Utility of the Validity-10 scale across the recovery trajectory following traumatic brain injury

Sara M. Lippa, PhD;1–2* Rael T. Lange, PhD;1–3 Jason M. Bailie, PhD;1,4 Jan E. Kennedy, PhD;1,5 Tracey A. Brickell, D.Psych;1–2,6 Louis M. French, PsyD1–2,6
1Defense and Veterans Brain Injury Center and 2National Intrepid Center of Excellence, Walter Reed National Military Medical Center, Bethesda, MD; 3Department of Psychiatry, University of British Columbia, Vancouver, Canada; 4Naval Medical Center, San Diego, San Diego, CA; 5San Antonio Military Medical Center, San Antonio, TX; 6Center for Neuroscience and Regenerative Medicine, Uniformed Services University of the Health Sciences, Bethesda, MD

Abstract—The Validity-10 scale was recently developed to screen for symptom exaggeration in patients following traumatic brain injury (TBI). However, it has only been validated on patients with TBI largely in the chronic phase of recovery. The influence of time since injury on the Validity-10 scale was investigated in 2,661 male servicemembers with TBI presenting to six U.S. Defense and Veterans Brain Injury Centers. Participants completed the Neurobehavioral Symptom Inventory (NSI). The Validity-10 scale and NSI total score were both weakly statistically significantly (1) positively correlated with time since injury, (2) negatively correlated with bodily injury severity, and (3) higher in participants undergoing medical board evaluations than in participants who returned to duty or were still hospitalized. Participants were statistically more likely to screen positive for possible symptom exaggeration on the Validity-10 scale as time since injury increased. However, the Validity-10 scale was only weakly related to time since injury, TBI severity, bodily injury severity, disposition, age, and return to duty status. That false positives are not increased in the acute phase of recovery and that the Validity-10 scale is not strongly related to clinical factors support the use of the Validity-10 scale in the acute recovery phase and across the TBI recovery trajectory.

Key words: military, Neurobehavioral Symptom Inventory, postconcussion symptoms, symptom exaggeration, symptom report, symptom validity, TBI, time since injury, traumatic brain injury, Validity-10 scale.

INTRODUCTION

Traumatic brain injury (TBI) has been a common occurrence in the Global War on Terror (GWOT) operations, with 15 to 23 percent of servicemembers sustaining a TBI during deployment [1–2]. Following a TBI, cognitive, emotional, physical, sensory, and/or sleep symptoms may be reported. Collectively known as postconcussive symptoms, these may be related to TBI itself or caused by a number of other factors unrelated to TBI (e.g., vestibular injury, depression, posttraumatic stress, anxiety, sleep disturbance, chronic headaches or bodily pain, personality characteristics, and diverse social psychological factors [3–5]). Regardless of etiology, the symptoms reported

Abbreviations: ANCOVA = analysis of covariance, GWOT = Global War on Terror, ISS = Injury Severity Score, LOC = loss of consciousness, NSI = Neurobehavioral Symptom Inventory, PTA = posttraumatic amnesia, SVT = symptom validity test, TBI = traumatic brain injury.

*Address all correspondence to Sara M. Lippa, PhD; Defense and Veterans Brain Injury Center, Walter Reed National Military Medical Center, Building 19, Room 6003, 8901 Wisconsin Ave, Bethesda, MD 20889; 301-400-1872. Email: sara.lippa.ctr@mail.mil; saralippa@gmail.com
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following TBI determine whether a servicemember is fit for duty, is deployable, requires a medical retirement, and/or requires a disability pension. These external factors may motivate under- or overreporting of symptoms. If patients are concerned that their history of TBI may limit their immediate or long-term career opportunities, they may be motivated to not report their TBI or minimize their symptoms. Underreporting of TBI and postconcussive symptoms is a particular concern in athletes [6–10]. In contrast, overreporting symptoms is often found in patients who are involved in litigation or otherwise have potential for secondary gain [11–15]. Performance validity test failure rates have previously been shown to be high in Active Duty and Veteran samples, ranging from 11 to 59 percent [16–24]. These failure rates vary by evaluation context. Higher rates of failure have been reported in servicemembers and Veterans undergoing medical board evaluations and compensation and pension evaluations, compared with evaluations that do not have clear financial consequences [18,21]. Elevated failure rates have also been found in servicemembers and Veterans undergoing research evaluations to be used clinically rather than strictly for research purposes [20].

