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## Predictors of six-month inability to return to work in previously employed subjects after mild traumatic brain injury: A TRACK-TBI pilot study

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### Abstract

**Introduction:** Return to work (RTW) is an important milestone of mild traumatic brain injury (mTBI) recovery. The objective of this study was to evaluate whether baseline clinical variables, three-month RTW, and three-month postconcussional symptoms (PCS) were associated with six-month RTW after mTBI.

<sup>‡</sup>TRACK-TBI Investigators are listed in the Appendix in alphabetical order by last name

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Ethics committee approval

This study received approval from the institutional review board of record at University of California, San Francisco (Committee on Human Research, study #10-00011).

Declaration of conflicting interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

**Methods:** Adult subjects from the prospective multicenter Transforming Research and Clinical Knowledge in Traumatic Brain Injury Pilot study with mTBI (Glasgow Coma Scale 13–15) who were employed at baseline, with completed three- and six-month RTW status, and three-month Acute Concussion Evaluation (ACE), were extracted. Univariate and multivariable analyses were performed for six-month RTW, with focus on baseline employment, three-month RTW, and three-month ACE domains (physical, cognitive, sleep, and/or emotional postconcussional symptoms (PCS)). Odds ratios (OR) and 95% confidence intervals [CI] were reported. Significance was assessed at  $p < 0.05$ .

**Results:** In 152 patients aged  $40.7 \pm 15.0$  years, 72% were employed full-time at baseline. Three- and six-month RTW were 77.6% and 78.9%, respectively. At three months, 59.2%, 47.4%, 46.1% and 31.6% scored positive for ACE physical, cognitive, sleep, and emotional PCS domains, respectively. Three-month RTW predicted six-month RTW (OR = 19.80, 95% CI [7.61–51.52]). On univariate analysis, scoring positive in any three-month ACE domain predicted inability for six-month RTW (OR = 0.10–0.11). On multivariable analysis, emotional symptoms predicted inability to six-month RTW (OR = 0.19 [0.04–0.85]). Subjects who scored positive in all four ACE domains were more likely to be unable to RTW at six months (4 domains: 58.3%, vs. 0-to-3 domains: 9.5%; multivariable OR = 0.09 [0.02–0.33]).

**Conclusions:** Three-month post-injury is an important time point at which RTW status and PCS should be assessed, as both are prognostic markers for six-month RTW. Clinicians should be particularly vigilant of patients who present with emotional symptoms, and patients with symptoms across multiple PCS categories, as these patients are at further risk of inability to RTW and may benefit from targeted evaluation and support.

## Keywords

Concussion; disability; mild traumatic brain injury; post-concussion syndrome; return to work

## Introduction

Traumatic brain injury (TBI) is a significant public health burden; there are about 2.8 million new cases of TBI in the United States (U.S.) per year,<sup>1</sup> and 2% of the U.S. population currently lives with TBI-related disability.<sup>2</sup> Up to 90% of TBI is mild (mTBI),<sup>3</sup> defined as head injury with a Glasgow Coma Scale (GCS) of 13–15 associated with loss of consciousness under 30 minutes, post-traumatic amnesia less than 24 hours, alteration of consciousness, and/or focal neurologic deficits.<sup>4</sup> Historically, subtle and long-term mTBI sequelae may have been underappreciated given the lack of apparent severity at the time of injury. However, substantial evidence now suggests that this condition can lead to lasting deficits in a significant minority of patients.<sup>5–7</sup> Residual symptoms have important implications for patients' abilities to return to their baseline functional level, and may warrant more proactive and targeted follow-up, screening, and intervention to support long-term recovery after mTBI.

One important recovery milestone for mTBI patients is return to work (RTW), which is a surrogate marker of functional recovery. Resuming work-related activities is recognized by the World Health Organization as a critical outcome measure in the context of injury and

disability, and delays have been shown to have significant psychosocial and economic consequences.<sup>8,9</sup> Furthermore, lost income associated with delayed RTW may have a synergistic relationship with injury-related medical expenses, leading to financially devastating impacts on patients and their families, and creating further barriers to optimal follow-up care and rehabilitation. Optimizing RTW is nuanced, and often depends on patient-provider communication, and patient self-efficacy,<sup>10</sup> in addition to clinical recovery. Although recent guidelines have encouraged gradual return to tolerable activity across the course of days after mTBI,<sup>11–13</sup> these guidelines are often eschewed in symptomatic patients by negative patient expectations and concerned clinicians which lead to delayed RTW.<sup>10,13</sup> It is important to note that RTW encompasses not only the ability to resume prior duties, but doing so with equal quality, efficiency, and stamina as pre-injury performance.<sup>14,15</sup>

