

Navigating Through Genomics in Military Medicine and its Ethical Aspects

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Use Genomic Medicine in the Military

- Precision medicine through DNA sequencing and biomarker discovery
- Civilian applications:
 - Oncology – Eg : BRCA1/2
 - Pharmacogenomics
 - Infectious disease – COVID -19
- Soldiers face unique stressors:
 - Combat injuries
 - Extreme environments
 - Infectious exposures
- Genomics offers tailored solutions for resilience and recovery



History of use genetics in military

- World War II Era Civilian applications:
 - Not advanced
 - But early blood typing and family history were used to assess medical fitness.
- Cold War Period (1950s–1970s)
 - Military medicine began exploring hereditary diseases (e.g., sickle cell trait screening in recruits).
 - This was one of the first systematic uses of genetic information in recruitment and deployment decisions.



The Case of Sickle Cell Trait in Recruits

- 1969 - The US Navy - the death of four recruits while undergoing training at moderate altitude (>4,060 feet)
- 1970, the Military Aviation Safety Subcommittee introduced several restrictions on recruits known to be trait carriers, including restricting their activities in
 - aviation
 - diving
 - special forces
 - high-altitude parachuting



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JOURNAL ARTICLE

Screening for Sickle-Cell Trait at Accession to the United States Military [Get access >](#)

Bryant J. Webber, USAF MC, Catherine T. Witkop, USAF MC

Military Medicine, Volume 179, Issue 11, November 2014, Pages 1184–1189,
<https://doi.org/10.7205/MILMED-D-14-00089>
Published: 01 November 2014


Volume 179, Issue 11
November 2014

The Case of Sickle Cell Trait cont...

- 1981 - US Department of Defence - drop the restrictions – due to conflicting evidence for a link between SCT vs increased mortality
 - But continued screening for the trait
- In mid-1990s - The deaths of three Air Force (SCT carriers) – the US Armed Forces Epidemiology Board revisited the issue
- 1996, US Secretary of Defence - ‘Testing for SCT should not be mandated for military accessions’
- The Ethical issues - of genetic and racial discrimination
 - as sickle cell is considerably more prevalent among African Americans.

Sickle cell trait contributed to death of captain during fitness test

By [Stephen Losey](#)

Jul 16, 2020



The Case of Sickle Cell Trait cont...

- Currently, - screen potential recruits for a personal history of haemoglobin disorders during the initial exam at military entrance processing stations
- Although having a history of sickle cell disease does disqualify a candidate
- Recruits with SCT are undergone genetic counselling to avoid
 - Exertional collapse associated with sickle cell trait (ECAST) - gradually increasing activity ,
 - maintaining adequate hydration,
 - ensuring proper rest between workouts,
 - avoiding exercise while ill and avoiding low-oxygen and increased-air-pressure environments.

1990s–2000s: Human Genome Project Influence

- The sequencing of the human genome opened possibilities for precision medicine in the military
- Research began on genetic predispositions to conditions like
 - Heat stroke
 - Musculoskeletal injuries
 - PTSD



Post-Traumatic Stress Disorder (PTSD)

- Significant gene expression changes associated with PTSD, highlighting dysregulation in immune, inflammatory, and neurodevelopmental processes

Review Article

Bull Emerg Trauma 2025;13(1):1-19.

Bulletin of Emergency And Trauma



Genetic Alterations in War-Related Post-Traumatic Stress Disorder: A Systematic Review

Amir Hossein Rajabi^{1}, Samaneh Zafarabadi², Kimia Jazi³, Maryam Moghbel Baerz^{4, 5}, Omid Bahrami⁶, Gelareh Azarinoush³, Pardis Habibi^{1, 7}, Negar Azami⁸, Shahram Paydar⁹*

Post-Traumatic Stress Disorder (PTSD) cont...

