

	Technology	Technology Features	Potential Contributions to Soldier Resilience	References
1	Advanced Synthetic Probiotics	Synthetic microorganisms that could increase the metabolism of target molecules and/or neutralize biological pathogens	➤ Treatment of infection and disease may improve health and protect against exposure to pathogens	[26,27]
2	Artificial Spleen	External blood-cleaning device that filters bacteria, viruses, and toxins out of the blood	➤ Treat pathogen infection quickly ➤ May reduce risk of death due to sepsis	[28]
3	<u>Astroskin/Hexoskin</u>	Shirt that monitors blood pressure, skin temperature, activity level, heart rate, electrocardiogram, and breathing rate and volume, among other physiological measures	➤ Biofeedback could be used to inform and adjust behaviour and thereby reduce the risk of injury	[29-31]
4	Bacterial Biosensors for Diagnostics	Genetically modified bacteria that recognize and signal the presence of internal targets such as infection, inflammation, disease markers or toxic chemicals	➤ Potential for highly specific, fast detection of specific disease, parasites, or toxins in the body may allow for early intervention and fast recovery	[32,33]
5	Bacterial Biosensors for Threat Detection	Genetically modified bacteria that, recognize and signal the presence of explosives	➤ Visual signalling of explosives in the environment may allow soldiers to avoid exposure to dangerous hazards that could cause injury or death	[34]
6	Biofuel Cell Non-Invasive Self-Powered Sensors	Self-powered enzymatic biofuel cells incorporated into clothing that detect levels of lactate and glucose in sweat	➤ Biofeedback could be used to inform and adjust behaviour and thereby reduce the risk of injury	[35,36]
7	<u>Checklight™</u>	Soft skull-cap worn under a helmet that indicates the severity of a head impact	➤ Could reduce the potential for injury by providing objective information about the severity of a head impact that can be used to determine when medical attention is needed	[37-39]

8	Cognitive Enhancement Drugs (Nootropics)	Medications to increase focus, attention, cognition, executive functioning, and reduce fatigue	➤ Reduced fatigue, enhanced alertness, and improved focus could prevent cognitive overload and could decrease the risk of errors and accidents leading to injury	[40,41]
9	Deep Bleeder Acoustic Coagulation	A portable, automated tourniquet that uses high intensity focused ultrasound to detect, locate, and stop bleeding in deep vascular wounds quickly	➤ Automated location and stopping of bleeding could reduce risk of death due to hemorrhage	[42,43]
10	Epidermal Electronic Biosensors	Flexible, breathable electronics that adhere to the skin and can detect <u>mechano</u> -acoustic heart signals, muscle contractions, electroencephalograms, skin temperature, UV exposure, blood flow, sweat rate and loss, sweat pH levels, sweat concentrations of chloride, glucose, creatinine, and lactate	➤ Biofeedback could be used to inform and adjust behaviour and thereby reduce the risk of injury	[44-51]
11	<u>ErythroMer</u> Blood Substitute	<u>Nanoproduct</u> that can be stored as a powder, reconstituted in water, and used as synthetic blood for transfusions	➤ Quick and easy access to a blood product could reduce the risk of death due to hemorrhage	[52]
12	Gait Modifying Insoles	Shoe insole that delivers imperceptible vibrations to the sole of the foot, which improves gait control and balance, and reduces time (but not accuracy) to perform an agility test	➤ Improvements in balance could reduce the risk of injury	[53-55]
13	Genome Editing	Genetic editing tools like CRISPR may be used to develop specific antimicrobials that target antibiotic-resistant bacteria, create new therapeutics, and develop new treatments for disease	➤ Creation of better therapeutics could reduce the risk of untreatable infection and hasten recovery from illness	[56-59]
14	G-Putty (Graphene Silly Putty)	Soft and extremely sensitive material that can detect pulse, blood pressure, and respiration when placed on the skin	➤ If incorporated into a wearable device, biofeedback could be used to inform and adjust behaviour and thereby reduce the risk of injury	[60]

