Acute Military mild traumatic brain injuries, how should it be managed in 2024 ?

Traumatismes crâniens légers aigus d'origine militaire : quelle prise en charge en 2024 ?

LAMY A[1] , PAULHIAC C[2] , JOUVION A[2], CLAUDEL L[1] , OBRECHT M[2], TRAPPIER T[2], DE BRIER G[2], THEFENNE L[2]

(1) Hôpital d'Instruction des Armées Saint Anne, Toulon | (2) Hôpital d'Instruction des Armées Laveran, Marseille

Abstract

Introduction :
Mild traumatic brain injury (TBI) is a common pathology among military personnel. In a number of cases, it can lead to post-concussion syndrome, which can persist over time if not detected and treated. To date, there is no standardized management of mTBI in the French army. The aim of this study is to carry out a qualitative review of the literature on the screening and management of military mTBI at the acute phase.

Material and Method :
The review was carried out using the PUBMED platform. Only articles in English and French published between June 2004 to January 2024 were eligible for inclusion. Of the 913 articles initially screened, 10 met the study's methodological criteria and were included.

Results :
Of the 10 articles included, 7 means of assessing and screening for acute mTBI and 3 articles evaluated the management of mTBI in the acute.

Conclusion :
This literature review summarizes some knowledges about the screening and management of mTBI at the acute phase in the armed forces.

Key words :
Mild traumatic brain injury, miilitary, systematic review, evaluation, management.

Résumé

Introduction
Le traumatisme crânien léger (TCL) est une pathologie fréquente chez les militaires. Il peut conduire dans un certain nombre de cas à l'apparition d'un syndrome post-commotionnel qui peut persister dans le temps s'il n'est pas dépisté et pris en charge. A ce jour il n'existe pas de prise en charge uniformisée au sein de l'armée française concernant le TCL. L'objectif de cette étude est de réaliser une revue qualitative de la littérature sur le dépistage et la prise en charge du TCL à la phase aigue.

Matériel et méthode
La revue a été réalisé à partir de la plateforme « PUBMED». Seuls les articles en anglais et en français publiés entre juin 2004 et janvier 2024 été éligible à l'inclusion. Sur les 913 articles initialement screenés, 10répondaient aux critères méthodologiques de l'étude et ont pu être inclus.

Résultats
Sur les 10 articles inclus 7 évaluaient les moyens de dépistages du TCL à la phase aigüe et 3 les moyens de prise en charge du TCL à la phase aigüe.

Conclusion
Cette revue de la littérature permet de synthétiser une partie des connaissances à propos du dépistage et de la prise en charge du TCL à la phase aigüe au sein des armées.

Mots clés
Traumatisme crânien légers, militaire, revue systématique, dépistage, prise en charge.

Introduction

According to the Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM V) V, traumatic brain injury (TBI) is defined as a "brain trauma with specific characteristics that include at least one of the following: loss of consciousness, posttraumatic amnesia, disorientation and confusion, or, in more severe cases, neurological signs (e.g., positive neuroimaging, a new onset of seizures or a marked worsening of a pre-existing seizure disorder, visual field cuts, anosmia, hemiparesis). To be attributable to TBI, a neurocognitive disorder must present either immediately after the injury or immediately after the individual recovers consciousness after the injury and persist past the acute post-injury period." *(1)*.

By convention, and for reasons linked to the organization of the care chain, head injuries are classified into three categories of severity according to the Glasgow Coma Scale (GCS): mild, moderate and severe.

There are several definitions of mild traumatic brain injury (mTBI). The most widely accepted is "a concussion resulting in the temporary interruption of normal brain function, manifested by:

- GCS ≥ 13
- loss of consciousness (LOC) < 30 min.
- post-traumatic amnesia (PTA) < 24h
- any transient post-traumatic abnormality of mental functioning" *(2)*.

It's a common pathology in France, with 155,000 patients a year admitted to emergency departments, the majority (80%) with a diagnosis of mild traumatic brain injury *(3)*. The population

at risk typically includes young men aged between 20 and 40, and people over 60 *(4)*.
Road accidents are the leading cause of mild head injuries, followed by falls, concussions during sporting activities and assaults *(5)*.