Symptom Validity Assessment

Symptom overreporting has been reported at rates of 9.8 [25], 22 [26], 33 [24], and 38 percent [27] in GWOT Veteran and military TBI samples. Detection of symptom exaggeration is paramount. If patients exaggerate their symptoms and this goes undetected, providers may conclude that the patients have more problems than they do in reality and may initiate improper treatments and disability classifications. This not only has substantial financial consequences for the Government and taxpayers but also could increase iatrogenesis because patients may come to believe that they have been put in particular treatments and given certain disability ratings because they truly do have many problems related to their TBI. Beliefs regarding mild TBI have been shown to be related to return to work, functional capacity, and post-concussive symptom report [28–30].

Symptom validity tests (SVTs) are designed to assess under- or overreporting of the presence and/or severity of symptoms using self-report measures or structured interviews. Ideally, the possibility that a person has minimized or exaggerated symptoms is evaluated using well-validated measures designed for this purpose, such as the Minnesota Multiphasic Personality Inventory-2 [31], Personality Assessment Inventory [32], Structured Inventory of Malingered Symptoms [33], or Structured Inventory of Reported Symptoms [34]. Unfortunately, clinicians often do not have time to administer these lengthy assessments; however, embedded measures of symptom validity, which are derived from existing self-report questionnaires, offer the advantage of screening for veracity with minimal or no additional resources.

Validity-10 Scale

Recently, Vanderploeg et al. [26] developed and cross-validated a potential embedded measure of symptom exaggeration from a commonly administered post-concussion symptom scale, the Neurobehavioral Symptom Inventory (NSI) [35]. The NSI is administered to every Veteran who screens positive for TBI at a Department of Veterans Affairs hospital [36] and every servicemember who has a concussion medical encounter [37]. Vanderploeg et al. identified NSI items that are most strongly correlated with report of atypical symptoms (NIM-5) and the items that were most infrequently endorsed (LOW-6) and combined these items to form the Validity-10 scale [26]. The Validity-10 scale has been suggested as a screen to identify possible symptom exaggeration, with positive screens indicating the need for a more in-depth analysis of symptom veracity.

The Validity-10 scale has primarily been investigated in patients who were in the chronic phase of recovery from injury. The original study was cross-validated on 206 military servicemembers an average of 32 wk following a TBI using the Personality Assessment Inventory Negative Impression Management scale as an external criterion for defining genuine versus invalid responding [26]. A cutoff of >22 was identified as optimal, with a sensitivity of 0.61 and a specificity of 0.85. In a follow-up study, Lange et al. examined the Validity-10 scale in 63 military servicemembers an average of 78 wk postinjury [27]. They used the Minnesota Multiphasic Personality Inventory-2-Restructured Form to differentiate between genuine versus invalid responding [38]. This study concluded that a cutoff of >12 was optimal for when providers do not want to miss any potential symptom exaggeration, with a sensitivity of 0.63, specificity of 1.0, positive predictive power of 0.93, and negative predictive power of 0.83. Finally, in a replication of the original cross-validation study, Lange et al. investigated the Validity-10 scale in 272 military servicemembers an average of 33 wk following a TBI [25]. A cutoff of >18 was found to
be optimal for differentiating possible symptom exaggeration from genuine responding but also supported the cutoff of >12 in situations in which it is particularly important not to miss potential invalidity. In this study, the cutoff of >18 had a sensitivity of 0.59, specificity of 0.89, positive predictive power of 0.74, and negative predictive power of 0.80. The cutoff of >12 had a sensitivity of 0.74, specificity of 0.71, positive predictive power of 0.58, and negative predictive power of 0.83.

Purpose

The Validity-10 scale has previously been studied in patients who are largely in the chronic phase of recovery, and it remains unclear whether the previously established cutoffs can be applied to patients in the acute recovery phase. The main aim of the current study was to determine whether there is a significant relationship between time since injury and the Validity-10 scale, and in particular, whether the previously suggested Validity-10 scale cutoffs result in similar classification rates across the acute, subacute, and chronic phases of recovery from TBI. This study also sought to determine whether other injury characteristics that may be related to postconcussion symptom reporting, such as age, TBI severity, bodily injury severity, and return to duty status, were related to the Validity-10 scale.

