

# Return to work after traumatic brain injury

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*A randomised controlled trial, long-term employment  
probability and predictors of employment status*

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## Summary

**Background:** The theme of this thesis is return to work (RTW) after traumatic brain injury (TBI). RTW has been identified as one of the main challenges for individuals who sustain a TBI, and failure to RTW can have profound consequences for the individual and society. The present thesis comprises papers reporting selected outcomes from two TBI research projects. The first project was initiated in 2016 as a cross-sectoral collaboration between clinicians and researchers at Oslo University Hospital (OUH), Sunnaas Rehabilitation Hospital, the Work Research Institute and the Norwegian Labour and Welfare Administration. Combining vocational and rehabilitation science perspectives, the project aimed to assess the effectiveness of a complex intervention on vocational and clinical outcomes after mild and moderate TBI. The second project was a longitudinal observational study of patients with moderate and severe TBI admitted to OUH between 2005 and 2007.

**Objectives:** This thesis aims to (1) present the study protocol for a randomised controlled trial designed to compare the effectiveness of a combined cognitive and vocational intervention to treatment as usual on employment outcomes after mild and moderate TBI (paper I), (2) assess the feasibility of a manual-based compensatory cognitive training program in preparation for a larger-scale randomised controlled trial for individuals with mild to moderate TBI in the Norwegian context (paper II), (3) compare the effectiveness of a combined cognitive and vocational intervention to treatment as usual on employment outcomes 3 and 6 months following study inclusion (paper III), and (4) assess employment probability and associated predictors up to 10 years after moderate and severe TBI (paper IV).

**Patients and methods:** The feasibility study (paper II) included six patients with mild TBI who were sick-listed (i.e. sick leave certified by a medical doctor) above 50% 3–5 months post injury due to persisting post-concussion symptoms. Participants received a group-based cognitive intervention, Compensatory Cognitive Training (CCT), targeting post-concussion symptom management and cognitive symptoms for 10 weeks. Its feasibility was assessed with regard to recruitment and retention, subjective satisfaction and ability to engage with the intervention. The randomised controlled trial (paper III)



included 116 patients with mild and moderate TBI who were employed at a minimum of 50% of full-time equivalent hours (i.e. 37.5) at the time of injury and sick-listed 50% or more 8–12 weeks post injury due to persisting post-concussion symptoms. Participants were randomised to one of two treatment groups: CCT and individualised vocational support (supported employment, SE) (n = 60) or multidisciplinary follow-up (treatment as usual, TAU) (n = 56) at a specialised outpatient clinic at the Department of Physical Medicine and Rehabilitation, OUH. Participants received the interventions for a total of 6 months, and employment outcomes (RTW proportion, employment stability and productivity) were assessed at baseline and 3 and 6 months following study inclusion. The longitudinal observational study (paper IV) assessed employment probability and associated sociodemographic and injury-related predictors in 97 patients who sustained a moderate or severe TBI between 2005 and 2007. Employment status was assessed at 1, 2, 5 and 10 years post injury. Predictors included time, gender, age, relationship status, education, employment pre injury, occupation, cause of injury, acute Glasgow Coma Scale (GCS) score, duration of posttraumatic amnesia (PTA), computed tomography (CT) findings and Injury Severity Score (ISS), as well as the interaction terms between significant predictors and time.

**Results:** Paper II: Attendance across CCT sessions was high. The majority of CCT topics were rated as useful, especially information about TBI and post-concussive symptoms, and strategies targeting fatigue, prospective memory, and memory and learning. Most participants attempted to apply the trained skills to real-life situations. Paper III: A statistically significant increase was observed in the RTW proportion, work percentage and hours worked, in both the CCT-SE and TAU groups from baseline to 6 months, but no between-group differences. Adjusting for the baseline difference, the results showed that a higher proportion of participants in the CCT-SE group had returned to work at 3 months. Paper IV: Employment probability remained stable at ~50% across 1, 2, 5 and 10 years after moderate and severe TBI. Predictors of higher employment probability were male gender, being in a partnered relationship at the time of injury, employment at the time of injury, white-collar profession and higher acute GCS score. Women had a decreased employment probability over time, while participants who were unemployed at the time of injury had an increased probability of employment over time.

