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Systematic Review

Long-Term Return to Work After Mild and Moderate Traumatic Brain Injury: A Systematic Literature Review

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Abstract: Background: Traumatic brain injury (TBI) is referred to as a "silent epidemic" due to its limited awareness in the general public. Nevertheless, it can cause chronic, lifelong physical and cognitive impairments with severe impact on quality of life, resulting in high healthcare costs and loss of employment. To evaluate the outcome after mild and moderate TBI, "return to work (RTW)" is a relevant parameter, reflecting the socio-economic consequences of TBI. Our study aims to summarize RTW-rates to raise awareness on the impact of non-severe TBI. Methods: We performed a systematic literature review screening the databases Medline, Embase and Web of Science for studies reporting RTW in mild to moderate TBI. Studies that reported on RTW after mild or moderate TBI (defined by GCS > 9) in adults, with a minimum follow-up of six months were included. Risk of bias was assessed using the QUIPS tool. Results: We included 13 studies with a total 22,550 patients. The overall RTW rate after at least six months, varies between 37% and 98%. Full RTW is reported in six of the included 13 studies and varies between 12% and 67%. In six studies (46%) the RTW-rate by the end of follow-up was ≤60%, with four studies being from high-income countries. Conclusion: Mild and moderate TBI have a high impact on employment rates with diverging rates for RTW even between high-income countries. Increasing the societal awareness of this silent epidemic is of utmost importance and is one of the missions of the Swiss Brain Health Plan.

Keywords: traumatic brain injury; brain health; awareness; return-to-work; mild TBI; moderate TBI

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1. Introduction

Traumatic brain injury (TBI) is defined as an "alteration in brain function, or other evidence of brain pathology, caused by an external force" [1]. Mild TBI accounts for 80–90% of all TBIs, however, the gross total of TBIs is likely to be higher as most TBIs are not recorded and potential consequences and long term sequelae remain undetected [2,3]. Although TBI can affect all age groups and despite its high incidence, TBI is still considered a "silent epidemy" due to its limited awareness in the general population [4,5].

While mortality in low- and middle-class-income countries is highest in younger patients, mortality is higher in elderly patients in high-income countries [6,7]. A study from 2012 revealed that Switzerland had the highest age-adjusted mortality rate in Europe with 21.8/100,000 deaths per year [7]. Overall, TBI accounted for 82,000 deaths in Europe in 2012 [7] and 56,000 deaths in 2013 in the US [8]. Despite these findings, the true incidence of TBI in Europe is believed to be underestimated [7].

TBI can result in chronic, lifelong physical and cognitive impairments with severe impact on quality of life [2,9]. It is a leading cause for injury-related morbidity and mortality worldwide and acts as risk factor for neurological disease like stroke and epilepsy as well as neurodegenerative diseases [9–14]. While neuroimaging plays an important role in traumatic injury, very often in mild to moderate brain injury CT may reveal very little and the severity of clinical signs is mostly correlated with more visible lesions on CT [15]. On the other hand, post mortem analysis of brain tissue of TBI patients revealed axonal injuries that contribute to the development of chronic traumatic encephalopathy, a neurodegenerative disease which can lead to cognitive, behavioral and mood changes [16,17]. It has been estimated, that in 2016 TBI caused 8.1 million years lived with disability [18].

Consequently, many patients have difficulties returning to work after TBI or accomplishing the same work-load and quality as pre-injury [19]. Evaluating the outcome after TBI can be challenging, since complaints after mild and moderate TBI are often very subjective and therefore difficult to measure [20]. Additionally, individual baseline factors of the patients regarding level of education, personality traits and gender are highly heterogeneous and complicate meaningful assessments of complications [21–23]. Return to work is a practicable surrogate marker and significant milestone after TBI, as it is highly relevant in patients personal life but equally important for the social care system.

A study from 2009 calculated the total lifetime costs of TBI patients to be around $945 million with medical costs of $292 million (31% of total costs) and loss-of-productivity costs of $653 million (69%) [24,25]. These numbers elucidate the enormous socio-economic burden that TBI is accountable for due to high healthcare costs and loss of employment [26].

The establishment of different safety measurements for example in road traffic hat a positive effect on the incidence of TBI [27,28]. Nevertheless, with increasing popularity of transportation devices like e-scooters, TBI will remain important in our society [29,30]. This systematic review aims to highlight outcome and consequences regarding return-to-work after mild and moderate TBI.

