McMaster University | HEALTH FORUM

Rapid Evidence Profile

Examining the association between the role of military breacher and sniper and the effects of mild traumatic brain injuries

2 July 2024

[MHF product code: REP 75]

Appendices

Appendix 1: Methodological details

We use a standard protocol for preparing rapid evidence profiles (REP) to ensure that our approach to identifying research evidence is as systematic and transparent as possible in the time we were given to prepare the profile.

At the beginning of each rapid evidence profile and throughout its development, we engage a subject matter expert, who help us to scope the question and ensure relevant context is taken into account in the summary of the evidence.

Identifying research evidence

For this REP, we searched PubMed, CINAHL, and Web of Science for:
1) evidence syntheses
2) protocols for evidence syntheses that are underway
3) single studies.

In PubMed, we used an open text search for ((SWAT OR snipe* OR "breach*"[All Fields]) AND ("brain concussion"[MeSH Terms] OR "mild traumatic brain injury"[All Fields] OR "mTBI" OR "concuss*")). In CINAHL, we used an open text search for (MH "Brain Concussion") OR (mTBI OR "mild traumatic brain injury") AND (breach* OR "SWAT" OR snipe*). In Web of Science, we used an open text search for (mtbi OR mild traumatic brain injury OR concuss* (Abstract)) AND (breach* OR swat OR snipe* (Abstract)). Links for CINAHL and Web of Science are not available as the URLs are specific to the institution.

Each source for these documents is assigned to one team member who conducts hand searches (when a source contains a smaller number of documents) or keyword searches to identify potentially relevant documents. A final inclusion assessment is performed both by the person who did the initial screening and the lead author of the rapid evidence profile, with disagreements resolved by consensus or with the input of a third reviewer on the team. The team uses a dedicated virtual channel to discuss and iteratively refine inclusion/exclusion criteria throughout the process, which provides a running list of considerations that all members can consult during the first stages of assessment.

During this process we include published, pre-print, and grey literature. We do not exclude documents based on the language of a document. However, we are not able to extract key findings from documents that are written in languages other than Chinese, English, French, or Spanish. We provide any documents that do not have content available in these languages in an appendix containing documents excluded at the final stages of reviewing. We excluded documents that did not directly address the research questions and the relevant organizing framework.

Assessing relevance and quality of evidence

We assess the relevance of each included evidence document as being of high, moderate or low relevance to the question.

Two reviewers independently appraised the quality of the guidelines we identified as being highly relevant using AGREE II. We used three domains in the tool (stakeholder involvement, rigour of development, and editorial independence) and classified guidelines as high quality if they were scored as 60% or higher across each of these domains.

Two reviewers independently appraise the methodological quality of evidence syntheses that are deemed to be highly relevant using the first version of the AMSTAR tool. Two reviewers independently appraise each synthesis, and disagreements are resolved by consensus with a third reviewer if needed. AMSTAR rates overall methodological quality on a scale of 0 to 11, where 11/11 represents a review of the highest quality. High-quality evidence syntheses are those with scores of eight or higher out of a possible 11, medium-quality evidence syntheses are those with scores between four and seven, and low-quality evidence syntheses are those with scores less than four. It is important to note that the AMSTAR tool was developed to assess evidence syntheses focused on clinical interventions, so not all criteria apply to those pertaining to health-system arrangements or implementation strategies. Furthermore, we apply the AMSTAR criteria to evidence syntheses addressing all types of questions, not just those addressing questions about effectiveness, and some of these evidence syntheses addressing other types of questions are syntheses of qualitative studies. While AMSTAR does not account for some of the key attributes of syntheses of qualitative studies, such as whether and how citizens and subject-matter experts were involved, researchers' competency, and how reflexivity was approached, it remains the best general quality assessment tool of which we're aware. Where the denominator is not 11, an aspect of the tool was considered not relevant by the raters. In comparing ratings, it is therefore important to keep both parts of the score (i.e., the numerator and denominator) in mind. For example, an evidence synthesis that scores 8/8 is generally of comparable quality to another scoring 11/11; both ratings are considered 'high scores.' A high score signals that readers of the evidence synthesis can have a high level of confidence in its findings. A low score, on the other hand, does not mean that the evidence synthesis should be discarded, merely that less confidence can be placed in its findings and that it needs to be examined closely to identify its limitations. (Lewin S, Oxman AD, Lavis JN, Fretheim A. SUPPORT Tools for evidence-informed health Policymaking (STP): 8. Deciding how much confidence to place in a systematic review. *Health Research Policy and Systems* 2009; 7 (Suppl1): sS8.)