Military personnel meet several criteria for populations at risk of TBI (age, gender, exposure to traumatic activities during training or missions). There is no epidemiological study of TBI in the French army. There are, however, a number of foreign studies showing high proportions of mild head injuries in the military. For example, Rona et al, described a 10% prevalence of mild traumatic brain injury among British servicemen deployed in combat zones in Iraq and Afghanistan *(6)*. In another American study, Hoge et al found that around 15% of soldiers reported head trauma with LOC or impaired mental function during their deployment in Iraq *(7)*.

The main mechanism described for the occurrence of TBI in the field is blast (7). Other mechanisms, such as direct trauma or whiplash, are probably underestimated due to a lack of cohort follow-up studies and under-reporting in the context of overseas operations (OvOp).

In addition to the operational context, military personnel may also be exposed to the risk of mTBI during training or the sports activities they practice frequently and intensively. Wasserman et al estimate the risk of sports-related concussion at 5.56/10,000 athlete-exposures *(8)*. Some sports, such as rugby and combat sports, are more prone to provide mTBI.

Although often "benign", mTBI can lead to long-term sequelae such as post-concussion syndrome (PCS). This is defined as the persistence of physical, cognitive and/or behavioural symptoms at a distance from the accident. It is also correlated with an increased risk of post-traumatic stress disorder *(9)*, suicide *(10)*, and dementia occurring earlier than in the general population *(11)*.

It can also have an impact on quality of life, work (risk of errors during military activities, loss of aptitude or even discharge) and daily activities *(12)*.

It is therefore important to identify and treat military personnel suffering from mTBI early and consistently. To date, there are few proposed protocols for the management of MTBI in the acute phase in both civilians and military personnel.

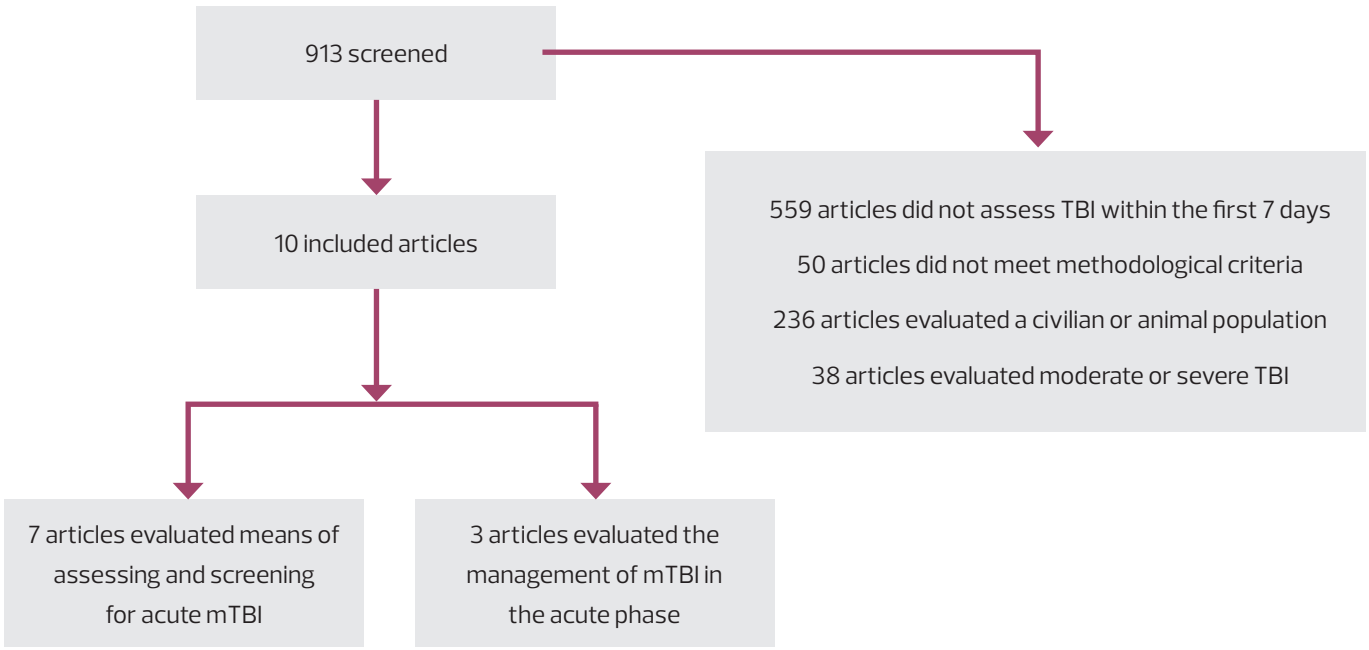
The aim of this article is to carry out a preliminary review of the literature on the detection and management of military mild traumatic brain injury in the acute phase.