Raising awareness about Traumatic Brain Injury (TBI) is crucial to improving prevention, early intervention, and support for those affected. Internationally several Brain Health initiatives have been launched with the missions to increase brain health and raise awareness in the society [31,32].

2. Methods

2.1. Literature Search

The search strategy was designed by the authors and reviewed by an information specialist according to the PRESS guidelines including variations of the terms mild and moderate TBI and RTW [33] (File S1). Primary outcome was defined as the RTW-rate after mild and moderate TBI. Secondary outcome was defined as median time until RTW and if full or partial RTW was achieved. Most studies did not define partial RTW more precisely. The search was performed using MEDLINE, EMBASE and Web of Science on 8 August 2024. For management of citations and identification of duplicates, EndNote (version X9.3.3, Thomson Reuters, New York, NY, USA, 2018) software was used. 1713 publications were selected for manual screening. Two independent reviewers (E.W. and T.H.) subsequently assessed articles for eligibility; screening all articles by title and abstract first, and by full text thereafter. A third reviewer was available for potential disagreements. This systematic literature review was conducted according to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines [34]. The study protocol was registered in the PROSPERO International Prospective Register of Systematic Review (registration number CRD42024575136).

2.2. Eligibility Criteria and Study Selection

We included studies with adult patient $\geq$ 18 years of age that recorded outcome-factors regarding return to work after mild or moderate TBI with a minimum follow-up of 6 months. TBI was classified according to the Glasgow Coma Scale (GCS), which is to date the most widely used score for the assessment of head trauma [35]. Patients with an initial post-resuscitation GCS of ≥9 were considered as mild or moderate TBI [36]. Case reports and other systematic reviews were excluded as well as all studies that were published before 1996, the year the first TBI guidelines were published [36]. Studies where numbers could not be differentiated for these forms of TBI, were previously excluded.

2.3. Data Extraction and Analysis

In studies with other forms of TBI than mild and moderate, outcome parameters were only reported for mild and moderate TBI. Data was reported descriptively using mean, median, ranges and percentages. If studies reported only numbers of patients, percentages were calculated and vice versa. In studies with other forms of TBI than mild and moderate, outcome parameters were only reported for mild and moderate TBI.

2.4. Risk of Bias

We assessed study quality using the Quality in Prognostic Studies Tool (QUIPS) [37]. The QUIPS tool is recommended by the Cochrane Prognosis Methods Group and can be used to rate the risk of bias as "low", "moderate" or "high" [38]. It includes six domains: (1) study participation, (2) study attrition, (3) prognostic factor measurement, (4) outcome measurement, (5) study confounding, and (6) statistical analysis and reporting [37].

3. Results

We identified 2770 records, of which 1713 were screened and 78 retrieved for full Text screening. We identified 13 studies that were eligible, with a total of 22,550 patients (Figure 1). Hereof 22,007 patients (97.6%) had mild TBI and 543 patients (2.4%) had moderate TBI.

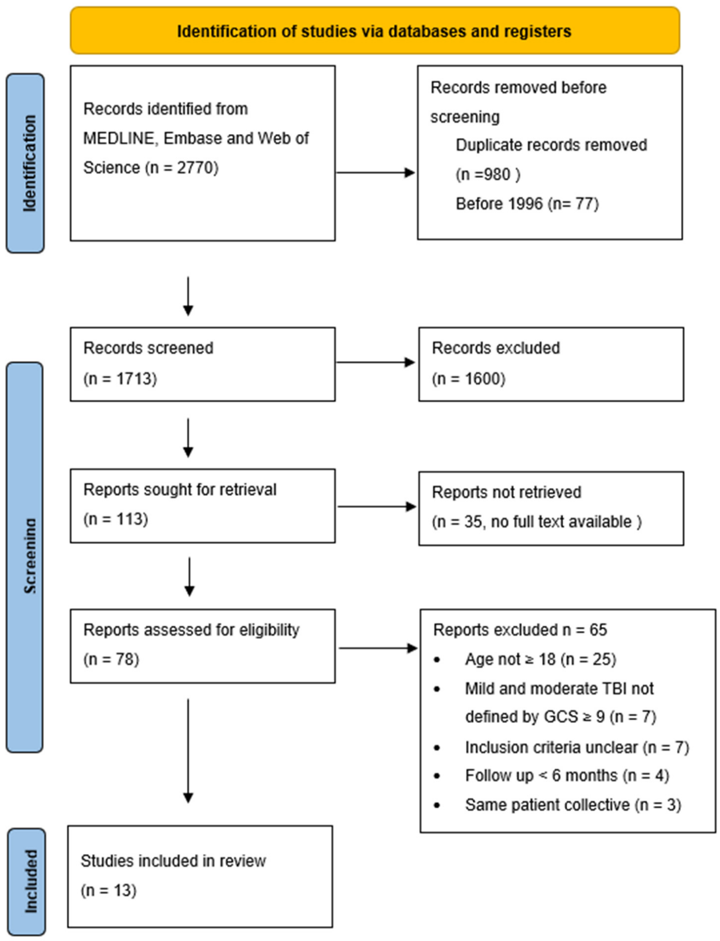

Figure 1. Flow chart for study selection.