As effective rehabilitation options begin to emerge,<sup>16,17</sup> it becomes increasingly important to accurately chart recovery trajectories and identify predictors of delayed RTW to proactively intervene. Several candidate risk factors for delayed RTW have been identified, e.g. lower educational level, concurrent extracranial injuries, re-injury, sex, and social/workplace-specific factors.<sup>13,18–21</sup> Certain post-injury symptoms such as dizziness and fatigue have also been shown to predict delayed RTW.<sup>8,22</sup> There is no current consensus on the symptoms most predictive of delayed RTW, nor the interval follow-up time points at which clinicians should be most vigilant for deficits and symptoms.<sup>18–20,23</sup> To address these questions, in the current study we specifically evaluated whether baseline employment, three-month RTW, and three-month postconcussional symptoms (PCS) were associated with six-month RTW in a prospective, multicenter cohort of mTBI patients.

## Methods

The prospective, multicenter Transforming Research and Clinical Knowledge in Traumatic Brain Injury Pilot (TRACK-TBI Pilot) study was conducted at three U.S. Level I trauma centers (University of California San Francisco (UCSF) - Zuckerberg San Francisco General Hospital (San Francisco, California), University of Pittsburgh Medical Center (Pittsburgh, Pennsylvania), University Medical Center Brackenridge (Austin, Texas)) using the National Institute of Neurological Disorders and Stroke (NINDS) TBI Common Data Elements (CDEs).<sup>24</sup> Inclusion criteria for TRACK-TBI Pilot were acute external force trauma to the head and presentation to a participating center, and a clinically-indicated head computed tomography (CT) scan within 24 hours of injury. Exclusion criteria were pregnancy, ongoing life-threatening disease (e.g., end-stage malignancy), police custody, involuntary psychiatric hold, and non-English speakers due to multiple outcome measures administered and/or normed only in English.

Eligible subjects were enrolled by convenience sampling from years 2010–2012. Institutional Review Board (IRB) approval for human studies was obtained at each participating site. The IRB of record for overall study approval was the UCSF Committee on Human Research (CHR), and TRACK-TBI Pilot was approved as CHR # 10–00011. Informed consent was obtained from each subject, or proxy, prior to enrollment. Subjects enrolled by surrogate consent were re-consented, if cognitively able, during the course of clinical care and/or follow-up timepoints for study participation.

The goal of the current analysis was to evaluate associations between baseline factors, three-month RTW and postconcussional symptomatology (PCS), and six-month RTW. TRACK-TBI Pilot subjects 18 years of age who were employed either full-time or part-time at time of injury, presented with GCS 13–15, completed the three-month Acute Concussion Evaluation (ACE), and had documented three- and six-month RTW status were included in the current analysis. The flowchart of included subjects is shown in Figure 1.

### Demographic and clinical variables

Subjects were assessed by in-person interview and medical record review for demographic, baseline medical history, as well as clinical and injury history variables upon emergency department (ED) admission in accordance with the NINDS CDE version 1.<sup>25</sup> If admitted to hospital, subjects were followed for the entirety of their hospital course.

### Neuroimaging

All subjects received a head CT within 24 hours of injury as part of their clinical evaluation for TBI. Head CTs were read and coded by a central board-certified neuroradiologist blinded to subject characteristics in accordance with the NINDS CDE version 1 for neuroimaging.<sup>26</sup>