Materials and methods

Articles

This is a qualitative systematic review of the literature using the PUBMED database.
The search was performed by "key words": (concussion, mild [MeSH Terms]) OR (brain concussion [MeSH Terms]) AND ((Military) OR (Army)).
Only articles published from June 2004 to January 2024 were considered.

FIG 1. FLOW CHART



Inclusion criteria:

To be included, articles had to:

- Have for main subject the management of mild traumatic brain injury (mTBI) in the military.
- Address the evaluation or management of MCT within 7 days of trauma.
- Be in French or English.
- Limit the risk of bias linked to the methodology of the articles, only randomized trials against a control group, prospective cohorts, systematic literature reviews, guidelines, and cross-sectional studies with comparison to a control group were included.

Results

Article characteristics:

Between June 2004 to January 2024, 913 articles met the key words in the database and could be screened.

After eliminating most of the articles, 10 meeting the inclusion criteria were included. Of these, 7 studied ways of assessing/screening for acute military mTBI, and 3 studied ways of managing it *(Fig 1)*.

All articles were in English, 4 were cross-sectional studies, 2 were randomized controlled trials, 2 were prospective cohorts, and 2 were literature reviews. All the studies including patients were from the US Army.

Assessment of mTBI in the acute phase:

7 articles evaluated the means of assessing and detecting mTBI in the first 7 days following trauma *(Table 1)*.

- Walsh et al. (13) tested oculomotricity in military personnel who had sustained mTBI within 72 hours, and in age-matched controls. The assessment consisted in performing the "King Devick©" (Appendix 1), which tests the performance of eye saccades by reading dots on cards. Patients in the mTBI group had mean scores 36% slower than the control group, with statistical significance.

- Kelly et al. (14) studied the results of the Automated Neuropsychological Assessment Metrics (ANAM4) test battery in military mTBI patients within 72 hours of trauma and in a control group. Of the 6 subtests studied: simple reaction time, procedural reaction time, matching to sample test and spatial memory measure were significantly poorer in the mTBI group. Combining the results of the simple reaction time and procedural reaction time subtests, mTBI and controls can be classified with a sensitivity of 59% and a specificity of 82%. This equates to a discrimination capacity of 71%. This ability to discriminate was enhanced when results could be compared with data acquired prior to deployment.

- Cole et al. (15) also compared the results of the ANAM 4 test battery between servicemen who had had a mTBI within 7 days and a group of control servicemen. They found a significant difference in ANAM 4 results between the mTBI group and the control group. Looking at each subtest more specifically, the differences were most marked for the simple reaction time test and the repeated simple reaction time test. They also noted greater variability of results over time in patients who had undergone mTBI.

- Coldren et al. (17) compared results on the Military Acute Concussion Evaluation (MACE) scale in mTBI patients after the first 12 hours post-trauma and in a control group. The MACE is a scale comprising a clinical history and post-trauma symptom section and a standardized 30-item section assessing orientation, concentration and memory. The results between the two groups were statistically significantly different but not clinically relevant, with a mean score of 26 for mTBI patients and 26.8 for controls. The area under the MACE curve was 0.5878.

- Ownbey et al. (18), in their review of the literature, stressed the importance of training healthcare personnel in the assessment and management of mTBI prior to deployment. For initial screening, they recommended the use of a standardized tool, the MACE 2, which incorporates the elements of the MACE and adds an assessment of oculomotor and visual functions. In their view, this assessment should be carried out as soon as possible after the trauma, once the area has been secured. They also explain that the use of an ANAM-type cognitive assessment can be useful, especially if it can be compared with a previous assessment carried out in the 12 months prior to deployment.

- The study by Edwards et al. (19) quantified blood inflammatory markers (IL-6, IL-10 and TNFα) at 8 and 24 hours after mTBI and compared them with a control group. There was a significant increase in IL-6 levels at the 8-hour assay, with a mean level of 2.62 pg/mL in the mTBI group versus 1.03 pg/mL in the control group, and the area under the curve for the IL-6 assay at 8 hours was 0.81 pg/mL. There was no difference between the mTBI and control groups. There was no significant difference in IL-6 levels at the 24 hours after mTBI. There were no significant differences for the other biomarkers.

