Differential Brain Age in Blast Exposed Service Members

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Introduction

Service members are frequently exposed to repetitive low-level blast in both training and operational settings, yet the long-term impact on brain structure remains poorly understood[1]. Although individual low-level blast events are often subclinical, accumulating evidence suggests that repeated exposure may be associated with neurocognitive changes and alterations in brain biomarkers over time[2].

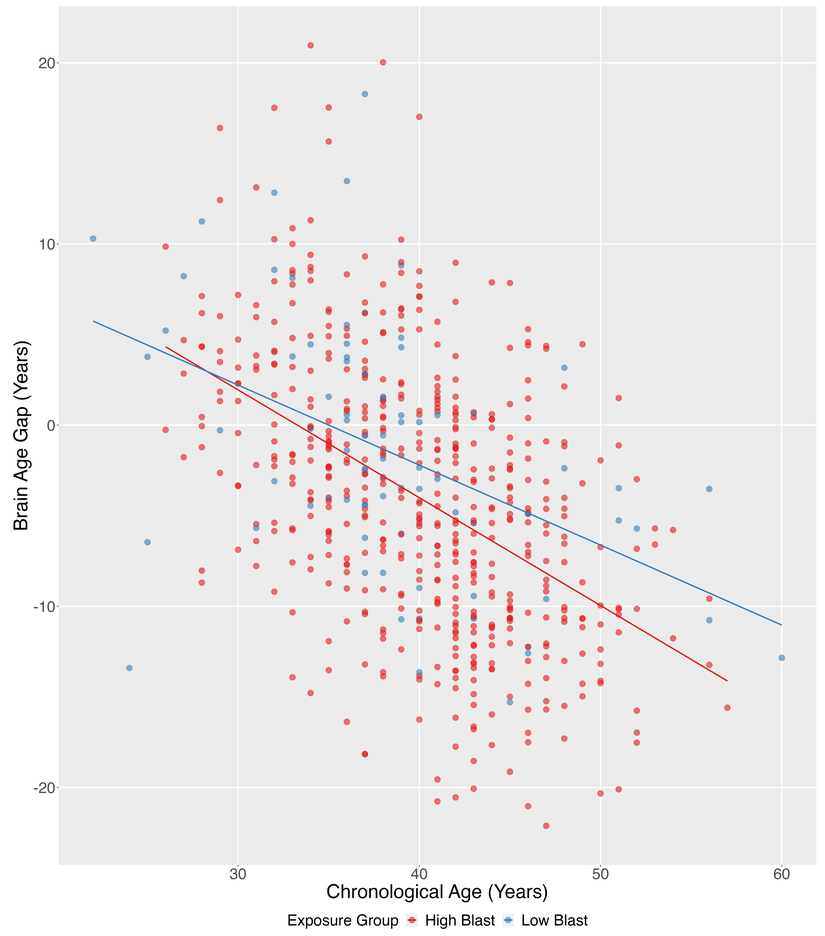
Recent advances in neuroimaging have enabled the development of brain age prediction models based on structural MRI features. The difference between an individual's predicted brain age and their chronological age—known as the brain age gap (BAG)—has been proposed as a potential biomarker of overall brain health. This study sought to determine whether a history of blast exposure is associated with accelerated brain aging, as reflected by a greater BAG.

Methods

The retrospective study included 608 service members enrolled in a large research study at the National Intrepid Center of Excellence (NICoE) between 2011-2024. Participants were categorized based on their self-reported military occupational specialty into a high blast-exposed group (n = 529; age = 40.1 ± 5.9yrs) and a low blast-exposed group (n = 79; age = 38.4 ± 7.1yrs).

All participants underwent 3T structural MRI. Cortical and subcortical features were extracted from T1-weighted images using Freesurfer[3] and served as input for a pre-trained Enhancing Neuro Imaging Genetics through Meta-Analysis (ENIGMA) Brain Age model to estimate brain age[4]. A linear regression model was conducted to examine the relationship between blast exposure and brain age gap, while controlling for chronological age.

		High Blast	Low Blast	P-value
N	608	529	79	
Mean Chronological Age (Years)	39.9±6.13	40.1±5.95	38.4±7.07	**0.009**
Mean Predicted Age (Years)	36.1±7.05	36.0±7.01	36.9±7.30	0.330
Mean Brain Age Gap (Years)	-3.72±7.45	-4.05±7.48	-1.49±6.89	**0.006**
Mean Cortical Thickness	2.44±0.11	2.45±0.11	2.41±0.11	**0.006**



Relationship Between Chronological Age and Brain Age Gap by Blast Exposure

Results

- The overall model was statistically significant, $F_{(2, 605)} = 90.47$, $p < .001$, accounting for 22.8% of the variance in BAG ($R^2 = .230$, adjusted$R^2 = .228$).
- After adjusting for chronological age, a significant difference in BAG emerged between the two blast-exposure groups.
- Specifically, the high blast-exposed group exhibited a significantly lower BAG than the low blast-exposed group ($B = -1.59$ years; $SE = 0.79$; 95% CI [0.04, 3.15]; $t(605) = 2.01$, $p = .045$).

This finding suggests that, on average, individuals in the high blast-exposed group displayed brains that appeared younger than expected relative to their chronological age, when compared to those with lower blast exposure.

Conclusions

Inclusion in the high blast-exposure group was associated with a lower BAG compared to low blast-exposed service members, indicating a comparatively younger brain in the high blast group. The pre-trained ENIGMA brain age model utilizes cortical thickness, subcortical volume measures, among other variables, to predict brain age. Conflicting evidence suggests blast exposure may cause the cortex to thicken, which could partly account for the observed lower BAG. Another potential confounder to this analysis may be lifestyle and health differences in high blast-exposure military occupations. The development of a military-specific brain age model represents a necessary next step toward providing a more precise and contextually relevant tool for brain health risk stratification in service members.

Disclaimer: The views expressed in this presentation are those of the authors and do not necessarily reflect the official policy of the Defense Health Agency, Department of War, or the U.S. Government.

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