### Outcomes

In TRACK-TBI Pilot, three-month PCS were evaluated using the Acute Concussion Evaluation (ACE). The ACE was first reported by a consensus sports neuropsychology panel in 1998, and was later adopted by the U. S. Centers for Disease Control and Prevention (CDC) in 2006.<sup>27</sup> It contains 22 specific post-concussive symptoms classified into 4 domains: physical (10 symptoms), cognitive (4 symptoms), sleep (4 symptoms), and emotional (4 symptoms). We decided to use the ACE given its reasonably strong psychometric properties. In particular, it demonstrates good item-total correlation (correlation up to 0.522 for individual items), moderate to high internal consistency (Cronbach  $\alpha = 0.82$ ), nonsignificant inter-rater variability, and strong validity (including content validity, convergent/discriminant validity, and construct validity as determined by exploratory factor analysis).<sup>28</sup> Subjects were queried regarding the presence/absence of each symptom and the corresponding domain was scored as positive/negative accordingly, where “positive” = “symptom present” and “negative” = “symptom absent”. Three- and six-month RTW were assessed using question 5 A of the Glasgow Outcome Scale-Extended (GOSE), which assesses whether subjects were able to return to their baseline work capacity after TBI.<sup>29–31</sup> The GOSE is considered the gold standard for TBI outcomes and widely utilized as an endpoint for clinical trials.<sup>32,33</sup> While the GOSE reliably captures a wide-range of functional outcomes with good test-retest (kappa 0.92) and inter-rater reliability (kappa 0.84),<sup>34</sup> recent psychometric analyses have shown some evidence of item redundancy and inefficiency.<sup>33</sup> In particular, GOSE question 5B, which asks “how restricted” subjects are with respect to work, has been shown to add relatively low additional information while being subject to interpretation bias.<sup>33</sup> As such, we opted to only use question 5 A, which is less prone to interpretation errors and offers greater psychometric reliability and validity.

## Statistical analysis

Descriptive statistics were reported using means and standard deviations (SD) for continuous variables and proportions for categorical variables. Variables of interest included baseline employment, three-month PCS by ACE domains (physical, sleep, cognition, emotional), three-month RTW, and six-month RTW. Multivariable regressions were performed for six-month RTW, controlling for known predictors from prior literature<sup>35,36</sup> including age, sex, race, education, psychiatric history, and polytrauma (defined as Abbreviated Injury Score (AIS) of  $\geq 3$  in any extracranial body system).<sup>33,37–40</sup> A composite score for three-month PCS was developed to reflect whether subjects scored positive in 0, 1, 2, 3, or all 4 domains of the ACE, and this was entered onto a separate regression for six-month RTW. Candidate predictors from univariate analyses with  $p < 0.10$  were included in multivariable analyses. Univariate and multivariable odds ratios (OR) and associated 95% confidence intervals [95% CI] were reported for predictors. Statistical significance was assessed at  $p < 0.05$ . Analyses were performed using Statistical Package for the Social Sciences (SPSS) version 25 (IBM Corporation, Chicago, IL).

## Results

Overall, 152 subjects were included in this analysis. Mean age was  $40.7 \pm 15.0$  years, 73% were male, and 80.9% were Caucasian. Average years of education were  $14.7 \pm 2.6$  and 72.4% were employed full-time at baseline. Sixty-three percent had posttraumatic amnesia, of which approximately half were under 30 minutes. Seventy-seven percent had an ED GCS of 15, and 61.2% had no intracranial abnormalities on CT. Measures of injury severity (LOC, PTA, GCS, CT results, and polytrauma) did not differ across six-month RTW status (Table 1). For validity, we compared measures of injury severity in a separate analysis for adult mTBI patients in TRACK-TBI Pilot who were included vs. excluded from the current study, and there were no statistically significant differences (data not shown).

RTW was 77.6% at three months and 78.9% at six months. At three months, the proportion of subjects scoring positive for ACE physical, sleep, cognitive, and emotional symptoms were 59.2%, 47.4%, 46.1% and 31.6%. The distribution of outcomes by six-month RTW status are shown in Table 2.

On univariate analysis, several notable findings were present between subjects who did and did not return to work at six months. Baseline history of illicit drug use showed a nonsignificant statistical trend for inability to RTW (six-month RTW=No: 31.3% with illicit drug use; six-month RTW=Yes: 17.5% with illicit drug use; univariate OR = 0.47 [95% CI 0.19–1.13]). Subjects who returned to work at three months were much more likely to return to work at six months (six-month RTW = No: 31.2% returned to work at three-month; six-month RTW = Yes: 90.0% returned to work at three months; OR = 19.80 [7.61–51.52]). Scoring positive in any three-month PCS domain predicted inability to RTW at six months: ACE-Physical (six-month RTW = No: 90.6% symptomatic; six-month RTW = Yes: 50.8% symptomatic; OR = 0.11 [0.03–0.37]); ACE-Sleep (six-month RTW = No: 84.4% symptomatic; six-month RTW = Yes: 37.5% symptomatic; OR = 0.11 [0.04–0.31]); ACE-Cognitive (six-month RTW = No: 84.4% symptomatic; six-month RTW = Yes: 35.8% symptomatic; OR = 0.10 [0.04–0.29]); ACE-Emotional (six-month RTW = No: 71.9%

symptomatic; six-month RTW = Yes: 20.8% symptomatic; OR = 0.10 [0.04–0.25]) (Table 2).