Management of mTBI in the acute phase:

Once the mTBI has been diagnosed, it must be managed appropriately to avoid the development of long-term complications. This literature review found 3 articles focusing on the management of mTBI in the acute phase (Table 2).

-Remigio-Baker et al. (20) in their paper evaluated the impact of patient beliefs regarding the beneficial effect of rest in the

acute phase of mTBI. This prospective cohort included mTBI patients initially assessed within 72 hours of trauma, some of whom had received education about mTBI and the benefits of rest, and some who had not. The results showed that patients who believed most in the beneficial effect of rest at the initial phase returned to a higher level of physical activity in the long term, but only in the sub-group of patients who had received specific education. There was also a significant reduction in the occurrence of post-concussion syndrome (PCS) assessed by the Neurobehavioral Symptom Inventory (NSI) *(Appendix 2)* in patients with the highest level of belief, whether or not they had received education.

-Bailie et al. *(21)* carried out an information-type intervention with doctors concerning a standardized 6-step protocol for returning activity: the "Progressive Return to Activity" (PRA) *(Appendix 3)*. Then they compared physical activity levels and NSI scores in two groups. A pre-intervention group and a post-intervention group. The post-intervention group showed a significant reduction in physical activity over the first 7 days. At 1 and 3 months, the post-intervention group had a significantly lower NSI score than the pre-intervention group. There was no significant difference in NSI scores between the two groups at 6 months follow-up.

Ownbey et al. *(18)* explained in their literature review that the only intervention in the acute phase that has been shown to reduce the onset of symptoms is patient education. Once the diagnosis of mTBI has been made, the patient must receive appropriate information on its pathology, the monitoring to be carried out and the conditions for returning activity. They recommended the use of PRA for a gradual return to activity. They also explained that medical and paramedical staff should not hesitate to reassess patients on a regular basis, and if necessary, refer them to specialist practitioners or evacuate them from the operating theater for further examinations. Finally, care must be taken to detect psychological trauma, which may present itself in the form of symptoms confusing with mTBI.

Discussion :

Assessment of mTBI in the acute phase

In view of the results of the articles, it seems necessary that the diagnostic strategy for mTBI should be based on the earliest possible assessment, because the initial evolution can be rapid, with objective signs disappearing within a few hours *(17)(19)*. This assessment should be carried out by any medical or paramedical staff who have received appropriate training beforehand *(18)*. It should be carried out systematically as soon as there is any evidence to suggest TBI.

This initial assessment must be standardized. It may include questioning about the accident and the signs experienced, a clinical assessment including a neurological examination, as well as an oculomotor and vestibular examination, as these are discriminating factors in the acute phase *(13)*. Studies evaluating cognitive tests in the acute phase have produced mixed results. Some tests, such as the ANAM, seem to be able to help diagnose mTBI, especially when compared with pre-deployment data *(14)*. Others, such as computerized tests, struggle to discriminate mTBI from controls, and correlate poorly with each other and with paper-and-pencil tests *(16)*.

This assessment can be grouped together in a questionnaire such as the MACE 2 used by the US Army *(18)*, validated in English, or the Sport Concussion Assessment Tool 6th Edition (SCAT 6), widely used in professional and amateur sport *(22)*. These two scales have many similarities: a description of the objective signs that should lead to a diagnosis of TBI (disorientation, confusion, blank stare, etc.), a search for post-concussion symptoms, a neurological and cervical examination, a rapid cognitive test, an examination of oculomotricity and a search for balance disorders. These two scales are used in current practice as close to the "field" as possible, whether in overseas operations once the area has been secured for the MACE 2, or directly on the bench after a concussion for the SCAT 6. We did not find any articles in the literature comparing SCAT 6 and MACE2, although one study did compare the older versions of the questionnaires, the SCAT2 (which differs from SCAT 6 in the order of tests, absence of cervical examination and patient questionnaire) and MACE (which differs from MACE 2 in the absence of vestibular and ocular examination), and found SCAT 2 to be superior *(23)*. A study comparing updated versions of the questionnaires may be of interest in the future.