METHODS

Participants and Procedures

The final sample consisted of 2,661 U.S. military servicemembers who sustained a mild (87.8%), moderate (6.8%), or severe (5.4%) TBI that was either GWOT-related (85.4%) or non-combat-related (14.6%). These participants were evaluated by the Defense and Veterans Brain Injury Centers at the San Antonio Military Medical Center, San Antonio, Texas (36.0%); Walter Reed National Military Medical Center, Bethesda, Maryland (or its predecessor, the Walter Reed Army Medical Center) (24.8%); Naval Medical Center, San Diego, San Diego, California (14.7%); Naval Hospital Camp Pendleton, Oceanside, California (13.5%); Wilford Hall Ambulatory Surgical Center, San Antonio, Texas (7.1%); and Robert E. Bush Hospital, Twentynine Palms, California (3.8%). Participants were selected from a larger sample of 3,205 patients with mild to severe TBI. Participants were excluded if they were >6.5 yr postinjury (n = 2), did not complete or had an incomplete NSI (n = 251), were female (n = 155), had a penetrating head injury (n = 59), or had missing data on key variables (i.e., time since injury [n = 303], sex [n = 21], or whether TBI was penetrating [n = 23]). This study excluded females given previous findings that women tend to report more postconcussion symptoms than men [39–41].

Excluded participants did not differ from included participants in terms of time since injury, NSI total score, Validity-10 scale total score, or bodily injury severity (all p > 0.06). Age, sex, return to duty status, and TBI severity did significantly differ between the included and excluded participants. Excluded participants were older (mean ± standard deviation: 28.6 ± 8.2 yr) than included participants (27.47 ± 7.39 yr; F(1, 692.6), p = 0.002), were female (29.6% vs 0%; p < 0.001), were more likely to return to duty (43.1% vs 33.4%; χ²(1, n = 2,842) = 14.335, p < 0.001), less likely to be on limited duty or a medical hold (36.5% vs 49.9%; χ²(1, 2,842) = 25.415, p < 0.001), and more likely to be undergoing a medical review (including in-theater medical records when available), interview of the patient and family, collection of other collateral information, and/or case conferencing. TBI severity was first divided into mild, moderate, and severe groups based on commonly used severity classification systems [42]. The mild TBI group was then divided into three groups based on the presence or absence of loss of consciousness (LOC) and/or posttraumatic amnesia (PTA) [43] and the presence or absence of neuroimaging findings [44]. The five final groups were (1) equivocal mild TBI (alteration of consciousness only), (2) uncomplicated mild TBI (absence of intracranial abnormality and LOC ≤30 min or PTA <24 h), (3) complicated mild TBI (presence of intracranial abnormality and LOC ≤30 min or PTA <24 h), (4) moderate TBI (LOC >30 min–24 h or PTA 1–7 d), and

Measures

Demographics, Traumatic Brain Injury Characteristics, and Return to Duty Status

Demographic information, TBI characteristics, and return to duty status were collected through medical chart review (including in-theater medical records when available), interview of the patient and family, collection of other collateral information, and/or case conferencing. TBI severity was first divided into mild, moderate, and severe groups based on commonly used severity classification systems [42]. The mild TBI group was then divided into three groups based on the presence or absence of loss of consciousness (LOC) and/or posttraumatic amnesia (PTA) [43] and the presence or absence of neuroimaging findings [44]. The five final groups were (1) equivocal mild TBI (alteration of consciousness only), (2) uncomplicated mild TBI (absence of intracranial abnormality and LOC ≤30 min or PTA <24 h), (3) complicated mild TBI (presence of intracranial abnormality and LOC ≤30 min or PTA <24 h), (4) moderate TBI (LOC >30 min–24 h or PTA 1–7 d), and


(5) severe TBI (LOC >24 h or PTA >7 d). Glasgow Coma Scale scores were not available. In order to differentiate between different phases of acute, subacute, and postacute recovery, time since injury was divided into seven a priori groups for most analyses: (1) ≤1 wk, (2) >1 wk to ≤1 mo, (3) >1 to ≤3 mo, (4) >3 to ≤6 mo, (5) >6 mo to ≤1 yr, (6) >1 to ≤3 yr, and (7) >3 to ≤6.5 yr. Return to duty status was divided into four groups for most analyses: (1) return to duty, (2) limited duty (medical hold), (3) pending medical board, and (4) still hospitalized.