Analysis of the relationship between the number of three-month ACE domains for which a subject scored positive, and six-month RTW, showed a trend between the number of positive ACE domains and inability to RTW (Figure 2). There was a clear dichotomy between scoring positive in all four ACE domains and reduced likelihood of RTW (all four domains: 58.3% unable to RTW at six months versus 0–3 domains: 9.5% unable to RTW at six months, univariate OR = 0.08 [0.03–0.19]).

Two multivariable analyses were performed. When the four individual ACE domains were entered as separate predictors, the ACE-Emotional domain was a significant predictor of inability to six-month RTW (OR = 0.19 [0.04–0.85]) (Table 3). The univariate relationship between scoring positive in all four ACE domains vs. 0–3 domains, and inability to RTW at six months, was conserved (OR = 0.09 [0.02–0.33]) (Table 4). The Nagelkerke  $R^2$  for these analyses were 0.585 and 0.572, respectively.

## Discussion

Mild TBI is increasingly understood as a condition with significant long-term sequelae.<sup>5–7</sup> It is crucial to identify those at risk of developing symptoms that prevent return to baseline functional and employment status. Failure to RTW within a reasonable timeframe is associated with poor psychosocial outcomes,<sup>41</sup> and can have compounding financial impacts. Lifetime healthcare costs for TBI treatment can reach \$1,875,000, and U.S. expenditures on acute medical and rehabilitation services for TBI exceeds \$9 billion annually.<sup>42</sup> This financial impact on patients and the healthcare system is exacerbated by an annual \$642 million in lost wages.<sup>43</sup> The overall direct and indirect financial impact of TBI in the U.S. is \$60 billion.<sup>44</sup>

These resources may benefit from targeted application to patients who are most at risk for poorer psychosocial recovery. In fact, one theme that has emerged from qualitative research on RTW in mTBI is that follow-ups remain unfocused on patient priorities.<sup>45</sup> Hence, channeling efforts towards those who require extra support may be more effective than a generalized incentive across all TBI. The development of effective mTBI rehabilitation protocols requires validated risk factors. Prior studies have shown that lower educational level, concurrent extracranial injuries, re-injury, sex, and social and workplace-specific factors may predict delayed RTW.<sup>13,18–21</sup> Subjective symptoms reporting has also demonstrated efficacy in predicting delayed RTW.<sup>8</sup> Multiple rehabilitation models have sought to treat these subjective symptoms with mixed results.<sup>23</sup>

The current study contributes to this discussion. Individually, three-month PCS symptom domains predicted delayed RTW at six months, each with odds ratio of 0.10–0.11 for inability to RTW. Interestingly, on multivariable analysis of individual PCS domains, emotional symptoms (e.g. irritability, sadness, nervousness, or being ‘more emotional’) were most predictive of delayed RTW. While emotional symptoms were present in a smaller proportion of patients compared to the other 3 domains (32% vs. 46–59%), their status as a

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multivariable predictor shows that emotional symptoms may constitute a distinct subset from other PCS symptom categories. In reality, emotional complaints are frequently under-assessed and overlooked due to their subjectivity. Patients often feel that their providers doubt their voracity,<sup>45</sup> and this mistrust may lead to delays in appropriate mTBI rehabilitation referrals.<sup>45</sup> Increased awareness and assessment for these symptoms may inform clinicians regarding appropriate follow-up with specialists and targeted referrals for at-risk patients.

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Furthermore, we showed that a composite ACE/PCS score is of high importance. While scoring positive in 0–3 ACE symptom domains associated with some reduction in six-month RTW (4–18% unable to RTW), scoring positive in all four domains (physical, cognitive, emotional, and sleep) associated with a significantly reduced likelihood of six-month RTW (56% unable to RTW). The Nagelkerke  $R^2$  values were comparable across both multivariable analyses for six-month RTW, and were reasonable at explaining over 57% of the variance. Hence, assessing three-month PCS by domain or as a composite score can provide utility in prognosticating six-month RTW. As such, providers should be vigilant in evaluating which patients score positive across multiple symptom categories, and targeted rehabilitation efforts should be invested in these high-risk patients.