- **FKBP5:** This gene is a critical regulator of the stress response
 - **Downregulation** of FKBP5 mRNA pre-deployment is a significant predictor for developing high levels of PTSD symptoms
- **SKA2:** This gene regulates cortisol feedback in the brain
 - **Decreased SKA2 methylation** has been found to predict the development of PTSD, particularly when combined with a history of childhood trauma
- **NR3C1:** This gene encodes the glucocorticoid receptor
 - Its methylation patterns may allow for the early identification of PTSD risk in trauma-exposed populations by indicating altered stress hormone activity

Pathophysiology of PTSD cont..

Immune dysregulation



Chronic stress responses



Increased inflammation and altered cytokine activity



Significantly contribute to the pathophysiology of PTSD

Post-Traumatic Stress Disorder (PTSD) cont..

- Prevalence - 7% in the US population and 12% in the military
- Four mutations (SNPs; rs3800373, rs9296158, rs1360780, rs9470080) covering the FKBP5 gene
- US service members deployed to Iraq and Afghanistan, a high-risk military population (n = 3890)
- FKBP5 gene - potential biomarker for PTSD



Journal of Psychiatric Research

Volume 122, March 2020, Pages 48-53



Genetic association of FKBP5 with PTSD in US service members deployed to Iraq and Afghanistan

Lei Zhang^{a,1}  , Xian-Zhang Hu^{a,1}, Tianzheng Yu^{b,1}, Ze Chen^a, Jacob Dohl^b, Xiaoxia Li^a, David M. Benedek^a, Carol S. Fullerton^a, Gary Wynn^a, James E. Barrett^c, Mian Li^d, Dale W. Russell^{a,b}, Biomarker team, Robert J. Ursano^{a,1}

DNA Repository - Armed Forces Repository of Specimen Samples for the Identification of Remains (AFRSSIR)

- The U.S. military in 1992 established the Armed Forces Repository of Specimen Samples for the Identification of Remains (AFRSSIR)
- Collecting DNA from all service members for casualty identification
- Hold over 9 million bloodstain cards from service members
- Long-term storage (up to 50 years) of samples to identify deceased or missing personnel

Genetics used in Military Forensics

- Unrecovered War Casualties - Australian WWI or WWII Army soldiers

Forensic Sciences Research, 2024, Vol. 9, Issue 1

<https://doi.org/10.1093/fsr/owad050>

Advance access publication date 25 December 2023

Review

Improving the strategy to identify historical military remains: a literature review and Y-STR meta-analysis

Melinda R. Mitchell^{1,*}, Janet Chaseling¹, Lee Jones², Toni White³, Andrew Bernie⁴,
Larisa M. Haupt¹, Lyn R. Griffiths¹, Kirsty M. Wright^{1,4,5}

Precision Medicine & Pharmacogenomics

- Genetic testing could determine how soldiers metabolize medications (e.g., painkillers, antidepressants), ensuring safer and more effective treatments in combat zones.

REVIEWS



Pharmacogenomics testing to optimize medical countermeasures against chemical warfare agents and bacterial biothreats in military settings

Samuel Chekabab^a and John Mikler^a



Precision Medicine & Pharmacogenomics

- Injury Prevention
 - Screening for variants linked to stress fractures, tendon injuries, or heat intolerance could reduce training-related casualties

Korvala *et al.* *BMC Genetics* 2010, **11**:95
<http://www.biomedcentral.com/1471-2156/11/95>



RESEARCH ARTICLE

Open Access

Genetic predisposition for femoral neck stress fractures in military conscripts

Johanna Korvala^{1†}, Heini Hartikka^{1†}, Harri Pihlajamäki^{2,3}, Svetlana Solovieva⁴, Juha-Petri Ruohola³, Timo Sahi^{3,5}, Sandra Barral⁶, Jürg Ott⁷, Leena Ala-Kokko^{1,8}, Minna Männikkö^{1*}

Common Ethical issue

- Commanders traditionally have greater access to medical information of SMs under their command
 - The access to medical information is kept to the minimum required to inform determinations of fitness for duty and safety
 - This is done in conjunction with medical personnel based on established standards
- Potential Discrimination: Genetic predispositions could influence career opportunities in the military
- Privacy Concerns
- Regulate military use of genomics to prevent misuse in warfare