Preparing the profile

Each included document is cited in the reference list at the end of the REP. For all included guidelines, evidence syntheses, and single studies (when included), we prepare a small number of bullet points that provide a summary of the key findings, which are used to summarize key messages in the text. Protocols and titles/questions have their titles hyperlinked, given that findings are not yet available.

We then draft a summary that highlights the key findings from all highly relevant documents (alongside their date of last search and methodological quality).

Upon completion, the REP is sent to a subject matter expert for their review.

Appendix 2: Details about each identified evidence synthesis

Dimension of organizing framework	Declarative title and key findings	Relevance rating	Living status	Quality (AMSTAR)	Last year literature searched	Availability of GRADE profile	Equity considerations
	None identified						

Appendix 3: Details about each identified single study

Dimension of organizing framework	Declarative title and key findings	Relevance rating	Study characteristic	Equity considerations

• Type of exposure
  ○ Primary (i.e., resulting from high pressure or overpressure created by explosions)
• Medium- to long-term sensory effects of mTBIs
  ○ Sensitivity to light
• Medium- to long-term cognitive and mental health effects of mTBIs
  ○ Memory of concentration problems
  ○ Dizziness or loss of balance
  ○ Mood changes
  ○ Depression
  ○ Difficulty sleeping
• Possible effect modifiers
  ○ Stage in military career
  ○ Setting
    ▪ Training
	Based on metabolomics profiling of Canadian Armed Forces (CAF) members, a cohort of Military Breachers and Range Staff (MBRS) suffer great post-concussive symptoms associated with mild traumatic brain injury (mTBI) and poorer health as compared to a matched cohort of other military service members
	• The study aims to determine key metabolomics and identify metabolite biomarkers for MBRS using blood samples
	• Breachers and range staff are routinely exposed to repetitive low-level blasts of two to 3 pounds per square inch (psi) during training and deployment
	• The MBRS cohort were more likely to be francophone, more senior in rank, had a longer duration of service and combat employment and had been exposed to a greater number of blasts over their career
	• Reported post-concussion symptoms were worse for the MBRS cohort, including both early and late symptoms of concussion as well as generally poorer health
	• Symptoms found to have statistically significant differences include headache, dizziness, sleep disturbance, fatigue, irritability, depression, frustration, forgetfulness, poor concentration, light sensitivity, restlessness, and impaired comprehension
	• The study also identified six metabolites for determining MBRS status (with a 98% classification accuracy), including acetic acid, formate, creatine, acetone, and methanol as well as glutamic acid
		High	*Focus of study:* Identifying metabolite biomarkers for MBRS
			
			Publication date: 2022
			
			Jurisdiction: Canada
			
			Methods: Matched cohort study
				• None reported

• Type of breacher exposure ○ Type of blast	Long-term occupational exposure to repeated low-level blasts from breaching techniques is associated with increased post-concussive symptoms, reduced energy levels, and impaired cognitive-motor integration, but these effects need to be considered within the broader	High	*Focus of study:* Assessing neuropsychological and neurocognitive outcomes for	• None reported