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We found that part-time versus full-time baseline employment status was associated with increased six-month RTW (OR = 6.12 [1.39–26.94]). This may simply be explained by the relative ease with which patients can return to part-time rather than full-time work. RTW at three months predicted RTW at six months (OR = 20.40 [6.04–68.86]); conversely, 78% of our cohort returned to work by three months, and of those who had not returned to work by that time, only one-third regained their baseline employment status at six months. Coupled with known poorer outcomes in those who report symptomatic complaints at three months,<sup>46</sup> our data suggests that patients should be screened at or prior to three months for risk of delayed RTW, and at-risk patients should be directed to vocational rehabilitation services as quickly as possible.

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Finally, it is worth noting that history of illicit substance use was a predictor for inability to RTW at six months. Substance use has been shown to be a predictor of poorer outcomes after mTBI in prior studies,<sup>47</sup> and the current analysis further underscores the need to identify patients with substance use disorders after mTBI as part of standard assessment, and triage these patients to counseling and treatment after mTBI to decrease the risk for deleterious functional and psychosocial outcomes.

## Limitations

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This study was limited by the standard NINDS follow-up time frame of six months in TRACK-TBI Pilot. One meta-analysis reports a 12-month RTW rate of 89%,<sup>48</sup> and it is possible that RTW continues to increase over time, which should be the topic of future studies. However, even relatively short-term delays in RTW can have significant financial and psychosocial consequences for patients and families and are thus important to investigate and intervene upon. Our study was also limited by the lack of variables regarding preinjury employment type, rehabilitation interventions and work performance upon return. Certain studies have shown that RTW should not be considered a dichotomous variable,



because even those who are able to RTW may continue to have impaired efficiency and/or other deficits compared to their preinjury functional level.<sup>14</sup> These variables were included in the subsequent, recently closed, 18-center Transforming Research and Clinical Knowledge in Traumatic Brain Injury (TRACK-TBI study; [ClinicalTrials.gov Identifier NCT02119182](https://ClinicalTrials.gov/Identifier/NCT02119182), recruitment years 2014–2020).

In addition, although the ACE is validated and endorsed by the CDC, alternative measures for PCS have comparable value. For example, despite good agreement between the ACE and Rivermead Post-Concussion Symptoms Questionnaire (RPQ), the RPQ has merits in specifically discriminating between subjective and objective cognitive complaints.<sup>49</sup> However, given the well-categorized structure of the ACE (breakdown into four distinct symptom domains), its higher number of specific questions (22 vs. 16 questions), as well as its superior sensitivity for uncovering complaints in certain categories,<sup>49</sup> we opted to use the ACE in the current study.

It should be noted that due to the complex social, legal, and financial dynamics surrounding many TBI cases, there may be bias in the reporting of subjective PCS complaints either consciously or unconsciously.<sup>50</sup> Although it is well known that litigation can influence both subjective symptom reporting and RTW,<sup>51</sup> determining effort and malingering remain complex endeavors especially given that mTBI can lead to true neuropsychological sequelae affecting motivation, attention, and testing performance.<sup>52,53</sup> We did not attempt to interpret effort in the current study, as appropriate tests for effort detection were not included in the TRACK-TBI Pilot.

Finally, our study was completed through convenience sampling across three Level 1 trauma centers. The urban trauma population may recruit from a population with greater comorbidities and injury severity. As such, our data may have limited generalizability to other mTBI subpopulations.

Future studies should seek to evaluate the details of interval rehabilitation, extended timeframe of follow-up (e.g. 12 months and beyond), measures of work performance in those who RTW after mTBI, as well as reasons for decreased work performance in those who are unable to return to baseline work status. Evaluating emerging vocational rehabilitation programs with successful pilot trials will also be of interest.

## Conclusions

Inability to RTW after mTBI is associated with significant psychosocial and financial impacts, which further exacerbate mTBI sequelae and impair recovery. It is important to screen broadly as well as provide focused rehabilitation resources to patients at highest risk of delayed RTW. Three-month post-injury is an important time point at which RTW status and PCS should be assessed, as both are prognostic markers for six-month RTW. Clinicians should be particularly vigilant of patients who present with emotional symptoms, and patients with symptoms crossing multiple PCS categories, as these patients are at further risk of inability to RTW and may benefit from targeted evaluation and support.