GINA does not apply to the military



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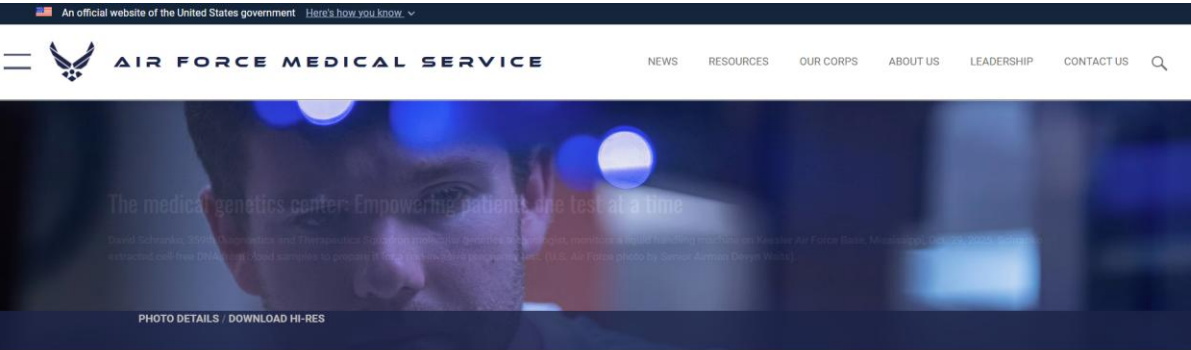
Genetic Information Nondiscrimination Act of 2008

An Act

To prohibit discrimination on the basis of genetic information with respect to health insurance and employment.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,

Medical genetic centres



The medical genetics center: Empowering patients one test at a time

Published Jan. 9, 2026
By Senior Airman Devyn Waits
81st Training Wing

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The way forward in Sri Lanka – Genetics in Military

- CBRN unit
- Genetic counselling
- Genetic testing facility



Future Applications of Genetics in the Military

- **AI-Driven Genomic Profiling**
 - Machine learning - integrate genetic, epigenetic, and environmental data to predict resilience, endurance, and cognitive performance
 - Potential use: Assigning recruits to roles where they are most likely to excel while minimizing health risks

NAR Genomics and Bioinformatics, 2025, **7**, lqaf038
<https://doi.org/10.1093/nargab/lqaf038>
Opinion Article

OXFORD

AI-powered precision medicine: utilizing genetic risk factor optimization to revolutionize healthcare

Sakhaa Alsaedi ^{1,2,3,4}, Michihiro Ogasawara⁵, Mohammed Alarawi^{2,3,6}, Xin Gao ^{1,2,3},
Takashi Gojobori ^{2,3,6,7,*}

Personalized Resilience Training (PTSD & Stress)

- miRNA biomarkers predicting PTSD resilience in military



International Journal of
Molecular Sciences



Article

Long-Term miRNA Changes Predicting Resiliency Factors of Post-Traumatic Stress Disorder in a Large Military Cohort—Millennium Cohort Study

Ruoting Yang ^{1,*}, Swapna Kannan ¹, Aarti Gautam ¹, Teresa M. Powell ², Cynthia A. LeardMann ^{3,4} ,
Allison V. Hoke ¹ , George I. Dimitrov ¹, Marti Jett ¹ , Carrie J. Donoho ⁵, Rudolph P. Rull ^{3,†}
and Rasha Hammamieh ^{1,†} 

Epigenetic inheritance of PTSD risk from war trauma

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Genetic heritage of war: exploring transgenerational inheritance of PTSD and its molecular background

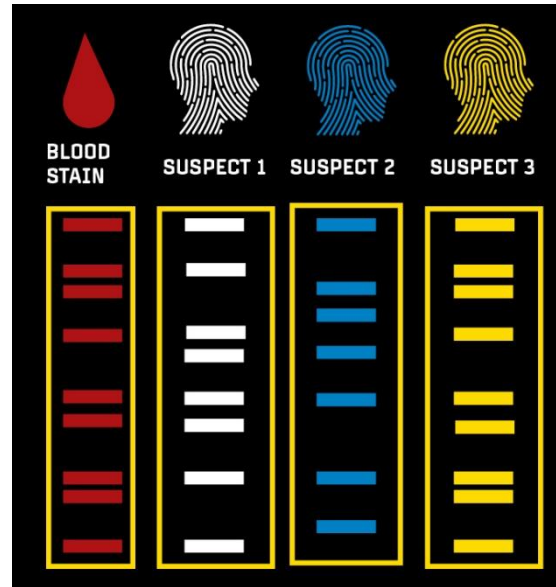
Published: 12 January 2026

Volume 37, article number 22, (2026) [Cite this article](#)