Dimension of organizing framework	Declarative title and key findings	Relevance rating	Study characteristic	Equity considerations
▪ Primary (i.e., resulting from high pressure or overpressure created by explosions) ○ Number of exposures ○ Intensity of exposures (low-level) • Medium- to long-term cognitive and mental health effects of mTBIs • Possible effect modifiers ○ Biological sex ▪ Male (89.5%) ▪ Female (11.5%) ○ Setting ▪ Training	context of military members' cumulative injuries and exposures from concussions, deployments, and other occupational hazards • The study aims to compare the impact of long-term occupational exposure to repeated low-level blasts on the health of breaching instructors and range staff, with sex- and age-matched CAF members as controls • There has been no prior quantification of the amount of blast exposure that breaching instructors and range staff experience during their careers at Canadian Forces School of Military Engineering (CFSME), despite administering 8–20 breaching courses per year, with one to two days of breaching per course, and factors like roles, positions, and blast environment characteristics influencing their varying exposure levels • Breaching instructors and range staff reported significantly lower energy levels (RAND SF-36 Health Survey) compared to controls, suggesting impairments from repetitive low-level blast exposure compared to CAF controls • Breaching instructors and range staff showed slower reaction times on a cognitive-motor integration task (BrDI, moving and thinking simultaneously) compared to controls • Breaching instructors and range staff showed greater post-concussive symptoms with higher scores on Rivermead Post-Concussion Questionnaire (RPQ) ○ Higher score on RPQ-3 (measuring early post-concussive symptoms like headache, dizziness, and nausea) ○ Higher score on RPQ-13 (measuring late post-concussive symptoms like sleep disturbance) ○ Higher scores across cognitive, emotional, and somatic symptom domains		breaching instructors and range staff *Publication date:* 3 December 2020 *Jurisdiction:* United States *Methods:* Sex- and age-matched cross-sectional cohort study	
• Type of breacher exposure ○ Type of blast ▪ Primary (i.e., resulting from high pressure or overpressure created by explosions) ○ Number of exposures (2–4 per training course) ○ Intensity of exposures (range 2.57–9.17 per square inch) • Medium- to long-term cognitive and mental health effects of mTBIs	Increasing peak overpressure exposure from explosives, even at sub-concussive levels, can lead to subtle but measurable transient impairments in neurocognitive abilities like procedural reaction time; sleep and years of service can impact blast-related performance deficits • This study aims to evaluate the effects of blast overpressure exposure during breacher training on neurocognitive performance among military personnel, using comprehensive blast measurements and neurocognitive assessments • Participants experienced two to four blast events from heavy breaching charges with net explosive weights of 10–15 lbs, resulting in peak overpressure exposures ranging from 2.57 to 9.17 per square inch (average 4.61)	Low	*Focus of study:* Evaluating neurocognitive performance for military personnel *Publication date:* 13 September 2019 *Jurisdiction:* Canada *Methods:* Observational repeated-measures study	• None reported

Dimension of organizing framework	Declarative title and key findings	Relevance rating	Study characteristic	Equity considerations

• Possible effect modifiers
  ○ Biological sex
    ▪ Male
  ○ Setting
    ▪ Training
	• Peak overpressure levels were consistently associated with neurocognitive performance changes on the Procedural Reaction Time (PRT) task
	  ○ Higher peak overpressure exposure linked to less improvement on PRT performance compared to baseline
	  ○ Significant effects of peak overpressure, time (immediately after blasts versus at end of day), military service duration, and sleep on PRT performance			

• Type of breacher exposure
  ○ Type of blast
    ▪ Primary (i.e., resulting from high pressure or overpressure created by explosions)
  ○ Number of exposures
  ○ Intensity of exposures
  ○ Time between exposures
• Medium- to long-term sensory effects of mTBIs
  ○ Sensitivity to light
• Medium- to long-term cognitive and mental health effects of mTBIs
• Possible effect modifiers
  ○ Setting
    ▪ Training
	Among military cohort members exposed to repeated blast during a two-week training protocol, glial fibrillary acidic protein (GFAP) levels, a possible biomarker used to identify people with traumatic brain injury, were supressed on days six and seven compared to matched controls
	• Findings also indicated that personnel with longer duration of service and exposed to cumulative pressure from previous exposures appear to contribute to the GFAP protein level changes, suggesting that cumulative history is perhaps more important than acute exposure to a relatively large overpressure event
	• Mild blast exposures may have cumulative effects that include headache, or psychological or cognitive changes that can be long-lasting
		Low	*Focus of study:* To assess protein levels in a military population exposed to repeated blast over the course of a two-week training protocol
			