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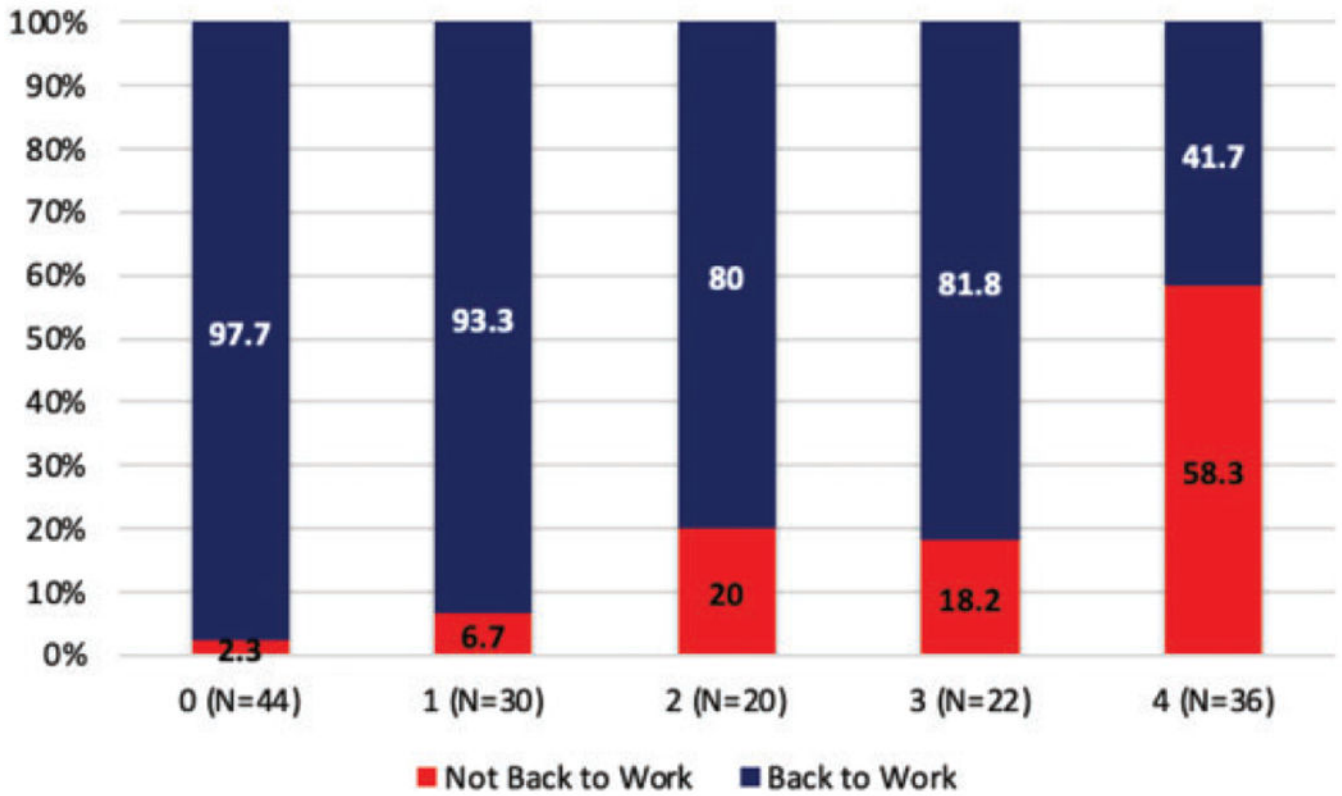
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**Figure 1.** Flowchart of included subjects. Flowchart of included patients in the current study. ACE: acute concussion evaluation; GOSE: Glasgow Outcome Scale–Extended; PCS: postconcussional symptoms; TRACK-TBI: Transforming Research and Clinical Knowledge in Traumatic Brain Injury



**Figure 2.** Relationship between symptomatic three-month ACE/PCS domains and six-month RTW. Bar graph showing proportion of patients back to work at three months (dark blue) versus not back to work (red) in accordance to number of concurrent symptomatic ACE domains (physical, cognitive, sleep, emotional). 0: no symptoms, 1: 1 symptomatic ACE domain, 2: 2 symptomatic ACE domains, 3: 3 symptomatic ACE domains, 4: 4 symptomatic ACE domains. Percentages are shown. ACE: acute concussion evaluation; GOSE: Glasgow Outcome Scale–Extended; PCS: postconcussional symptoms; TRACK-TBI: Transforming Research and Clinical Knowledge in Traumatic Brain Injury.

