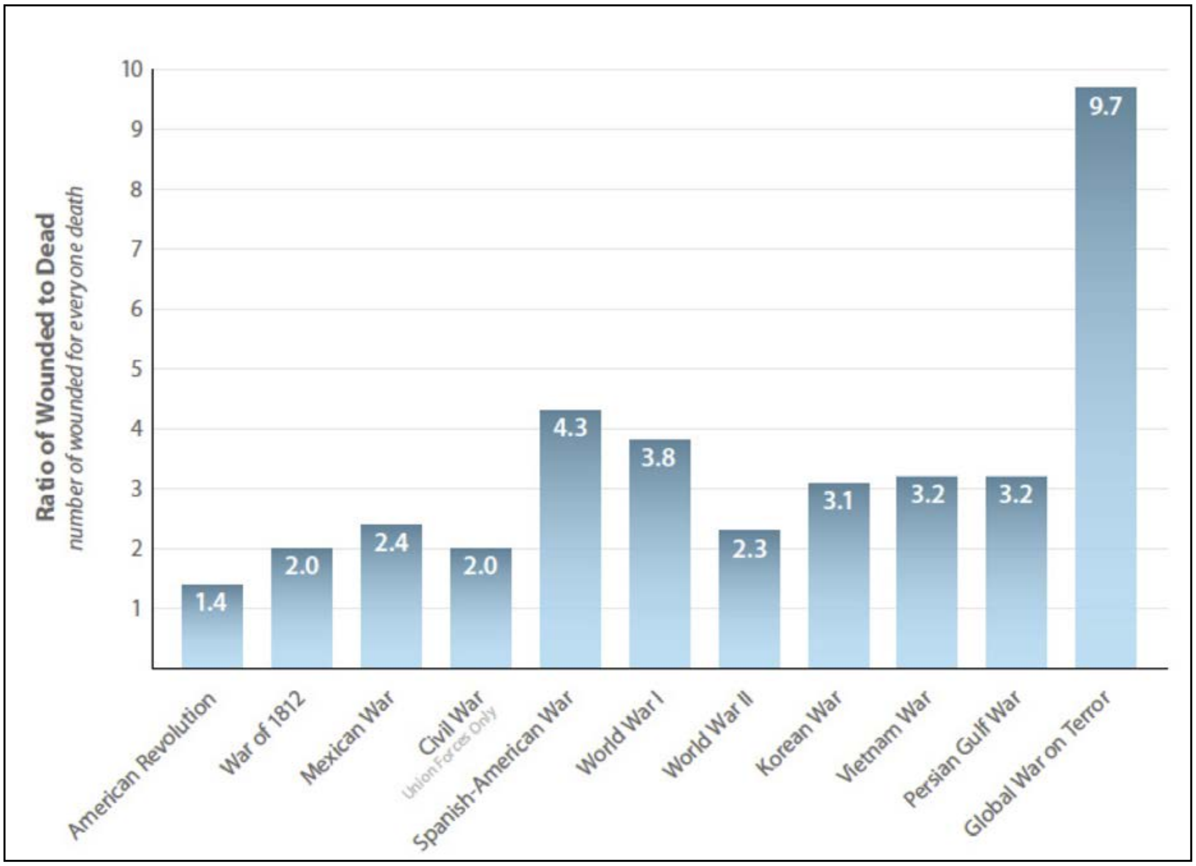
Summary of Key Findings

- Body armor is effective at ballistic protection.
- Such protection comes at a price, and the weight of body armor has increased substantially.
- The conservative nature of body armor standards may mean that armor is overdesigned in several respects. This means there may be opportunities for weight savings while still addressing the most prevalent threats.
- Body armor does not provide adequate protection from blast-induced brain injury, the signature wound of today's wars.

The Value of Armor

Body armor dates to antiquity. Siberian archaeological sites reveal body armor from at least 3,500 years ago.[1] Armor has changed over time, from plates of animal bones to chain mail to today's ceramic armor, with the constant aim to protect from contemporary threats. In each case, armor designs have balanced protection and mobility,[2] a challenge that persists today. Elements of protection have been largely static – predominantly a helmet and body armor to protect the vulnerable head and torso – but design and materials have improved to keep pace with adversary weapons.[3] Today's body armor consists of hard ceramic plates to protect the torso from high-velocity rifle rounds, overlaid on top of soft flexible armor to protect the torso from blast fragments and pistol rounds. Armor systems also include optional soft armor protection for the groin, neck, and upper arms, as well as a Kevlar helmet with ballistic protection from pistol rounds.