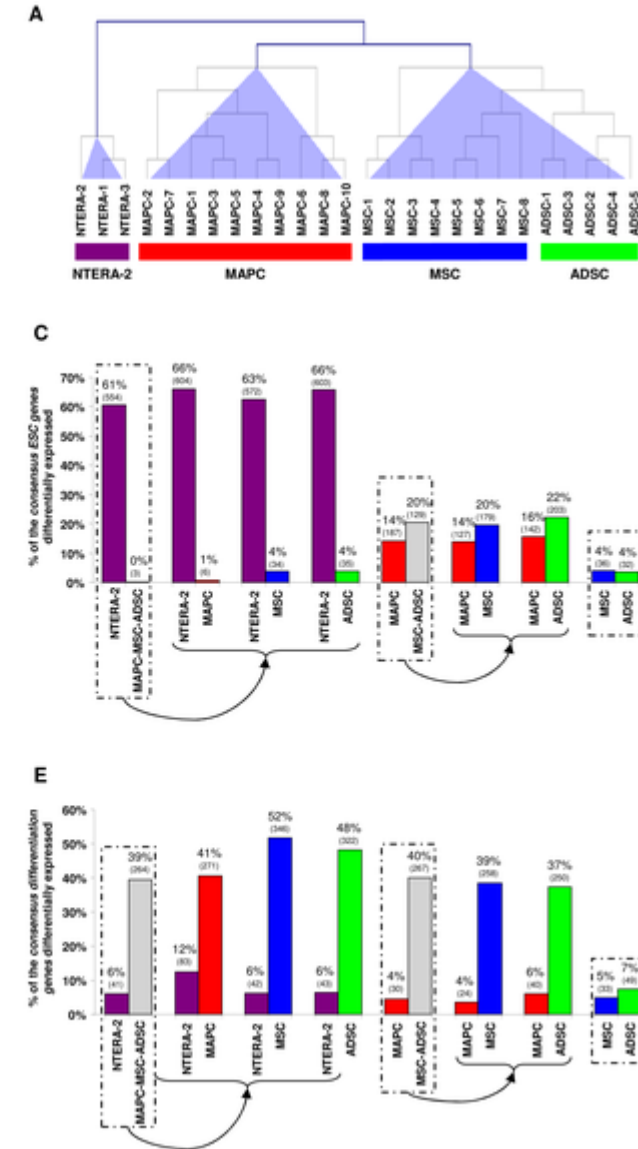
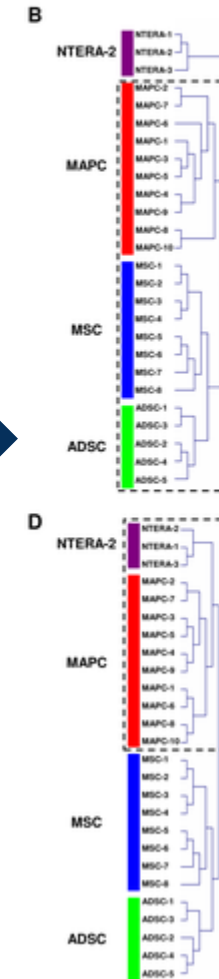
Epigenetic signatures



Hand signature



DNA fingerprints



Epigenetic signature

DNA sequencing in the field

- From Lab to the field – Direct victim identification at the war field
- 'MinION sketching'

TOOLS AND RESOURCES



Rapid re-identification of human samples using portable DNA sequencing

Sophie Zaaijer^{1,2†*}, Assaf Gordon², Daniel Speyer^{1,2}, Robert Piccone³, Simon Cornelis Groen⁴, Yaniv Erlich^{1,2,5*}