3.1. Study Quality

Using the QUIPS tool, seven studies showed a low overall risk, five studies a moderate risk and one study a high risk for bias. Table 1 shows the six subgroups that are assessed, as well as the overall risk resulting from them.

Table 1. Study Quality assessment using the QUIPS tool.

Study	1. Study Participation	2. Study Attrition	3. Prognostic Factor Measurement	4. Outcome Measurement	5. Study Confounding	6. Statistical Analysis and Reporting	Overall Rating
Ruffolo et al. [39]	M	H	M	L	H	L	M
Fourtassi et al. [40]	L	L	M	L	H	L	M
Beseoglu et al. [41]	H	H	M	M	M	M	H
Waljas et al. [42]	L	M	L	L	H	L	L
De Koning et al. [43]	L	H	L	L	M	L	L
Singh et al. [44]	L	L	M	L	M	L	L
Graff et al. [45]	M	L	L	H	L	M	M
Fure et al. [46]	L	M	L	L	L	L	L
Huovinen et al. [47]	L	H	L	L	H	L	M
Thor et al. [48]	L	H	L	L	L	L	L
Yue et al. [49]	L	M	L	L	M	L	L
Gaudette et al. [25]	L	L	L	L	L	M	L
Sekely et al. [50]	L	H	L	L	H	M	M

L = low, M = medium, H = high.

3.2. Study Characteristics and Outcome

The baseline study characteristics are reported in Table 2. Three out of the 13 studies reported on mild and moderate TBI, the remaining eleven studies reported only on mild TBI. TBIs were acquired between 1992 and 2019 and the majority of the studies (n = 9, 69%) had a prospective study design. The smallest sample size from Germany included 36 patients, the largest cohort was from Denmark with 19,732 patients. Median age at inclusion ranged between 31 and 51 years. Follow up was defined as a minimum of six months in the inclusion criteria, Graff et al. had the longest follow-up time with five years [51]. Three cohorts included more female patients than male patients, Fourtassi et al. from Morocco had the highest rate of male participants with 88% [52].

Table 2. Baseline Study characteristics.

Study	Inclusion Period	Study Design	Population	Included GCS	Mild TBI	Moderate TBI
Ruffolo et al., Canada [39]	1992–1994	prospective cohort	50	NR	50	0
Fourtassi et al., Morocco [40]	2006–2007	retrospective	42	13–15	42	0
Beseoglu et al., Germany [41]	NR	retrospective	36	13–15	36	0
Waljas et al., Finland [42]	2006–2009	prospective cohort	109	13–15	109	0
De Koning et al., Netherlands [43]	2013–2015	prospective cohort	319	13–15	319	0
Singh et al., United Kingdom [44]	2011–2015	prospective cohort	1322	3–15	651 (580 *)	448 (379 *)
Graff et al., Denmark [45]	2003–2007	Prospective case control cohort	19,732	NR	19,732	0

Table 2. *Cont.*

Study	Inclusion Period	Study Design	Population	Included GCS	Mild TBI	Moderate TBI
Fure et al., Norway [46]	2017–2019	prospective RCT	116	3–15	109	7
Huovinen et al., Finland [47]	2015–2018	prospective cohort	113	NR	113	0
Thor et al., Malaysia [48]	2011–2013	retrospective	370	3–15	135	88
Yue et al., USA [49]	2010–2012	prospective multicenter	152	13–15	152	0
Gaudette et al., USA [25]	2014–2016	prospective multicenter	435	13–15	435	0
Sekely et al., Canada [50]	NR	retrospective	125	13–15	125	0

* With complete follow up. RCT = randomized controlled trial, NR = not reported, GCS = Glasgow Coma Scale.

Most studies reported on the amount or percentage of patients that had returned to work after end of follow-up as shown in Table 3. The percentages for overall RTW after a minimum of six months varied between 37% and 98%. In six studies (46%) the RTW-rate was ≤60%.