The use of biology in the initial phase is not routine, but there does appear to be an increase in inflammatory markers during this phase (19). This has also been found in athletes *(24)*. In the future, it may be interesting to carry out more studies evaluating the value of inflammatory biomarkers in the acute phase of mTBI, and to highlight their involvement in the development of PCS.

No article addressed the diagnostic utility of imaging in the initial phase. This is probably because the literature is well-supplied on this subject, and the majority of recommendations are against imaging in the acute phase of mTBI.

Finally, although no article specifies which patients should be screened, it is conceivable that the protocol should cover any patient falling within the strict definition of mTBI, as well as any patient who has been blasted, polytraumatized or has cervical spine involvement, because these pathologies are often associated with mTBI.

Management of mTBI in the acute phase:

The first rule after a diagnosis of mTBI is to organize surveillance of the patient for the first 24 hours. This monitoring can be carried out by the medical team or the paramedics/members of the casualty's company, depending on the conditions. This initial stage enables us to detect the onset of clinical deterioration, which would require the patient to be transferred to an appropriate facility *(18)*.

Once the first 24 hours have elapsed, the main task is to educate the patient about its pathology, the symptoms to be monitored and the importance of a gradual, asymptomatic return to activities *(18)(20)*.

Several standardized protocols already exist for this purpose, such as the US Army's 6-step PRA, which includes a list of physical and cognitive activities of increasing intensity to be started after the initial rest period *(21)*. A similar protocol has been developed by World Rugby for resumption of play after concussion *(25)*. The PRA is more precise and has already been adapted for military personnel.

Good patient information can only exist if caregivers are well informed themselves *(21)*.

Care must also be taken to screen for comorbidities, and in particular the occurrence of acute stress disorder, a common pathology in military personnel that can eventually lead to PTSD, with symptomatology confounding mTBI (18) (26). A PCL-M score could be proposed for patients presenting with PCS, followed by a consultation with a psychiatrist depending on the results.

Apart from the articles found in our literature review, some teams recommend avoiding the use of psychostimulants in the acute phase (coffee, alcohol, tobacco, etc.), although the literature on this subject is poor and heterogeneous *(27) (28) (29)*.

We found no study giving the repatriation delay to be considered in the event of persistent symptoms of mTBI in OvOP despite adequate management.

Limitations:

This literature review has the advantage of having studied head injury in the military in a broad and comprehensive way. However, there are several limitations. Due to the heterogeneity of the articles studied, the results are qualitative and the statistics of the different articles cannot be analyzed in a global way. The articles were drawn almost exclusively from American military literature, and the question of generalizability to the French army is open.

The majority of studies were of low level of evidence (cross-sectional studies, controlled trials with small samples, etc.).

No other databases apart from PUBMED were unitized.

Most of the studies focused on OvOP related mTBI. However, there are other modes of occurrence in military personnel, such as during sporting activities or training exercises.

Conclusion:

In conclusion, this literature review summarizes some of what we know about the assessment and management of acute-phase mTBI in the armed forces. Current data, although not uniform and often of low level of evidence, once gathered and complemented by what is being done in other environments, such as sports, enable us to imagine an outline of management based on scientific facts for our French military personnel. The ultimate goal is to provide standardized, optimal care for French servicemen and women on mission and in France, from injury to rehabilitation and reintegration.

TABLE 1. SUMMARIES OF THE ARTICLES APPROACHING THE ASSESSMENT OF THE MTBI AT THE ACUTE PHASE

Authors	Reviews	Type of study	Goal	Population	Results
Coldren et al 2010	Mil Med	Transversal study	Evaluation of MACE for acute mTBI screening	237 patients	No clinical efficacy of MACE if used more than 12 hours after trauma.
Cole et al 2017	J Int Neuropsychol Soc	Transversal study	Evaluate differences on ANAM 4 between military personnels with mTBI and a control group	100 mTBI and 231 controls	Significant difference in ANAM 4 results between mTBI patients and controls, particularly in reaction time.
Cole et al 2018	Arch Clin Neuropsychol	Randomized contrlled trial	Validate 4 computerized neurocognitive tests in the mTBI acute phase	503 patients	Lack of validity of computerized tests for mTBI diagnosis, no correlation between computerized and pa-per-and-pencil tests
Edwards et al 2020	BMC Neurol	Prospective cohort	Assess inflammatory markers in mTBI	94 patients	Significant increase in IL-6 within 8 hours of mTBI.
Kelly et al 2012	Arch Clin Neuropsychol	Transversal study	Assessing the validity of ANAM for mTBI screening in OvOp	212 patients	Validation of ANAM as a screening aid for mTBI in OvOP.
Ownbey et Pekari 2022	Mil Med	Systematic littérature review	Summarize the key elements in evaluating mTBI in OvOP	100 articles	-Pre-deployment training for nursing staff. -Use of MACE 2 as a screening tool for mTBI in OvOP.
Walsh et al 2016	J Neurol Sci	Transversal study	Evaluate the King-Devick© for acute mTBI screening	200 patients	King Devick© shows significant differences between mTBI group and controls.