Postconcussion Symptoms and Validity-10 Scale

The NSI is a 22-item questionnaire of postconcussion symptoms [35]. Whether the NSI is an accurate assessment of emotional and functional outcomes has yet to be established; however, it has been recommended as a common data elements outcome measure for TBI research [45]. It is also one of two core outcome measures within the military healthcare system [46]. Participants are asked to rate symptoms on a 5-point Likert scale ranging from 0 (none) to 4 (very severe), with higher scores related to increased symptom report. The Validity-10 scale is calculated by summing the scores on 10 items that are infrequently endorsed and/or related to atypical symptom report [26]. Scores on the Validity-10 scale range from 0 to 40. We investigated Validity-10 scale failure rates at three previously suggested cutoffs: >22 [26], >18 [25], and >12 [25,27].

Bodily Injury Severity

Bodily injury severity was measured using the Injury Severity Score (ISS) derived from the Abbreviated Injury Scale [47]. On the ISS, higher scores are associated with increased injury severity. For the current study, a modified ISS that excluded intracranial injuries was calculated. In addition to using the ISS as a continuous variable, in some analyses, ISS scores were collapsed into the following categories [48]: minor (1–3), moderate (4–8), serious (9–15), severe (16–24), and critical (25–75).

RESULTS

Demographics and Clinical Characteristics

Table 1 presents primary summary data for the total sample, including demographics, injury characteristics, and clinical characteristics.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean ± SD or n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, yr (n = 2,659)</td>
<td>27.47 ± 7.39</td>
</tr>
<tr>
<td>Bodily Injury Severity (n = 2,246)</td>
<td>6.69 ± 7.20</td>
</tr>
<tr>
<td>Time Postinjury, d (n = 2,661)</td>
<td>289.08 ± 408.91</td>
</tr>
<tr>
<td>NSI Total Score (n = 2,661)</td>
<td>27.17 ± 17.98</td>
</tr>
<tr>
<td>Validity-10 Scale (n = 2,661)</td>
<td>9.77 ± 7.53</td>
</tr>
<tr>
<td>Severity of TBI (n = 2,509)</td>
<td></td>
</tr>
<tr>
<td>Equivocal (AOC only)</td>
<td>653 (26.0)</td>
</tr>
<tr>
<td>Uncomplicated Mild</td>
<td>1,434 (57.2)</td>
</tr>
<tr>
<td>Complicated Mild</td>
<td>116 (4.6)</td>
</tr>
<tr>
<td>Moderate</td>
<td>171 (6.8)</td>
</tr>
<tr>
<td>Severe</td>
<td>135 (5.4)</td>
</tr>
<tr>
<td>Severity of Bodily Injury (n = 2,246)</td>
<td></td>
</tr>
<tr>
<td>Minor</td>
<td>694 (30.9)</td>
</tr>
<tr>
<td>Moderate</td>
<td>955 (42.5)</td>
</tr>
<tr>
<td>Serious</td>
<td>375 (16.7)</td>
</tr>
<tr>
<td>Severe</td>
<td>164 (7.3)</td>
</tr>
<tr>
<td>Critical</td>
<td>58 (2.6)</td>
</tr>
<tr>
<td>Return to Duty Status (n = 2,417)</td>
<td></td>
</tr>
<tr>
<td>Return to Duty</td>
<td>808 (33.4)</td>
</tr>
<tr>
<td>Limited Duty (medical hold)</td>
<td>1,205 (49.9)</td>
</tr>
<tr>
<td>Still Hospitalized</td>
<td>308 (12.7)</td>
</tr>
<tr>
<td>Pending Medical Board</td>
<td>96 (4.0)</td>
</tr>
<tr>
<td>Time Since Injury (n = 2,661)</td>
<td></td>
</tr>
<tr>
<td>&lt;1 wk</td>
<td>135 (5.1)</td>
</tr>
<tr>
<td>&gt;1 wk–1 mo</td>
<td>586 (22.0)</td>
</tr>
<tr>
<td>&gt;1–3 mo</td>
<td>573 (21.5)</td>
</tr>
<tr>
<td>&gt;3–6 mo</td>
<td>355 (13.3)</td>
</tr>
<tr>
<td>&gt;6 mo–1 yr</td>
<td>337 (12.7)</td>
</tr>
<tr>
<td>&gt;1–3 yr</td>
<td>510 (19.2)</td>
</tr>
<tr>
<td>&gt;3–6.5 yr</td>
<td>165 (6.2)</td>
</tr>
</tbody>
</table>