			Publication date: 2020
			
			Jurisdiction studied: United States
			
			Methods used: Matched cohort study
				None reported

• Type of breacher exposure
  ○ Type of blast
    ▪ Primary (i.e., resulting from high pressure or overpressure created by explosions)
• Medium- to long-term sensory effects of mTBIs
  ○ Blurred vision
• Medium- to long-term cognitive and mental health effects of mTBIs
  ○ Dizziness or loss of balance
• Possible effect modifiers
  ○ Setting
    ▪ Training
	Eleven breachers and four engineers exposed to repeated blast exposures during explosive breaching training demonstrated no acute effects or longitudinal deteriorations in vestibular dysfunction after 17 months of follow-up, although some potentially important baseline differences were present
	• Some vestibular abnormalities were identified in breachers immediately after blast (mostly upbeat positional nystagmus), but participants reported almost no vestibular problems in the subjective visual analog test administered during all evaluations
	• However, one subject worsened with sequential recordings, which together with breachers having had more upbeat positional nystagmus immediately after blasts highlighted the need for a larger study
		Medium	*Focus of study:* To identify acute or long-term vestibular dysfunction from repeated blast exposures during explosive breaching training among United States Marine Corps instructors
			
			Publication date: 2016
			
			Jurisdiction studied: United States
			
			Methods used: Prospective, non-randomized cohort study
				None reported

Dimension of organizing framework	Declarative title and key findings	Relevance rating	Study characteristic	Equity considerations

• Type of breacher exposure
  ○ Type of blast
    ▪ Primary (i.e., resulting from high pressure or overpressure created by explosions)
• Medium- to long-term cognitive and mental health effects of mTBIs
  ○ Memory or concentration problems
  ○ Dizziness or loss of balance
• Possible effect modifiers
  ○ Setting
    ▪ Training
	This study shows evidence of bacterial translocation into circulation and alterations in intestinal permeability protein biomarkers, which can cause degradations in cognitive performance typically reported by individuals experiencing mTBI
	• This study investigated microbial variability and alterations in intestinal permeability biomarkers using blood samples collected from military service members participating in repeated blast training events
	• The study was conducted during military breaching training between August 2016 and July 2018
	• Thirty male service members participated
	• Training involved heavy wall-breaching exercises using explosive charges with a Net Explosive Weight of 10 lbs; individuals encountered at least two breaching charges where they were positioned in a breaching stack formation at a minimum safe distance of 40 ft from the blast source
	• Blood samples were collected serially pre-blast (morning 7:30 a.m. to 9:00 a.m.), post-blast (afternoon 4:30 p.m. to 5:30 p.m.), on the training day, and upon follow-up the next day (morning 7:30 a.m. to 9:00 a.m.)
	• Participants reported elevated symptoms of headache, dizziness, concentration, and taking longer to think, dissipating 16 hours following blast exposure
	• The symptoms observed were in line with mTBI injury and were linked to alterations in bacterial translocation and increased intestinal permeability; this suggests that changes in intestinal permeability might be connected to a decline in cognitive function
		Medium	*Focus of study:* The association between self-reported concussion-like symptomology and physiological changes such as increased intestinal permeability was investigated
			