TABLE 2. Summaries of articles on the management of acute mTBI

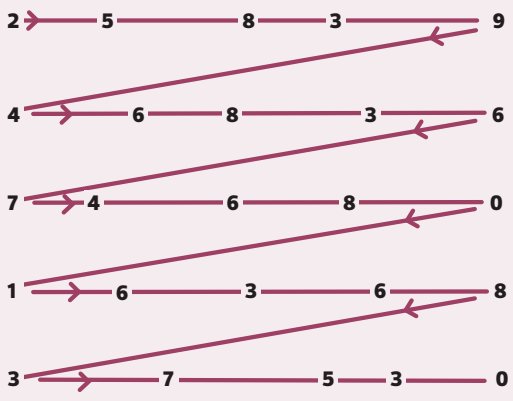
Authors	Reviews	Type of study	Goal	Population	Results
Bailie et al 2019	Am J Sports Med	Prospective cohort	Evaluate the effective-ness of an intervention to inform caregivers about a PRA.	144 patients	Improvement in PCS (NSI) in the post-inter-vention group.
Ownbey et Pekari 2022	Mil Med	Systematic literature review	Summarize the import-ant elements of mTBI management in OvOp.	100 articles	Patient education is the most useful measure in the acute phase.
Remigio-Baker et al 2020	Arch Phys Med Rehabil	Randomized contrlled trial	Evaluate the effective-ness of a patient educa-tion intervention on the benefits of rest in the acute phase of mTBI.	111 patients	Patients who received the intervention returned to a higher level of physical activity at the distance of the mTBI.

Mr LAMY Alexis

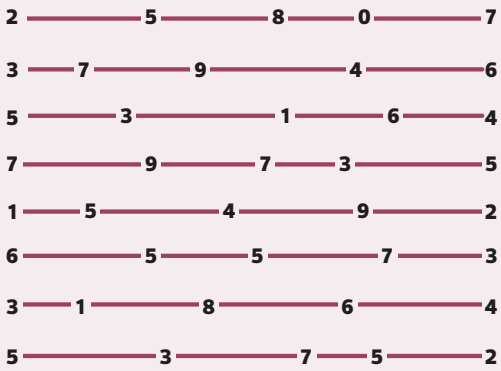
Born on October 14, 1996, he joined the French Army Medical Corps in 2014.
He chose to specialize in physical and rehabilitation medicine in 2020. After a 4-year internship in Marseille, he was posted to the Saint Anne Army Training Hospital in Toulon on November 2, 2024.
He holds an inter-university diploma in head trauma, and wrote his doctoral thesis on the subject of mild head trauma in the military.

APPENDIX 1. King Devick ©

Demonstration card

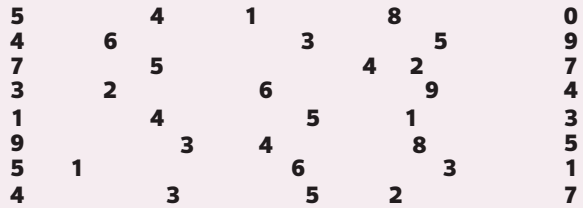


Test 1



Test 2

Test 3



APPENDIX 2. Neurobehavioral Symptom Inventory (NSI)

Please rate the following symptoms with regard to how much they have disturbed you IN THE LAST 2 Weeks. The purpose of this inventory is to track symptoms over time. Please do not attempt to score.

0 : None – Rarely if ever present; not a problem at all

1 : Mild – Occasionally present, but it does not disrupt my activities; I can usually continue what I'm doing; doesn't really concern me.

2 : Moderate – Often present, occasionally disrupts my activities; I can usually continue what I'm doing with some effort; I feel somewhat concerned.