Validity-10 Scale and Neurobehavioral Symptom Inventory Total Score

Table 1. Descriptive statistics for demographic variables and injury characteristics.

Validity-10 Scale

The overall ANCOVA model investigating factors related to the Validity-10 scale was significant (F(10,
Return to duty status and bodily injury severity explained approximately 2 percent of variability in Validity-10 scale scores ($R^2$ change = 0.019 and 0.013, respectively). Age ($R^2$ change = 0.004) and TBI severity ($R^2$ change = 0.003) all statistically improved the model but contributed less than 0.5 percent unique variance to the model; therefore, they were deemed not meaningful and were not included as covariates in subsequent analyses.

**Neurobehavioral Symptom Inventory Total Score**

The overall ANCOVA model investigating factors related to the NSI total score was significant ($F(10, 2,011) = 26.165, p < 0.001$). TBI severity ($F(1, 2,011) = 3.941, p = 0.047$), bodily injury severity ($F(1, 2,011) = 34.475, p < 0.001$), return to duty status ($F(1, 2,011) = 54.345, p < 0.001$), and time since injury group ($F(6, 2,011) = 31.670, p < 0.001$) were all significantly related to the NSI total score. In contrast, age was not related to NSI total score ($F(1, 2,011) = 3.545, p = 0.06$). Post hoc analyses revealed that the NSI total score increased with time since injury. Most time since injury groups had significantly higher NSI total scores than earlier time since injury groups. The only nonsignificant differences were between the following groups: >3 to ≤6 mo versus >6 mo to ≤1 yr, >6 mo to ≤1 yr versus >3 to ≤6.5 yr, and >1 to ≤3 yr versus >3 to ≤6.5 yr.

**Validity-10 Scale Failure Rates**

Table 2 presents Validity-10 scale failure rates, stratified by time since injury, bodily injury severity, and return to duty status (variables that explained over 1% additional variance to Validity-10 scale). Validity-10 scale failure rates are presented using three different cutoff scores (i.e., >22, >18, >12) as recommended by previous research [25–27]. Chi-square analysis indicated that the number of participants exceeding all three of the Validity-10 scale cutoffs differed across time since injury groups (i.e., >22 cutoff, $\chi^2(6, 2,661) = 19.230, p = 0.004$; >18 cutoff, $\chi^2(6, 2,661) = 35.491, p < 0.001$; and >12 cutoff, $\chi^2(6, 2,661) = 74.278, p < 0.001$). The number of participants exceeding all three cutoffs increased as time since injury increased. Bodily injury severity was related to exceeding the Validity-10 scale >22 cutoff ($\chi^2(4, 2,246) = 10.164, p = 0.04$) and >12 cutoff ($\chi^2(4, 2,246) = 32.295, p < 0.001$). Similarly, bodily injury severity approached, but did not reach, significance at the >18 cutoff ($\chi^2(4, 2,246) = 9.243, p = 0.06$). Participants with mild and moderate bodily injuries were more likely to exceed the >22 and >12
cutoffs than participants with serious, severe, and critical injuries. Return to duty status was related to exceeding the Validity-10 scale >22 cutoff ($\chi^2 (3, 2,417) = 24.335, p < 0.001$), >18 cutoff ($\chi^2 (3, 2,417) = 49.113, p < 0.001$), and >12 cutoff ($\chi^2 (3, 2,417) = 55.954, p < 0.001$). Participants in the limited duty (medical hold) and pending medical board groups fell above the cutoffs more frequently than participants who were still hospitalized or who had returned to duty.