			Publication date: 21 March 2024
			
			Jurisdiction: United States
			
			Methods: Pre-post
				None reported

• Type of breacher exposure
  ○ Type of blast
    ▪ Primary (i.e., resulting from high pressure or overpressure created by explosions)
  ○ Number of exposures
  ○ Intensity of exposures
• Medium- to long-term cognitive and mental health effects of mTBIs
  ○ Difficulty sleeping
	This study indicated that breachers reported more symptoms related to mTBI than non-breachers and rated them as more severe and significantly more disruptive to their daily activities
	• The study aimed to collect empirical data to explore the relationship between repeated low-level blast exposure and various neurological impairments associated with mTBI
	• Participants comprised 184 military and non-military law enforcement personnel including 135 participants exposed to occupational blast and 49 controls
	• The survey explored the self-reported history of occupational exposure to repeated low-level blast (breaching blast) and symptomology similar to mTBI
		High	*Focus of study:* To explore self-reported evidence about repeated exposure to low-level explosive blasts, and what health impacts they may have
			
			Publication date: February 2015
			
			Jurisdiction: United States
			
			Methods: Cross-sectional
				None reported

Dimension of organizing framework	Declarative title and key findings	Relevance rating	Study characteristic	Equity considerations
	• Confounding factors of age, previous head injuries, other health conditions with similar symptoms, and other exposure to blast (such as shoulder-fired weapons) were taken into account • Most reported symptoms included headaches, difficulty sleeping, and difficulty hearing • This study supports a role for blast surveillance programs to monitor, assess, and mitigate the health impacts of exposure to explosive blasts			

• Type of breacher exposure
  ○ Type of blast
    ▪ Primary (i.e., resulting from high pressure or overpressure created by explosions)
    ▪ Secondary (i.e., resulting from strong winds following the blast wave that propel fragments and debris towards the body)
    ▪ Tertiary (i.e., resulting from strong blast winds and pressure gradients that can accelerate and cause blunt force injury)
• Possible effect modifiers
  ○ Biological sex
    ▪ Male
  ○ Setting
    ▪ Training
    ▪ Deployed
	A longitudinal study indicated significant brain structural changes (i.e., volume loss, white matter lesions, and enlarged Virchow-Robin spaces) among military personnel exposed to repeated blast overpressure
	• The study aims to examine the impact of repeated blast exposure on personnel given that the Canadian Special Operations Forces Command routinely conducts operations involving close-proximity explosive charges
	• This five-year longitudinal trial followed up on a previous study that used MRI and electroencephalogram to assess brain changes pre- and post-blast exposure in military breachers
	• The study also identified vascular lesions and other brain anomalies, but no new ischemic injuries or progression of hemorrhages were detected
	• The findings highlighted the need for pre-exposure screening and continuous monitoring to identify and manage potential brain abnormalities in individuals exposed to repetitive blasts
		High	*Focus of study:* Assessing structural brain changes over five years in military personnel exposed to repeated blast overpressure
			
			Publication date: 2024
			
			Jurisdiction: Canada
			
			Methods: Longitudinal study	

• Type of breacher exposure
  ○ Number of exposures
  ○ Intensity of exposures
• Possible effect modifiers
  ○ Biological sex
    ▪ Male
  ○ Setting
    ▪ Training
	The potential neurological impacts of moderate blast overpressure exposure during military training highlights the need for improved safety protocols and biomarker monitoring in high-risk occupational settings
	• The case study aims to investigate a single military member's moderate blast overpressure exposure during breacher training
	• The intervention involves a two-week explosive entry course, including both classroom instruction and practical training sessions with controlled detonations
	  ○ With the use of personal protective equipment and pressure transducers, the subject experienced varying levels of blast overpressure exposure monitored
		Medium	*Focus of study:* Examining the association between blast overpressure exposure and neurotrauma biomarkers in military personnel undergoing breacher training
			
			Publication date: 2020
			
			Jurisdiction: Not specified
			
			Methods: Case study	

Dimension of organizing framework	Declarative title and key findings	Relevance rating	Study characteristic	Equity considerations
	• The case study demonstrated that high blast overpressure exposure was associated with elevated levels of neurotrauma biomarkers in an individual, particularly glial fibrillary acidic protein (GFAP) ○ These elevated levels were found to resolve highlighting a dose-response rather than a diagnosable concussion or mTBI • The findings highlighted that current safety standards may not adequately protect against blast effects in dynamic urban environments, requiring a reassessment of blast exposure protocols and safety guidelines			