Modern Body Armor Has Dramatically Improved Soldier Survivability



(Source: Institute of Medicine, Gulf War and Health, Volume 9: Long-Term Effects of Blast Exposures (Washington, DC: National Academies Press, 2014), x, figure P-1)

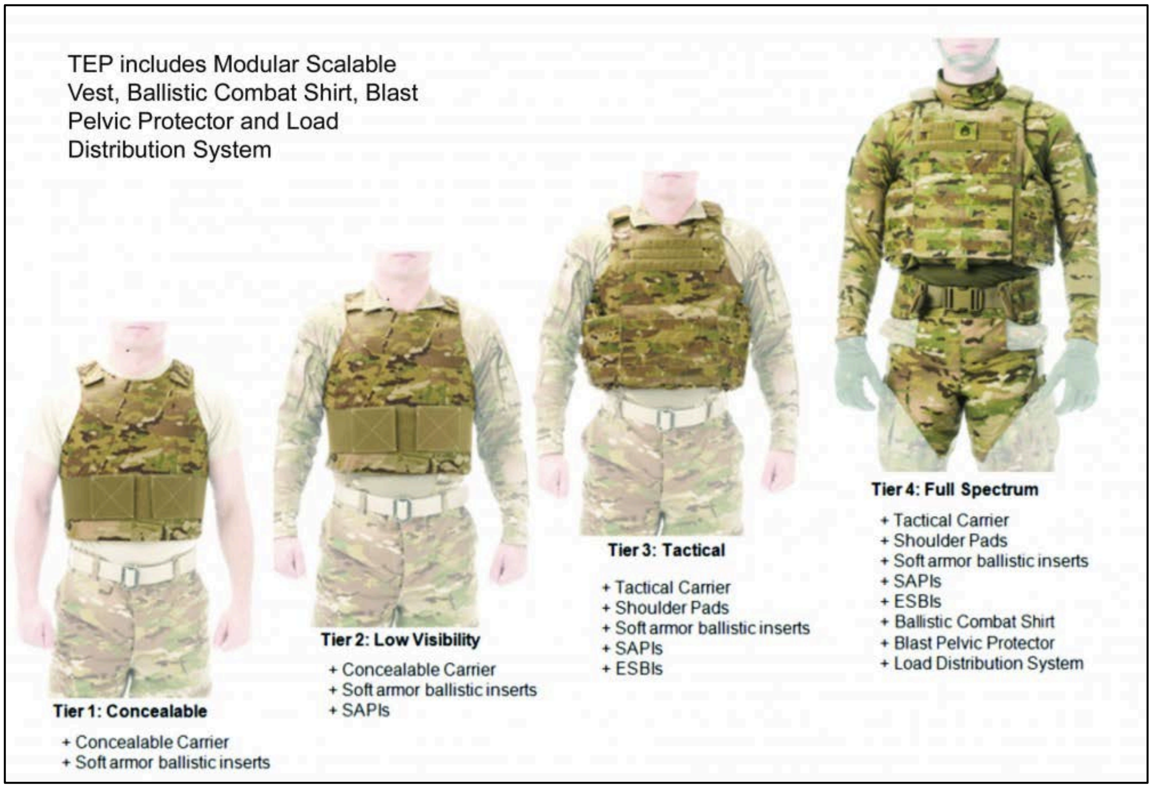
Modern body armor, in concert with other technologies such as improved medical care, has dramatically improved soldier survivability in recent conflicts. Body armor covers the most vulnerable areas of the torso, allowing soldiers to survive injuries that would have been fatal in previous wars.

Body Armor Is Effective, but at a Heavy Cost in Weight

Over the past 15 years of war, as body armor has evolved, it has nearly doubled in weight. As of 2016, the average total protective equipment for a soldier weighed approximately 27 pounds (weight given for size medium body armor; actual weight would vary by size). This equipment consists of a soft armor vest (7.5 pounds), hard armor ballistic plates that are inserted into the armor (5.5 pounds each for front and back plates, plus 2.5 pounds each for side plates), and a helmet (3 pounds).[4]

The Army has taken steps to reduce this load. In 2009, in response to concerns about weight, the Army issued a contract for a reduced weight Soldier Plate Carrier System for fielding to certain combat units deploying to Afghanistan. The Army's current plan for armor is to increase modularity across four threat levels with the Soldier Protection System (SPS). The full ensemble of all subsystems has a goal of reducing overall weight by 10 percent. SPS has significant weight-reduction goals, including an 8–14 percent weight reduction in the plates over the current system and a 26 percent decrease in the vest's weight compared to the current soft armor vest system.[5]

Soldier Protection System Modular Levels of Protection



(Source: U.S. Army)

Soldier Protection System Modular Helmet with Optional Appliqué Hard Armor

(Source: U.S. Army)

The Soldier Protection System helmet includes a goal of 5 percent reduction in helmet weight while also increasing blunt impact performance and adding passive hearing protection and a modular face shield.