**Conclusions:** Delivery of the CCT intervention was feasible in patients with TBI in the Norwegian context. Compared to multidisciplinary follow-up in specialised healthcare, the combined CCT and vocational intervention may have accelerated early RTW in patients with persisting symptoms after mild and moderate TBI. However, both groups improved significantly during the study period, and no between-group differences on any employment outcome were observed 6 months after study inclusion. Employment probability remained stable from 1 to 10 years after moderate and severe TBI, and was related to injury severity, pre-injury employment status and specific demographic characteristics.

## Sammendrag

**Bakgrunn:** Det overordnede temaet i denne avhandlingen er tilbakeføring til arbeid etter traumatisk hjerneskade. Tilbakeføring til arbeid er en av hovedutfordringene for personer som får en traumatisk hjerneskade, og mislykket tilbakeføring til arbeid kan ha store individuelle og samfunnsøkonomiske konsekvenser. Denne avhandlingen består av artikler som rapporterer utvalgte endepunkter fra to forskningsprosjekter på traumatisk hjerneskade. Det første prosjektet ble startet i 2016 som et tverretattlig samarbeid mellom klinikere og forskere ved Oslo universitetssykehus (OUS), Sunnas rehabiliteringssykehus, Arbeidsforskningsinstituttet og Arbeids- og Velferdsetaten. Ved å kombinere perspektiver fra rehabiliterings- og arbeidslivsforskning, søkte prosjektet å evaluere effekten av en kompleks intervensjon på arbeidsdeltakelse og andre kliniske endepunkter etter mild og moderat traumatisk hjerneskade. Det andre prosjektet var en longitudinell observasjonsstudie av pasienter med moderat og alvorlig traumatisk hjerneskade som ble innlagt på Oslo universitetssykehus mellom 2005 og 2007.

**Formål:** Formålet med denne avhandlingen var å (1) presentere studieprotokollen til en randomisert kontrollert studie utformet for å sammenligne effekten av en kombinert kognitiv og arbeidsrettet intervensjon med ordinær oppfølging på arbeidsdeltakelse etter mild og moderat traumatisk hjerneskade (artikkel I), (2) undersøke hvorvidt en manualbasert kompensatorisk kognitiv treningsintervensjon utviklet for personer med mild og moderat traumatisk hjerneskade var gjennomførbar i norsk kontekst som forberedelse til en større randomisert kontrollert studie (artikkel II), (3) sammenligne effekten av en kombinert kognitiv og arbeidsrettet intervensjon med ordinær oppfølging på arbeidsutkomme 3 og 6 måneder etter studieinkludering (artikkel III), og (4) undersøke arbeidsdeltakelse og assosierte prediktorer opp til 10 år etter moderat og alvorlig traumatisk hjerneskade (artikkel IV).

**Pasienter og metode:** Gjennomførbarhetsstudien (artikkel II) inkluderte seks pasienter med mild traumatisk hjerneskade som var sykemeldt mer enn 50 % 3–5 måneder etter skaden som følge av vedvarende post-hjernerystelse symptomer. Deltakerne mottok en gruppebasert kognitiv intervensjon, Compensatory Cognitive Training (CCT), rettet mot håndtering av post-hjernerystelse symptomer og kognitive symptomer med varighet 10