• Type of breacher exposure
  ○ Type of blast
    ▪ Primary (i.e., resulting from high pressure or overpressure created by explosions)
• Medium- to long-term cognitive and mental health effects of mTBIs
  ○ Memory or concentration problems
  ○ Mood changes
  ○ Depression
  ○ Anxiety
  ○ Difficulty sleeping
  ○ Fatigue
• Possible effect modifiers
  ○ Stage in a military career
  ○ Setting
    ▪ Training
	Breachers and snipers with a history of repeated occupational exposure to low-level blasts demonstrated higher levels of post-concussive symptoms compared to controls, highlighting the distinct impacts of occupational blast exposure on health outcomes (i.e., potential difference in these results between training and warzone settings)
	• The study focuses on military personnel (breachers and snipers) and their exposure to low-level blasts, often leading to comorbidities with mild traumatic brain injury and psychiatric diagnoses
	• The study findings highlighted that breachers and snipers reported more recent exposure to blast events compared to controls, suggesting that recent blast exposure could worsen post-concussive symptoms, indicating a potential link between recent events and symptom severity
		High	*Focus of study:* Examining the effects of repeated occupational exposure to low-level blast on post-concussive symptoms and mental health outcomes among military personnel
			
			Publication date: 2022
			
			Jurisdiction: Canada
			
			Methods: Cross-sectional study design	

• Type of breacher exposure
  ○ Type of blast
    ▪ Primary (i.e., resulting from high pressure or overpressure created by explosions)
• Possible effect modifiers
  ○ Stage in a military career
    ▪ Mid
  ○ Biological sex
    ▪ Male
  ○ Setting
    ▪ Training
	Male breachers in the CAF, exposed to repeated low-level blast events during training exercises, reported poorer health outcomes and exhibited reduced grey matter volume compared to controls, highlighting potential long-term impacts on cognitive and physical well-being
	• The study aims to assess various measures (e.g., neuropsychological, neurocognitive, physiological, and neuroimaging) to study blast wave effects on breachers
	• The study's findings highlighted that breachers reported greater impairments on self-reported measures of health and daily function than controls
	  ○ Breachers had:
	    ▪ higher scores on the cognitive and emotional subscales of the Rivermead Post Concussion Symptoms Questionnaire
		High	*Focus of study:* Examining the long-term neurocognitive, physiological, and neuroimaging effects of repetitive low-level blast exposure in breachers within the Canadian Armed Forces
			