**Table 1.**

Descriptive variables by return to work status at six months.

Descriptive variable	Overall (N = 152)	No RTW (N = 32)	Yes RTW (N = 120)	Sig. (p)
Age				
Mean (SD)	40.7 (15.0)	42.5 (14.2)	40.2 (15.2)	0.435
Gender				
Male	111 (73.0%)	24 (75.0%)	87 (72.5%)	0.777
Female	41 (27.0%)	8 (25.0%)	33 (27.5%)	
Race				
Caucasian	123 (80.9%)	24 (75.0%)	99 (82.5%)	0.629
African American/African	7 (4.6%)	2 (6.3%)	5 (4.2%)	
Other races	22 (14.5%)	6 (18.8%)	16 (13.3%)	
Education (years)				
<i>M (SD)</i>	14.7 (2.6)	14.1 (2.3)	14.8 (2.7)	0.159
Baseline employment				
Full time	110 (72.4%)	25 (78.1%)	85 (70.8%)	0.412
Part time	42 (27.6%)	7 (21.9%)	35 (29.2%)	
PMH psychiatric				
No	112 (73.7%)	23 (71.9%)	89 (74.2%)	0.794
Yes	40 (26.3%)	9 (28.1%)	31 (25.8%)	
PMH illicit drug use				
No	121 (79.6%)	22 (68.8%)	99 (82.5%)	0.086
Yes	31 (20.4%)	10 (31.3%)	21 (17.5%)	
Mechanism of injury				
MVA/MCC	41 (26.9%)	8 (25.0%)	33 (27.5%)	0.105
PVA	22 (14.5%)	5 (15.6%)	17 (14.2%)	
Fall	67 (44.1%)	11 (24.4%)	56 (46.7%)	
Assault	18 (11.8%)	8 (25.0%)	10 (8.3%)	
Struck by	4 (2.6%)	0 (0.0%)	4 (3.3%)	
LOC				
No	34 (22.4%)	5 (15.6%)	29 (24.2%)	0.543



Descriptive variable	Overall (N = 152)	No RTW (N = 32)	Yes RTW (N = 120)	Sig. (p)
Yes	107 (70.4%)	25 (78.1%)	82 (68.3%)	
Unknown	11 (7.2%)	2 (6.3%)	9 (7.5%)	
PTA				
No	44 (28.9%)	8 (25.0%)	36 (30.0%)	0.783
Yes	96 (63.2%)	20 (62.5%)	76 (63.3%)	
Unknown	12 (7.9%)	4 (12.5%)	8 (6.7%)	
ED GCS				
13	4 (2.6%)	1 (3.1%)	3 (2.5%)	0.952
14	31 (20.4%)	6 (18.8%)	25 (20.8%)	
15	117 (77.0%)	25 (78.1%)	92 (76.7%)	
CT intracranial lesion				
No	93 (61.2%)	18 (56.2%)	75 (62.5%)	0.519
Yes	59 (38.8%)	14 (43.8%)	45 (37.5%)	
Polytrauma				
No	130 (85.5%)	25 (78.1%)	105 (87.5%)	0.180
Yes	22 (14.5%)	7 (21.9%)	15 (12.5%)	

CT: computed tomography; ED: emergency department; mTBI: mild traumatic brain injury; MCC: motorcycle crash; MVA: motor vehicle accident; PMH: prior medical history; PVA: pedestrian versus auto; RTW: return to work; SD: standard deviation.

Demographic and clinical variables for patients who did and did not return to baseline level of work at six months post-mTBI.

**Table 2.**

Three-month variables by return to work status at six months.

<b>3-Month variable</b>	<b>Overall (N = 152)</b>	<b>No RTW (N = 32)</b>	<b>Yes RTW (N = 120)</b>	<b>Sig. (p)</b>
<b>Return to work</b>				
No	34 (22.4%)	22 (68.8%)	12 (10.0%)	<0.001
Yes	118 (77.6%)	10 (31.2%)	108 (90.0%)	
<b>ACE physical</b>				
No	62 (40.8%)	3 (9.4%)	59 (49.2%)	<0.001
Yes	90 (59.2%)	29 (90.6%)	61 (50.8%)	
<b>ACE sleep</b>				
No	80 (52.6%)	5 (15.6%)	75 (62.5%)	<0.001
Yes	72 (47.4%)	27 (84.4%)	45 (37.5%)	
<b>ACE cognitive</b>				
No	82 (53.9%)	5 (15.6%)	77 (64.2%)	<0.001
Yes	70 (46.1%)	27 (84.4%)	43 (35.8%)	
<b>ACE emotional</b>				
No	104 (68.4%)	9 (28.1%)	95 (79.2%)	<0.001
Yes	48 (31.6%)	23 (71.9%)	25 (20.8%)	

ACE: acute concussion evaluation; mTBI: mild traumatic brain injury; RTW: return to work.