3 : Severe – Frequently present and disrupts activities; I can only do things that are fairly simple or take little effort; I feel I need help.

4: Very Severe – Almost always present and I have been unable to perform at work, school or home due to this problem; I probably cannot function without help.

Symptoms	0	1	2	3	4
Feeling Dizzy	◯	◯	◯	◯	◯
Loss of balance	◯	◯	◯	◯	◯
Poor coordination, clumsy	◯	◯	◯	◯	◯
Headaches	◯	◯	◯	◯	◯
Nausea	◯	◯	◯	◯	◯
Vision problems, blurring, trouble seeing	◯	◯	◯	◯	◯
Sensitivity to light	◯	◯	◯	◯	◯
Hearing difficulty	◯	◯	◯	◯	◯
Sensitivity to noise	◯	◯	◯	◯	◯
Numbness or tingling on parts of my body	◯	◯	◯	◯	◯
Change in taste and/or smell	◯	◯	◯	◯	◯
Loss of appetite or increased appetite	◯	◯	◯	◯	◯
Poor concentration, can't pay attention, easily distracted	◯	◯	◯	◯	◯
Forgetfulness, can't remember things	◯	◯	◯	◯	◯
Difficulty making decisions	◯	◯	◯	◯	◯
Slowed thinking, difficulty getting organized, can't finish things	◯	◯	◯	◯	◯
Fatigue, loss of energy, getting tired easily	◯	◯	◯	◯	◯
Difficulty falling or staying asleep	◯	◯	◯	◯	◯
Feeling anxious or tense	◯	◯	◯	◯	◯
Feeling depressed or sad	◯	◯	◯	◯	◯
Irritability, easily annoyed	◯	◯	◯	◯	◯
Poor frustration tolerance, feeling easily overwhelmed by things	◯	◯	◯	◯	◯
Date: Name: Medical Record #:					

Stage	Objective	Environment	Physical/ Vestibular Activity	Cognitive/ Oculomotor Activity	Restrictions Stages 1–5
Stage 1* Relative Rest	Avoid symptom provocation, and rest to promote recovery	• Minimize light and noise. • Stay home/ in quarters	• Daily activities that do not provoke symptoms. • Limit large or sudden changes in head position • No exercise	• Limit screen time as needed to avoid symptom provocation. • Very light leisure activity (e.g., reading, television, conversation)	• Do not go outside the wire in a combat zone. • Maintain or r educe pre-injury levels of caffeine/ energy drinks and nicotine. • No alcohol** • No combative or contact sports*** • No driving until visual and vestibular symptoms have resolved. • No weapons fire or blast exposure***
Stage 2 Symp- tom-Limited Activity	Introduce and promote mild exertion	Calm and familiar environment with limited distractions	• Limit large or sudden changes in head position • Light routine exertion (e.g., walking on even terrain, light household chores, stationary bike) • No weight or resistance training	Simple, familiar activities performed one at-a-time (e.g., routine computer use, leisure reading)	
Stage 3 Light Activity	Introduce occupation-specific exertion and environmental distractions	• Introduce environmental distract ions during activity. • Return to work on limited duty/profile without significant symptom provocation	• Initiate tasks requiring changes in head position. • Light aerobic exercise without resistance (e.g. elliptical, stationary bike, walking on uneven terrain) • No lifting > 20 pounds • No resistance training	• Simple, unfamiliar tasks or complex familiar tasks (e.g., grocerys hopping, technical reading)	
Stage 4 Moderate Activity	Increase activity intensity and duration	Distracting or busy environment during activity as tolerated	• Attempt asks requiring more significant or sudden changes in head position • Increase intensity and duration of activities (e.g., non-contact sports, hiking or running, push-ups, s it-ups) • Introduce resistance training as tolerated	Increase intensity and duration of activities (e.g. navigate busy environments, recall and follow complex instructions)	
Stage 5*** Intensive Activity	Introduce exertion of dura- tion and intensity that parallels service member's typical role. • Complete RTD Screening prior to advancement to Stage 6	Typical daily environment EXCEPT listed restrict ions	Resume pre-injury exercise routine and training activities	• Complex problem solving or multitasking with exertion or distracting environment	
Stage 6 Return to Full Duty	Return to pre-injury activities	Typical daily environment	Unrestricted activity		

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