			Publication date: 2021
			
			Jurisdiction: Canada
			
			Methods: Longitudinal cohort design	

Dimension of organizing framework	Declarative title and key findings	Relevance rating	Study characteristic	Equity considerations
	▪ higher scores on the subscale that captures late post-concussive symptoms (e.g., sleep disturbance) • The findings also indicated that there was no negative impact on neurocognitive performance (i.e., balance, ataxia, and postural tremor) in breachers following immediate blast exposure			
• Type of breacher exposure ○ Type of blast ▪ Quaternary (i.e., resulting from other explosive products and from exposure to toxic substances that can cause burns, blindness, and inhalation injuries) ○ Number of exposures ○ Intensity of exposures • Medium- to long-term cognitive and mental health effects of mTBIs ○ Memory or concentration problems ○ Mood changes ○ Difficulty sleeping ○ Fatigue • Possible effect modifiers ○ Stage in military career ▪ Early ○ Setting ▪ Training	No longitudinal effects were seen in biomarkers, behavioral characterization, and neuroimaging in military breaching early career soldiers with repeated low-level blast exposure • This study aimed to characterize longitudinal effects of repeated low-level blast exposure using biomarkers and behavioural characteristics • Data was collected during 2008 to 2013 at three time periods: baseline (2008/2009), T1 (2010 or 2011), and T2 (14–16 months after T1) • Participants were all soldiers in the New Zealand Defence Force military breaching unit, with a minimum of one year of training, and with the mean age of 29.7 years • All participants were in a new breaching facility that decreased blast exposure to less than 4 psi safety threshold • All participants had blast exposure occurring from initial training, operational training, and occupational exposure • The average amount of blast exposure was 1.9 PSI ranging from 0 to 5 events • There was no evidence that symptom reporting changed over time, but the most common symptoms were headache, sleep disturbance, restlessness, fatigue, poor memory, concentration, ringing in ears, and irritability • This study did not find any significant changes in biomarker concentrations, neurocognitive performance, symptom reporting, or neuroimaging changes ○ This could be because the tests used were not sensitive enough to capture changes or that the period of blast exposure was not long enough to cause a diagnosable injury	Medium	*Focus of study:* Longitudinal investigation of biomarkers, behavioral characterization, and neuroimaging changes in soldiers with repeated low-level blast exposure *Publication date:* April 2018 *Jurisdiction:* New Zealand *Methods:* Longitudinal observational study	None reported
• Type of breacher exposure ○ Type of blast ▪ Quaternary (i.e., resulting from other explosive products and from exposure to toxic substances that can cause burns, blindness, and inhalation injuries) ○ Number of exposures	Current training for military personnel involving overpressure and/or repeated low-level exposure can have negative effects on soldiers overall health • This study aimed to explore the training environment and contexts involving overpressure and impulse exposure ranges during military training • Negative effects associated with overpressure include hearing damage, Alzheimer's, and repeated blast exposure • A total of five different sites between 2014 and 2016 were investigated	Medium	*Focus of study:* Explore overpressure exposure of breachers and military personnel *Publication date:* 22 August 2017 *Jurisdiction:* United States	None reported

Dimension of organizing framework	Declarative title and key findings	Relevance rating	Study characteristic	Equity considerations
○ Intensity of exposures • Possible effect modifiers ○ Stage in military career ▪ Early ○ Setting ▪ Training	• Exposures were indoor and outdoor involving breaching, small arms, mortars, and artillery • This study found that operator exposure can be affected by distance to overpressure source and the environment ○ Indoor spaces have the highest risk for overpressure exposure and can be dangerous for training soldiers • The study found that current safety distances exceeded 4 psi, the U.S. determined safety threshold for blast exposure during training ○ This suggests that current minimum safe distances may be inaccurate, putting soldiers at risk for unnecessary injury • Although shotgun breaching is a low peak exposure, the repeated number of exposures can have negative cumulative effects		*Methods:* Observational study using blast gauge sensors	
• Type of breacher exposure ○ Type of blast ▪ Quaternary (i.e., resulting from other explosive products and from exposure to toxic substances that can cause burns, blindness, and inhalation injuries) • Possible effect modifiers ○ Stage in military career ▪ Early ○ Biological sex ▪ Male ○ Setting ▪ Training	Low-level blasts from breacher training is associated with increased biomarkers of serum concentrations and worsened neurocognitive performance • This study examined the effects of repeated exposure to low-level blasts during military training in breachers • Data was collected before and after the breachers training course ○ Collected data included serum samples, neurocognitive performance, and self-reported symptoms • Participants were all male, mean age 28.9, with minimal blast exposure (maximum one event) prior to training • During training, all participants were exposed to blasts from overpressure • Low-level blast exposure was associated with brain biomarker and neurocognitive performance changes ○ Biomarkers included UCH-11 levels of 0.1392 ng/ml during training, alpha2 sceptrin breakdown product, and glial fibrillary acid protein ○ Neurocognitive changes included longer reaction times ○ More neurocognitive symptoms were reported after breacher training ○ Individuals displaying increased biomarkers also showed worsened neurocognitive performance and more symptoms • Longitudinal research is needed to see if the long-term implications of training and to monitor if biomarkers and neurocognitive changes persist	Medium	*Focus of study:* Examine effects of repeated exposure to low-level blasts during training *Publication date:* 1 October 2013 *Jurisdiction:* New Zealand *Methods:* Cross-sectional observational study	None reported