Table 2.
Rates of Validity-10 scale failure by time since injury, bodily injury severity, and return to duty status, n (% of failure).

<table>
<thead>
<tr>
<th>Variable</th>
<th>&gt;22 Cutoff</th>
<th>&gt;18 Cutoff</th>
<th>&gt;12 Cutoff</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time Since Injury</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;1 wk</td>
<td>2 (1.5)</td>
<td>6 (4.4)</td>
<td>20 (14.8)</td>
</tr>
<tr>
<td>&gt;1 wk–1 mo</td>
<td>28 (4.8)</td>
<td>63 (10.8)</td>
<td>139 (23.7)</td>
</tr>
<tr>
<td>&gt;1–3 mo</td>
<td>38 (6.6)</td>
<td>74 (12.9)</td>
<td>162 (28.3)</td>
</tr>
<tr>
<td>&gt;3–6 mo</td>
<td>24 (6.8)</td>
<td>51 (14.4)</td>
<td>126 (35.5)</td>
</tr>
<tr>
<td>&gt;6 mo–1 yr</td>
<td>28 (8.3)</td>
<td>55 (16.3)</td>
<td>119 (35.3)</td>
</tr>
<tr>
<td>&gt;1–3 yr</td>
<td>48 (9.4)</td>
<td>93 (18.2)</td>
<td>210 (41.2)</td>
</tr>
<tr>
<td>&gt;3–6.5 yr</td>
<td>17 (10.3)</td>
<td>38 (23.0)</td>
<td>72 (43.6)</td>
</tr>
<tr>
<td>Total</td>
<td>185 (7.0)</td>
<td>380 (14.3)</td>
<td>848 (31.9)</td>
</tr>
<tr>
<td>Bodily Injury Severity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mild</td>
<td>54 (7.8)</td>
<td>105 (15.1)</td>
<td>233 (33.6)</td>
</tr>
<tr>
<td>Moderate</td>
<td>71 (7.4)</td>
<td>151 (15.8)</td>
<td>352 (36.9)</td>
</tr>
<tr>
<td>Serious</td>
<td>12 (3.2)</td>
<td>40 (10.7)</td>
<td>91 (24.3)</td>
</tr>
<tr>
<td>Severe</td>
<td>9 (5.5)</td>
<td>16 (9.8)</td>
<td>36 (22.0)</td>
</tr>
<tr>
<td>Critical</td>
<td>5 (8.6)</td>
<td>7 (12.1)</td>
<td>12 (20.7)</td>
</tr>
<tr>
<td>Total</td>
<td>151 (6.7)</td>
<td>319 (14.2)</td>
<td>724 (32.2)</td>
</tr>
<tr>
<td>Return to Duty Status</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Return to Duty</td>
<td>36 (4.5)</td>
<td>76 (9.4)</td>
<td>211 (26.1)</td>
</tr>
<tr>
<td>Limited Duty (medical hold)</td>
<td>108 (9.0)</td>
<td>226 (18.8)</td>
<td>465 (38.6)</td>
</tr>
<tr>
<td>Still Hospitalized</td>
<td>12 (3.9)</td>
<td>25 (8.1)</td>
<td>64 (20.8)</td>
</tr>
<tr>
<td>Pending Medical Board</td>
<td>12 (12.5)</td>
<td>21 (21.9)</td>
<td>36 (37.5)</td>
</tr>
<tr>
<td>Total</td>
<td>168 (7.0)</td>
<td>348 (14.4)</td>
<td>776 (32.1)</td>
</tr>
</tbody>
</table>