¹Department of Computer Science, New York Genome Center, New York, United States; ²New York Genome Center, New York, United States; ³Data Science Institute, Columbia University, New York, United States; ⁴Department of Biology, Center for Genomics and Systems Biology, New York University, New York, United States; ⁵Department of Computer Science, Fu Foundation School of Engineering, Columbia University, New York, United States

Military pharmacogenomics

- Enhanced PON1 activity could reduce vulnerability to chemical warfare agents
- Enhancing genes like TP53, ATM, RAD51 could improve cellular repair after radiation exposure

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Author Manuscript
Toxicology. Author manuscript; available in PMC 2014 May 10.

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Published in final edited form as:
Toxicology. 2013 May 10; 307: 115–122. doi:10.1016/j.tox.2012.07.011.

PARAOXONASE 1 (PON1) AS A GENETIC DETERMINANT OF SUSCEPTIBILITY TO ORGANOPHOSPHATE TOXICITY

Lucio G. Costa^{1,3}, Gennaro Giordano¹, Toby B. Cole^{1,2}, Judit Marsillach², and Clement E. Furlong²

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Weaponized genomics: potential threats to international and human security

[Subhayan Chattopadhyay](#), [Tony Ingesson](#), [Alberto Rinaldi](#), [Oscar Larsson](#), [J. J. Widen](#), [Jessica Almqvist](#) & [David Gisselsson](#) 

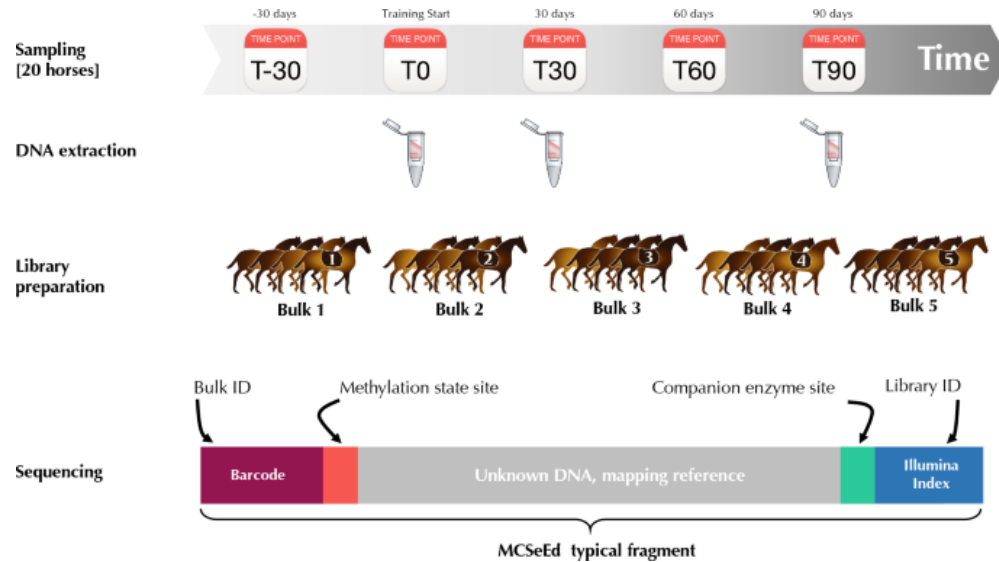
[Nature Reviews Genetics](#) **25**, 1–2 (2024) | [Cite this article](#)

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Creating super soldiers ?

If they have done for animals , why not humans



BIO-WEAPON SOLDIERS

Experts have warned how scientists could create DNA-altered super soldiers

- Enhanced reaction times and intelligence with gene-edited brains
- Brains connected with computers allowing telepathic communication
- Super strength and bigger muscles 'bred' into the soldiers
- Body flooded with pain-numbing stimulants
- Ability to regrow lost limbs & quickly heal wounds like a lizard
- Man-made viruses could also be programmed & unleashed in future wars

Thank you