uker. Gjennomførbarhet ble undersøkt med hensyn til rekruttering og frafall, subjektiv tilfredshet og evne til å engasjere seg i intervensjonen. Den randomiserte kontrollerte studien (artikkel III) inkluderte 116 pasienter med mild og moderat traumatisk hjerneskade som var ansatt minst 50 % på skadetidspunktet og sykemeldt 50 % eller mer 8–12 uker etter skaden som følge av vedvarende post-hjernerystelse symptomer. Deltakerne ble randomisert til en av to behandlingsgrupper: CCT og individualisert jobbstøtte (supported employment, SE) (n = 60) eller multidisiplinær oppfølging i spesialisthelsetjenesten (ordinær behandling, TAU) (n = 56) på en poliklinikk ved Avdeling for Fysikalsk Medisin og Rehabilitering, OUS. Deltakerne mottok intervensjonene i 6 måneder, og arbeidsutkomme (andel i arbeid, arbeidsstabilitet og produktivitet) ble undersøkt ved inklusjon i studien, 3 og 6 måneder etter studieinklusion. Den longitudinale observasjonsstudien (artikkel IV) undersøkte arbeidsstatus og assosierte sosiodemografiske og skaderelaterte prediktorer blant 97 pasienter som fikk en moderat eller alvorlig traumatisk hjerneskade mellom 2005 og 2007. Arbeidsstatus ble undersøkt 1, 2, 5 og 10 år etter skaden. Prediktorene som ble undersøkt var tid, kjønn, alder, sivilstatus, utdanning, arbeidsstatus før skaden, yrke, skadeårsak, akutt Glasgow Coma Scale (GCS) skår, varighet posttraumatisk amnesi (PTA), CT-funn, og Injury Severity Score (ISS), i tillegg til interaksjonen mellom signifikante prediktorer og tid.

**Resultater:** Artikkel II: Det var god deltakelse på CCT-samlingene. De fleste temaene i CCT intervensjonen ble vurdert som nyttige, særlig informasjon om traumatisk hjerneskade og post-hjernerystelse symptomer, strategier for å håndtere redusert kapasitet, prospektiv hukommelse, og hukommelse og læring. De fleste deltakerne forsøkte å anvende de lærte ferdighetene i hverdagssituasjoner. Artikkel III: Det var en statistisk signifikant økning med hensyn til andel i arbeid, arbeidsprosent, og antall arbeidstimer i både CCT-SE og TAU gruppene fra studieinklusion til 6 måneder, men ingen forskjell mellom gruppene. Ved å korrigere for gruppeforskjeller ved studieinklusion, viste resultatene at en større andel deltakere i CCT-SE gruppen var tilbake i arbeid ved 3 måneder. Artikkel IV: Sannsynligheten for å være i arbeid var stabil på ~50 % 1, 2, 5 og 10 år etter moderat og alvorlig traumatisk hjerneskade. Mannlig kjønn, å være i et forhold på skadetidspunktet, å være i arbeid på skadetidspunktet, ikke-manuelt yrke, og høyere akutt GCS skår predikerte høyere sannsynlighet for arbeid.

Kvinner hadde redusert sannsynlighet for å være i arbeid over tid, mens de som var arbeidsledige på skadetidspunktet hadde økt sannsynlighet for å være i arbeid over tid.

**Konklusjoner:** En kompensatorisk kognitiv treningsintervensjon var gjennomførbar for pasienter med traumatisk hjerneskade i norsk kontekst. Sammenlignet med multidisiplinær oppfølging i spesialisthelsetjenesten, kan en kombinert kognitiv og arbeidsrettet intervensjon ha akselerert tidlig tilbakeføring til arbeid hos pasienter med vedvarende symptomer etter mild og moderat traumatisk hjerneskade. Det var imidlertid signifikant forbedring i begge grupper i løpet av studieperioden og ingen forskjell mellom gruppene 6 måneder etter studieinkludering. Sannsynligheten for å være i arbeid var stabil fra 1 til 10 år etter moderat og alvorlig traumatisk hjerneskade, og var relatert til skadens alvorlighetsgrad, arbeidsstatus før skaden og spesifikke sosiodemografiske karakteristika.

## List of publications

This thesis is based on the following papers, which will be referred to by their Roman numbers in the text.