Next, the possibility of a moderating relationship between (1) time since injury and bodily injury severity or (2) time since injury and return to duty status on Validity-10 scale failure rates was examined. Each of these categories was collapsed into fewer groups to clarify the relationships and ensure adequate cell counts and power for analyses. Time since injury was collapsed into three groups representing acute, subacute, and chronic recovery: (1) ≤1 mo, (2) >1 mo to 1 yr, and (3) >1 yr. Return to duty status was also collapsed into three groups: (1) return to duty, (2) medical board or limited duty (medical hold) (these two groups were combined because they are both the most likely to have fitness for duty evaluations that might influence the incentive to exaggerate or minimize symptoms), and (3) still hospitalized. Bodily injury severity was collapsed into two groups to distinguish the most severe injuries from more mild injuries: (1) mild or moderate and (2) serious or higher. The three levels of time since injury were then combined with the three levels of return to duty status (e.g., ≤1 mo time since injury and returned to duty) and the two levels of bodily injury severity (e.g., ≤1 mo time since injury and mild or moderate bodily injury) to create mutually exclusive groups. Figure 2 presents failure rates at the >18 cutoff for each of the combined groups. In each group, failure rates increased with time since injury (except for the still hospitalized group, which had a very small sample size at >1 yr postinjury [n = 11]). The time since injury group was related to Validity-10 scale scores >18 in all three return to duty status groups (all $\chi^2 > 9.356, p < 0.01$). The time since injury group was related to Validity-10 scale scores >18 in participants with mild or moderate bodily injuries ($\chi^2 (2, 1,649) = 14.515, p = 0.001$) but not in participants with serious or higher bodily injuries ($\chi^2 (2, 597) = 1.112, p = 0.57$).
DISCUSSION

The main goal of the present study was to examine the relation between time since injury and the Validity-10 scale to determine whether the Validity-10 scale can be used in the acute recovery phase following a TBI without increasing the rates of screening positive for possible symptom exaggeration. The closer participants were to their date of injury, the less likely they were to fall above Validity-10 scale cutoffs. This suggests that the current proposed cutoffs will not result in an increased rate of identifying patients with acute TBI as exaggerating their symptoms. Additionally, although the Validity-10 scale was higher in participants who were evaluated further from their date of injury, this statistically significant relationship is likely the result of large sample size and does not appear to have significant clinical implications given that time since injury explained less than 5 percent of the variance in the Validity-10 scale. This suggests that the Validity-10 scale changes minimally over time and further supports the use of the Validity-10 scale in the acute phase and across the time since injury spectrum. Similarly, other clinical variables, such as TBI severity, bodily injury severity, return to duty status, and age each explained less than 2 percent of the unique variance in the Validity-10 scale, suggesting that the Validity-10 scale is not meaningfully affected by these clinical factors, supporting its use as an SVT. Both the relatively low rate of potential false positives in patients with acute TBI and the rather weak relationship between the Validity-10 scale and a variety of clinical factors support the use of the Validity-10 scale and its previously suggested cutoffs in acute TBI and across different phases of recovery.

Given that symptoms generally improve with time following a TBI, it was interesting that the NSI total score and Validity-10 scale scores were higher in participants assessed many years following their injury than in participants who were assessed days or weeks following their injury. Some studies have demonstrated the persistence of symptoms many years following mild TBI [49–51]; however, in the overwhelming majority of patients, symptom complaints following a mild TBI resolve completely within a year of the injury [52]. Although persisting symptoms are generally thought to be the result of
other factors, such as psychological and medical comorbidities [52], the origin of persisting symptoms is unknown. The finding that symptom report was higher as time since injury increased is likely a result of sample bias. Military personnel who are many months or years post mild TBI and asymptomatic are presumably relatively unlikely to actively seek out or be referred for a TBI evaluation. Often, patients who are many months postinjury are referred to clinical care because they are reporting impaired functioning and also have a remote history of TBI; the symptoms and injury may not be related [53]. Further, patients may be referred for evaluation as part of the process for separation from the military such as medical retirement. As a result, the present study includes many participants, years from injury, who are highly symptomatic. These results may not apply to all people who have experienced a TBI (including those who would not normally present for evaluation and/or treatment). The findings are most applicable to patients presenting for evaluation and/or treatment of TBI at military treatment facilities. Additionally of note, this study did not reassess participants across the recovery trajectory but sampled each participant only once. Therefore, this study cannot speak to changes in symptom report or symptom exaggeration over time. It is possible that symptom exaggeration may be best assessed by the change (or lack thereof) in Validity-10 scale score over time rather than the Validity-10 scale score at a single point in time.