Table 3. Outcome parameters.

Study	Age	Male	Follow-Up	All RTW	Full RTW
Ruffolo et al., Canada [39]	31 ± 10.03	N = 31 (62%)	7.4 months ± 22 days, range 6–9 months	N = 21 (42%)	*n* = 6 (12%)
Fourtassi et al., Morocco [40]	34.4 ± 15.5	N = 37 (88%)	minimum 12 months, mean 15 months	N = 22 (52%)	NR
Beseoglu et al., Germany [41]	51.4 ± 18	N = 24 (67%)	36 months ± 14.8 months	N = 20 (55%)	*n* = 19 (53%)
Waljas et al., Finland [42]	37.4 ± 13.2	N = 52 (48%)	12 months	N = 106 (97%)	NR
De Koning et al., Netherlands [43]	18–65 nRTW 49.1 ± 11, pRTW 44.6 ± 13.8, cRTW 44.7 ± 12.1	N = 222 (70%)	6 months	N = 266 (83%)	*n* = 213 (67%)
Singh et al., United Kingdom [53]	all patients 46.7 ± 20.6	N = 909 (69%)	12 months	N = 764 (80%)	*n* = 492 (51%)
Graff et al., Denmark [45]	18–29 n = 8734 (44%), 30–30 n = 4290 (22%), 40–49 n = 3653 (19%), 50–60 n = 3055 (16%)	N = 11,872 (60%)	five years	6 months: N = 7289 (37%), 5 years: N = 8420 (43%)	NR
Fure et al., Norway [46]	Median 43 (range 24–60)	*n* = 47 (41%)	12 months	N = 101 (87%)	*n* = 69 (60%)
Huovinen et al., Finland [47]	39.2 ± 12.2	N = 64 (57%)	12 months	N = 111 (98%)	NR
Thor et al., Malaysia [48]	31.3 ± 11	N = 304 (82%)	23 ± 14	N = 133 (60%)	NR
Yue et al., USA [49]	40.7 ± 15	N = 111 (73%)	6 months	N = 120 (79%)	NR

Table 3. *Cont.*

Study	Age	Male	Follow-Up	All RTW	Full RTW
Gaudette et al., USA [25]	37.3 ± 12.9	N = 288 (66%)	12 months	N = 361 (83%)	NR
Sekely et al., Canada [50]	42.96 ± 12.74 (19–73)	N = 57 (46%)	34.69 ± 21.32	N = 56 (45%)	*n* = 19 (15%)

RTW = Return to Work, NR = not reported.

Beside the total rate of RTW, Huovinen et al. additionally reported a median RTW time of 9 days (IQR 4.0–3.0) [47]. Waljas et al. was the only study that reported on the rate of RTW at different time-points: 1 week = 46.8%, 2 weeks = 59.6%, 3 weeks = 67%, 4 weeks = 70.6%, 2 months = 91.7%, one year = 97.2% concluding that the vast majority of the cohort returned to work within the first two months [42].

Six studies analyzed not only the RTW-rate, but also if full or partial RTW was achieved. Full RTW was achieved in 12–67%, therefore between 33% and 88% patients achieved only partial RTW. Out of the three research-groups that included mild and moderate TBI, only Singh et al. differentiated the RTW for mild and moderate TBI as following:

Mild (*n* = 580): full RTW *n* = 345 (59.5%), partial RTW *n* = 149 (25.7%).

Moderate *n* = 379: full RTW *n* = 147 (38.8%), partial RTW = 123 (32.5%).

Combined, this results in a total RTW rate of 764 patients (80%) out of the *n* = 959 (73%) patients with completed follow up.

4. Discussion

The overall RTW rate in patients that suffered from mild or moderate TBI after at least six months, varies between 37% and 98%. Full RTW (and therefore partial RTW) is reported in six of the included 13 studies and varies between 12% and 67%. Two studies from Canada and one study from Denmark, had the cohorts with the lowest RTW-rate of 42–45%. The highest RTW rates, with 97% and 98%, were both from Finland. Only one study reported a median RTW-time (9 days).

There is great variety in causes for TBI. While 24% Moroccan patients from the cohort of Fourtassi et al. sustained TBI from an assault, only one patient (3%) in the cohort of Beseoglu et al. from Germany had suffered from a criminal attack [41,52]. In low- and middle-income countries, the leading reason for TBI were motor-vehicle accidents, while in high-income countries the incidence of TBI in elderly, e.g., due to falls, is increasing [14]. TBI can lead to a variety of symptom, caused by pathophysiological damages to the brain, such as neurodegeneration, demyelination, inflammatory processes and many more [2]. Overall, TBI is the greatest contributor to death and disability globally among all trauma-related injuries [54].