15	Graphene-Based Wireless Contaminant Detection	Small chip placed on a tooth or other tissue that emits a radio signal when it detects a contaminant such as bacteria	➤ Detection of contaminants at very low concentrations in the environment or in saliva could allow early intervention to treat infections or prevent exposure to dangerous environmental contaminants	[61]
16	Multi-Joint Soft Exosuit	Lightweight soft exoskeleton that reduces net metabolic power expended during walking while carrying a heavy load	➤ By reducing the metabolic cost of walking with a heavy load, fatigue and subsequent risk of injury may be reduced in soldiers wearing this device	[62-64]
17	Neuroprosthetics	Brain-computer interface that records and translates brain signals into movement of paralyzed limbs, prosthetics, or other external robotic devices	➤ Improved and realistic prosthetics may allow injured soldiers to return to the battlefield	[65-70]
18	Non-Invasive Transcranial Direct Current Stimulation	Electrical stimulation through electrodes placed on the scalp that can temporarily alter brain activity. May improve multitasking, memory, learning, cognition, focus, or reduce fear, stress, and pain depending on electrode placement	<ul style="list-style-type: none"> ➤ May improve focus and cognition and decrease the effects of sleep deprivation on cognition leading to fewer mistakes resulting in injury ➤ May also have utility in treating depression and anxiety disorders such as PTSD, and chronic pain which could allow soldiers to return to the battlefield after psychological or physical injury 	[71-78]
19	PowerWalk® Wearable Power Generator	Leg braces that harvest energy from leg movement during walking and facilitate downhill walking	➤ Reduced effort walking downhill may decrease fatigue and subsequent risk of injury	[79-81]
20	Rovables: Robotic Mobile Wearables	On-body, freely moving autonomous robotic sensors attached to clothing that can be used for continuous physiological monitoring (e.g., heart rate and respiration, muscle activity, sleep quality, and skin lesions), wearable displays, and tactile feedback for GPS directions	➤ Biofeedback could be used to inform and adjust behaviour and thereby reduce the risk of injury	[82]

21	Single-Walled Carbon Nanotube Breathable Protective Membranes	Breathable membranes that allow water vapour transport but stop the transport of dangerous biological molecules such as viruses and bacteria and may be modified to prevent the transport of chemical toxins	<ul style="list-style-type: none"> ➤ Could be incorporated into clothing that protects soldiers from biological and chemical threats ➤ Breathability may also reduce the risk of heat exhaustion 	[83]
22	Skin-Mounted Sweat Biosensors	Wearable devices that measure <u>analytes</u> of interest in sweat such as sodium, potassium, lactate, glucose, creatinine, cortisol, and sweat pH	<ul style="list-style-type: none"> ➤ Biofeedback could be used to adjust behaviour and thereby reduce the risk of injury 	[50,84-88]
23	Soft Robots	Soft robotic devices designed for resilience and their ability to get into and move around in confined spaces	<ul style="list-style-type: none"> ➤ Could be used to develop more comfortable and realistic prosthetic limbs, enabling injured soldiers to return to the battlefield ➤ Could be used to develop ingestible robots for internal physiological monitoring, allowing for early detection of injury, inflammation, or disease markers 	[89-92]
24	Speech/Gesture Control of unmanned aerial vehicles (UAVs)	Flexible and stretchable electronic patch that can adhere to the skin like a temporary tattoo and detect electrical signals generated by skeletal muscle contractions and acoustic vibrations from the vocal cords; these signals can be translated into directions to dictate the movement of UAVs or other robotic systems	<ul style="list-style-type: none"> ➤ May enable soldiers to remain further from dangerous zones while controlling unmanned vehicles in an area of interest through vocal commands or wrist gestures, which could reduce the risk of injury 	[51,93]
25	Stem-Cell-Derived Synthetic Blood	Synthetic blood made from stem cells in the laboratory	<ul style="list-style-type: none"> ➤ Consistent supply of universal donor blood may reduce the risk of death due to blood loss if real blood of the correct type is unavailable in an emergency, and could also reduce the risk of blood borne illness 	[94-96]

26	Sweat Glucose Biosensor and Drug Delivery Patch	Wearable patch that detects glucose levels in sweat and automatically releases a drug into the wearer's system to reduce glucose when sweat levels reach a certain threshold	<ul style="list-style-type: none"> ➤ Automated glucose monitoring and management could enable diabetic soldiers to serve ➤ Could be configured to measure a number of <u>analytes</u> in sweat and deliver various medications ➤ A patch that detects stress levels and releases anti-anxiety drugs or detects a chemical toxin in the system and releases an antidote could prevent illness or injury in soldiers 	[97,98]
27	Transplanted Limbs	Amputees with transplanted upper limbs can regain sensation and motor control of the new limb	<ul style="list-style-type: none"> ➤ Better, more effective prosthetics may enable injured soldiers to return to the battlefield 	[99-102]
28	Virtual Reality	Immersive head-mounted displays with audio, visual, and sometimes haptic feedback used for training simulations, preventing and treating PTSD, improving stress resilience, and pain control	<ul style="list-style-type: none"> ➤ May help soldiers prepare for and successfully deal with emotionally challenging and stressful situations on the battlefield, reducing the risk of physical and psychological injury ➤ May help soldiers prepare for complex missions by practicing in a simulated environment, which could reduce the risk of errors and injury ➤ May be used to prevent or treat PTSD and allow soldiers to return to the battlefield ➤ May be used to reduce pain, which could decrease the need for pain medications in injured soldiers, potentially allowing them to recover faster 	[103-108]
29	<u>XStat</u> ® Rapid Hemostasis System	Syringe filled with sponges that are injected directly into a wound and expand to stop bleeding quickly in the field	<ul style="list-style-type: none"> ➤ Reduce risk of death due to hemorrhage from wounds not amenable to tourniquet 	[109-112]