The current study found that return to duty status was related to overall postconcussion symptom report and rates of symptom exaggeration in a clinic-based TBI sample. Participants who were on limited duty (medical hold) or undergoing a medical board evaluation reported more symptoms and were at increased likelihood of screening positive for symptom exaggeration based on the Validity-10 scale than participants who had returned to duty or who were still hospitalized. Despite this statistically significant relationship, and after controlling for other variables, return to duty status only explained 1.9 percent of the variance in the Validity-10 scale. Previous research has shown that external incentives increase rates of invalid responding on neuropsychological tests [11–15,18,20–21]; however, the current results suggest only a very mild relationship between external incentives and Validity-10 scale. It is likely that the small increase in Validity-10 scale in participants undergoing medical board evaluations and on limited duty (medical hold) is driven by underlying psychological distress. Although the Validity-10 scale is a screener for symptom validity, it is important to acknowledge that it comprises nearly half of the NSI. Scores on the Validity-10 scale therefore likely increase not only with symptom exaggeration but with an increase of true symptomatology as well. This study did not assess the effect of psychological factors on the Validity-10 scale score. It is likely that psychological factors affect symptom validity; however, the purpose of this study was to examine the Validity-10 scale regardless of etiology of symptom exaggeration. It is difficult to clearly determine the strength of the relationship between symptom exaggeration and emotional distress because psychological distress is measured by self-report and therefore can be exaggerated as well.

Along with time since injury and return to duty status, bodily injury severity was also related to postconcussion symptom report. Possible explanations for this phenomenon have included that patients who have survived severe bodily injuries may view any postconcussion symptoms as minor inconveniences not worth being concerned about and may subsequently underreport these symptoms; patients may have more visible evidence of their recovery and/or adaptation, which may help to confirm that their brain is recovering as well; and patients may have increased social support [54].

The present study also examined three different Validity-10 scale cutoffs that have previously been supported in the literature. Though it did not employ an external criterion to compare Validity-10 scale results (and subsequently calculate sensitivity, specificity, and positive and negative predictive power), the large sample allowed exploration of the implications of using different cutoffs. The cutoff of >12, which has been suggested for use as a screen when providers do not want to miss any potential symptom exaggeration [25], identified a total of 31.9 percent of the participants as needing additional symptom validity testing. There is some concern that patients presenting within 3 mo of injury may have actual neurological symptoms that may be inflating their score above this cutoff. The originally suggested cutoff of >22 [26] identified only 7 percent of the participants as needing additional symptom validity testing and may not be sensitive enough because this is much lower than the majority of previous studies investigating rates of SVT failure in GWOT personnel [24,26–27]. These base rates suggest that the cutoff of >18, which generated a positive screen in 14.7 percent of participants in the current study and has
most recently been suggested as the optimal cutoff for identifying possible symptom exaggeration [25], may be the most appropriate of the three suggested cutoffs.

CONCLUSIONS

In sum, the present study was the largest yet to investigate the Validity-10 scale and the first to specifically investigate the relationship between time since injury and Validity-10 scale performance. Validity-10 scale and NSI total score both increased with time since injury; however, the Validity-10 scale was more resistant to change over time than the NSI total score. Participants were significantly more likely to screen positive for possible symptom exaggeration on the Validity-10 scale the further they were from their injury date. This study provides evidence to support the use of the Validity-10 scale in patients with acute, subacute, and chronic TBI. Continued research on the Validity-10 scale and other efficient measures of symptom validity is necessary to improve the accuracy of these instruments because symptom exaggeration has numerous diagnostic, treatment, and financial implications.

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Author Contributions:
Study concept and design: S. M. Lippa, R. T. Lange, J. M. Bailie, J. E. Kennedy.
Acquisition of data: R. T. Lange, J. M. Bailie, J. E. Kennedy, L. M. French, T. A. Brickell.
Analysis and interpretation of data: S. M. Lippa, R. T. Lange, J. M. Bailie.
Drafting of manuscript: S. M. Lippa.
Critical revision of manuscript for important intellectual content: S. M. Lippa, R. T. Lange, J. M. Bailie, J. E. Kennedy, L. M. French, T. A. Brickell.
Statistical analysis: S. M. Lippa.

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