The fact that even high-income countries like Canada or Denmark report RTW-rates for mild and moderate TBI under 50%, demonstrate how big the impact of TBI still is. Sekely et al. discussed in their study a selection bias as possible reason for the low RTW-rate in their cohort, since their patients were recruited from a cohort that was referred for neuropsychological examination after TBI [50]. Predictors for non-RTW after TBI have been investigated in different studies, such a psychological comorbidities and level of education, still the individual situation is often complex and multifactorial determined [43,55,56].

Three studies included mild and moderate TBI with RTW-rates between 60% and 80%. One study divided TBI by severity, which showed lower RTW for moderate TBI compared to mild TBI, however, the low sample size prevents meaningful assessment of inference. This could lead to the conclusion, that, excluding severe TBI, the severity of the acquired TBI does not necessarily determine the outcome regarding RTW.

Consequences of TBI, such as the inability to RTW, are referred to as indirect costs and can have a high impact on society, economy, and the individual patient [26]. Indirect costs of TBI account for approximately 60%, and therefore for the highest part of overall costs related to brain damage caused by trauma [57]. Although in some cohorts RTW can be achieved in up top 98% of the cases, many studies report RTW-rates under 60%. These numbers elucidate how enormous the financial impact of non-RTW even after non-severe TBI is.

Neuroimaging plays an important role in TBI. In most acute cases and situations CT will be performed at first in order to evaluate for acute changes such as hemorrhage or direct traumatic brain lesions, which often correlates with the severity of clinical signs [15]. Very often in mild TBI one will have to perform MRI with sequences such as T1 and T2, T2*, Flair, diffusion-weighted-imaging (DWI) and susceptibility-weighted-imaging (SWI). In TBI additionally the capacity of MRI to perform direct multiplanar imaging allows for imaging of lesions located in the corpus callosum or the brain stem that may not be always clearly visible in the axial plane and neuroimaging using MRI will help both to assess damage and clinical outcome [58]. More and more advanced imaging techniques will be used in addition to the standard anatomical imaging techniques to determine post-traumatic pathophysiological changes [59]. SWI MRI, a technique that is very sensitive to blood is gaining in importance due to its higher sensitivity to detect small lesions in comparison with “standard” T2* imaging [60,61]. Techniques such as diffusion-weighted or diffusion tensor imaging will be of great use additionally: indeed, diffusion imaging can detect ischemic complications and allow mapping of the apparent diffusion coefficient in order to quantify edema, whereas diffusion tensor imaging techniques will allow additionally to assess damage to the underlying white fibers [62]. The use of combined SWI and diffusion-tensor-imaging-tractography (DTIT) techniques will be used to look for underlying shearing injuries that may be present and not easily detectable with standard techniques. Perfusion imaging can also be used if there is any need to assess for underlying pathophysiological changes in brain hemodynamics [63]. Our included studies focused mostly on the outcome of TBI regarding RTW. However, for example Huovinen et al. and Yue et al. assessed imaging findings like intracranial lesions or microbleeds as predictors for RTW [47,49].

Prevention is essential for reducing subsequent monetary and brain-damage caused by TBI. Beside identifying groups at risk, the implementation of safety measurement and raising awareness in the general public are key factors. An example for well-established prevention practice are helmets for bicycles and motorcycles, which have proven to reduce TBI and mortality [64,65]. Together with other efforts, like traffic calming, safety belts or regulation of drinking and driving, prevention programs have led to a reduction of TBI [27,28]. All these preventive measures have in common, that first awareness in the society had to be established, for them to succeed. The role of public awareness in society for the prevention of TBI cannot be overestimated. The greater the public awareness of the dangers and the overall problem of TBI, the more willing political bodies are to get involved. The “Alliance against Traumatic Brain Injury” for example, an initiative of the German Brain Council founded in 2024, aims to do just that and is striving to improve and intensify preventive measures, especially in sports, in the home environment and in road traffic [66].

5. Conclusions

Mild and moderate TBI can have a high long-term impact on employment even in high-income countries. RTW-rate show a great variety between 37% and 98%. Data on median RTW-Time or quantitative evaluation of working hours after mild and moderate TBI remain scarce. Public awareness is playing a key-role in defeating the “silent epidemy” of TBI and the goal of several brain health initiatives.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/ctn8040031/s1, File S1.

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