Comparison of three-month RTW and ACE domains (PCS symptoms) in patients who did and did not return to baseline level of work at six months post-mTBI. ACE domains are dichotomized to “No symptoms” and “Yes symptoms.”

**Table 3.**

Multivariable regression for six-month return to work, with individual three-month postconcussional symptom categories.

Predictor	OR [95% CI]	Sig. ( <i>p</i> )
Age		
Per-year	0.97 [0.93–1.02]	0.236
Sex		
Male	Reference	–
Female	1.13 [0.24–5.26]	0.876
Race		0.677
Caucasian	Reference	–
African American/African	0.86 [0.07–11.04]	0.908
Other	0.49 [0.10–2.37]	0.377
Education		
Per-year	1.06 [0.84–1.34]	0.645
Baseline employment		
Full time	Reference	–
Part time	5.57 [1.14–27.17]	0.034
PMH psychiatric		
No	Reference	–
Yes	1.45 [0.36–5.85]	0.606
PMH illicit drug use		
No	Reference	–
Yes	0.24 [0.06–0.97]	0.045
CT intracranial lesion		
Negative	Reference	–
Positive	1.45 [0.40–5.34]	0.575
Polytrauma		
No	Reference	–
Yes	0.72 [0.14–3.76]	0.692
RTW at three months		
No	Reference	–
Yes	15.39 [4.21–56.27]	0.000
ACE physical (three months)		
No	Reference	–
Yes	0.86 [0.14–5.17]	0.865
ACE sleep (three months)		
No	Reference	–
Yes	0.31 [0.06–1.52]	0.149
ACE cognitive (three months)		
No	Reference	–
Yes	0.74 [0.13–4.13]	0.729

Predictor	OR [95% CI]	Sig. ( <i>p</i> )
ACE emotional (three months)		
No	Reference	–
Yes	0.19 [0.04–0.85]	0.030

ACE: acute concussion evaluation; CT: computed tomography; PMH: prior medical history; RTW: return to work.

Multivariable logistic regression of six-month return to work, with odds ratio (OR) and corresponding 95% confidence interval (CI) reported for each predictor. ACE domains are dichotomized to “No symptoms” and “Yes symptoms.”

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**Table 4.**

Multivariable regression for six-month return to work, with dichotomized three-month postconcussional symptom categories.

Predictor	OR [95% CI]	Sig. ( <i>p</i> )
Age		
Per-year	0.98 [0.94–1.02]	0.277
Sex		
Male	Reference	–
Female	1.35 [0.28–6.44]	0.705
Race		0.558
Caucasian	Reference	–
African American/African	0.82 [0.06–11.66]	0.885
Other	0.43 [0.10–1.98]	0.281
Education		
Per-year	1.04 [0.82–1.31]	0.736
Baseline employment		
Full time	Reference	–
Part time	4.23 [0.90–19.95]	0.068
PMH psychiatric		
No	Reference	–
Yes	1.65 [0.39–6.97]	0.494
PMH illicit drug use		
No	Reference	–
Yes	0.24 [0.06–0.93]	0.039
CT intracranial lesion		
Negative	Reference	–
Positive	1.43 [0.42–4.93]	0.571
Polytrauma		
No	Reference	–
Yes	0.69 [0.15–3.14]	0.634
RTW at three months		
No	Reference	–
Yes	16.08 [4.63–55.82]	<0.001
ACE concurrent categories at three months		
<4	Reference	–
=4	0.09 [0.02–0.34]	<0.001

ACE: acute concussion evaluation; CT: computed tomography; PMH: prior medical history; RTW: return to work.

Multivariable logistic regression of six-month return to work, with odds ratio (OR) and corresponding 95% confidence interval (CI) reported for each predictor. ACE Concurrent Categories is dichotomized to scoring positive in all four ACE subdomains at three months versus scoring positive in 0–3 categories.