Appendix 4: Documents excluded at the final stages of reviewing

Document type	Hyperlinked title
Single study	Repetitive low-level blast exposure and neurocognitive effects in army ranger mortarmen
	Repeated low-level blast exposure alters urinary and serum metabolites
	Differential effects on TDP-43, piezo-2, tight-junction proteins in various brain regions following repetitive low-intensity blast overpressure

DeMaio P, Waddell K, Ali A, Dass R, Grewal E, Wu N, Wilson MG. Rapid evidence profile #75: Examining the association between the role of military breacher and sniper and the effects of mild traumatic brain injuries, Hamilton: McMaster Health Forum, 2 July 2024.

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References

1. Carr W, Polejaeva E, Grome A, et al. Relation of repeated low-level blast exposure with symptomology similar to concussion. *J Head Trauma Rehabil* 2015; 30(1): 47-55.
2. Eonta SE, Kamimori GH, Wang KKW, et al. Case study of a breacher: Investigation of neurotrauma biomarker levels, self-reported symptoms, and functional mri analysis before and after exposure to measured low-level blast. *Mil Med* 2020;185(3-4): e513-e517.
3. Glikstein R, Melkus G, Portela de Oliveira E, et al. Five-year serial brain mri analysis of military members exposed to chronic sub-concussive overpressures. *J Magn Reson Imaging* 2024; May 18.
4. Kamimori GH, LaValle CR, Eonta SE, Carr W, Tate C, Wang KKW. Longitudinal investigation of neurotrauma serum biomarkers, behavioral characterization, and brain imaging in soldiers following repeated low-level blast exposure (New Zealand Breacher Study). *Mil Med* 2018;183 (suppl_1): 28-33.
5. Kamimori GH, Reilly LA, LaValle CR, Olaghere Da Silva UB. Occupational overpressure exposure of breachers and military personnel. *Shock Waves* 2017;27: 837-847.
6. LaValle CR, Carr WS, Egnoto MJ, et al. Neurocognitive performance deficits related to immediate and acute blast overpressure exposure. *Front Neurol* 2019; 10: 949.
7. Littlefield PD, Pinto RL, Burrows HL, Brungart DS. The vestibular effects of repeated low-level blasts. *J Neurotrauma* 2016; 33(1): 71-81.
8. Liu Q, Wang Z, Sun S, et al. Association of blast exposure in military breaching with intestinal permeability blood biomarkers associated with leaky gut. *Int J Mol Sci* 2024; 25(6): 3549.
9. Miller MR, DiBattista A, Patel MA, et al. A distinct metabolite signature in military personnel exposed to repetitive low-level blasts. *Front Neurol* 2022; 13: 831792.
10. Tate CM, Wang KK, Eonta S, et al. Serum brain biomarker level, neurocognitive performance, and self-reported symptom changes in soldiers repeatedly exposed to low-level blast: a breacher pilot study. *J Neurotrauma* 2013; 30(19): 1620-1630.
11. Tschiffely AE, Statz JK, Edwards KA, et al. Assessing a blast-related biomarker in an operational community: Glial fibrillary acidic protein in experienced breachers. *J Neurotrauma* 2020; 37(8): 1091-1096.
12. Vartanian O, Coady L, Blackler K, Fraser B, Cheung B. Neuropsychological, neurocognitive, vestibular, and neuroimaging correlates of exposure to repetitive low-level blast waves: evidence from four nonoverlapping samples of Canadian breachers. *Mil Med* 2021; 186(3-4): e393-e400.
13. Vartanian O, Tenn C, Rhind SG, et al. Blast in context: The neuropsychological and neurocognitive effects of long-term occupational Exposure to repeated low-level explosives on Canadian Armed Forces' breaching instructors and range staff. *Front Neurol* 2020; 11: 588531.
14. Vartanian O, Rhind SG, Nakashima A, et al. Blast effects on post-concussive and mental health outcomes: Data from Canadian Armed Forces breachers and snipers. *Journal of Military, Veteran and Family Health* 2022; 8(S2): 82-96.