In addition to meeting these weight-reduction goals, body armor must continue to keep pace with threats as they evolve. Over time, personal armor systems have increased their protection level to stay ahead of evolving threats. However, this added protection has generally come with a corresponding increase in weight. Material improvements to decrease weight are typically incremental, and any savings are often reinvested into improved protection at the same weight. This makes finding significant and lasting weight reductions challenging.

Remaining Vulnerabilities

In spite of the weight of current armor, soldiers remain vulnerable to blast and ballistic injury on the battlefield. Most significantly, existing body armor is not designed to protect from blast-induced brain injuries, the signature wound of today's conflicts. Blast pressure waves can come from improvised explosive devices (IEDs) or from firing heavy weapons, such as artillery, anti-tank rifles, or high caliber (.50) rifles.[6] Blast injury mechanisms are poorly understood. Explosions can knock soldiers over or overturn vehicles, causing soldiers to suffer secondary brain injuries due to concussion. Blast overpressure waves can also cause direct injury to the brain, but there are contradictory theories regarding the primary mechanism by which blasts cause traumatic brain injury (TBI). These include air or liquid pressure moving from the core of the body into the brain, movement of the brain inside the skull, and/or the movement of pressure waves through the brain. It is possible that existing torso armor reduces blast impacts against the body, and some experimental modeling indicates that the Army's current combat helmet modestly mitigates blast pressure inside the skull.[7] This suggests that there are opportunities to improve blast protection through modified designs. However, poorly designed armor could, in principle, potentially amplify blast waves and magnify brain injury by reflecting blast waves and concentrating them in focused areas, similar to the effect of reflected blast waves inside buildings or vehicles. Because blast injury is so poorly understood, at present soldiers remain highly vulnerable to blast-induced brain injury.

Additionally, even while current body armor systems are effective against the most prevalent ballistic threats on the battlefield today, vulnerable areas of the body remain exposed. These include the head, neck, groin, upper side torso, and limbs. The Soldier Protection System will expand coverage of the head and face with the Integrated Head Protection System with modular appliqué and maxillofacial (face shield) protection. With the SPS helmet, the most vulnerable areas of the body will be covered, but additional area coverage for hard armor could somewhat improve soldier survivability. For example, hard armor on the thighs, upper arms, and shoulders could protect vulnerable areas. Adding more hard armor is not feasible today given the weight of today's armor. Area coverage could be increased, however, by reducing armor weight or augmenting soldier strength, such as through exoskeletons for human performance enhancement. Off-body protection could also improve soldier survivability without increasing weight by using emerging technologies such as robotic teammates.

Future reports in this series will explore these and other opportunities for improving soldier protection.

NOTES

[1] Shawn M. Walsh and Daniel M. Baechle, "Robotic Augmented Soldier Protection," Army Research Labs document, 2.

[2] J. Q. Zheng and S. M. Walsh, "Materials, Manufacturing, and Enablers for Future Soldier Protection," in *Lightweight Ballistic Composites*, 2nd ed. (Woodhead Publishing, 2016), 393–437.

[3] Ibid, 393–437.

[4] Government Accountability Office, "Personal Protective Equipment," GAO-17-431, May 2017, 6, 8.

[5] U.S. Army, "Soldier Protection System (SPS)," http://asc.army.mil/web/portfolio-item/soldier-protection-system-sps/.

[6] Annette Saljo, Fredrik Arrhén, Hayde Bolouri, Maria Mayorga, and Anders Hamberger, "Neuropathology and Pressure in the Pig Brain Resulting from Low-Impulse Noise Exposure," *Journal of Neurotrauma* 25 no. 12 (December 2008), 1397–1406.

[7] Michelle K. Nyein, Amanda Jason, Li Yu, Claudio Pita, John D. Joannopoulos, David F. Moore, and Raul Radovitzky, "In Silico Investigation of Intracranial Blast Mitigation with Relevance to Military Traumatic Brain Injury," *Proceedings of the National Academy of Sciences*, 107 no. 48 (November 2010), http://www.pnas.org/content/107/48/20703.