- I. Howe EI, Langlo KPS, Terjesen HCA, Røe C, Schanke AK, Sjøberg H, Sveen U, Aas E, Enehaug H, Alves DE, Klethagen P, Sagstad K, Moen CM, Torsteinsbrend K, Linnestad AM, Nordenmark TH, Rismyhr BS, Wangen G, Lu J, Ponsford J, Twamley EW, Ugelstad H, Spjelkavik Ø, Løvstad M, Andelic N. **Combined cognitive and vocational interventions after mild to moderate traumatic brain injury: study protocol for a randomized controlled trial.** *Trials.* 2017;18:483.
- II. Howe EI, Løvstad M, Langlo KPS, Hellstrøm T, Spjelkavik Ø, Ugelstad H, Twamley EW, Andelic A. **Feasibility of a cognitive rehabilitation program for individuals with mild-to-moderate traumatic brain injury: participants' engagement and satisfaction.** *Cogent Medicine.* 2019;6:1565614.
- III. Howe EI, Fure SCR, Løvstad M, Enehaug H, Sagstad K, Hellstrøm T, Brunborg C, Røe C, Nordenmark TH, Sjøberg HL, Twamley EW, Lu J, Andelic N. **Effectiveness of a combined compensatory cognitive training and vocational intervention on return to work following mild-to-moderate traumatic brain injury: a randomized controlled trial.** *Accepted for publication in Frontiers in Neurology July 2020.*
- IV. Howe EI, Andelic N, Perrin PB, Røe C, Sigurdardottir S, Arango-Lasprilla JC, Lu J, Løvstad M, Forslund MV. **Employment probability trajectories up to 10 years after moderate-to-severe traumatic brain injury.** *Frontiers in Neurology.* 2018;9:1051.

## Abbreviations

ACRM	American Congress of Rehabilitation Medicine
AFI	Arbeidsforskningsinstituttet (Work Research Institute)
AIS	Abbreviated Injury Scale
CCT	Compensatory Cognitive Training
CogSMART	Cognitive Symptom Management and Rehabilitation Therapy
CR	Cognitive rehabilitation
CT	Computed tomography
DAI	Diffuse axonal injury
DSM-IV	Diagnostic and Statistical Manual of Mental Disorders – 4 <sup>th</sup> edition
ED	Emergency department
FSS	Fatigue Severity Scale
GAD-7	General Anxiety Disorder – 7-item scale
GCS	Glasgow Coma Scale
GOS	Glasgow Outcome Scale
GOSE	Glasgow Outcome Scale Extended
GP	General practitioner
HLM	Hierarchical linear modelling
ICD-10	International Classification of Diseases – 10 <sup>th</sup> edition
ICF	International Classification of Functioning, Disability and Health
INCOG	International Cognitive
IPS	Individual Placement and Support
ISS	Injury Severity Score
LOC	Loss of consciousness
LOS	Length of stay

MD	Medical doctor
MRI	Magnetic resonance imaging
mTBI	Mild traumatic brain injury
NAV	Norwegian Labour and Welfare Administration
OUH	Oslo University Hospital
PCS	Post-concussion syndrome
PHQ-9	Patient Health Questionnaire – 9-item scale
PM&R	Department of Physical Medicine and Rehabilitation
PTA	Posttraumatic amnesia
PTC	Posttraumatic confusion
RCT	Randomised controlled trial
RPQ	Rivermead Post Concussion Symptoms Questionnaire
RTW	Return to work
SE	Supported employment
SRH	Sunnaas Rehabilitation Hospital
TAI	Traumatic axonal injury
TAU	Treatment as usual
TBI	Traumatic brain injury
VR	Vocational rehabilitation
WAIS-IV	Wechsler Adult Intelligence Scale – 4 <sup>th</sup> edition
WHO	World Health Organization



# 1 Introduction

Traumatic brain injury (TBI) is a public health challenge and leading cause of death and disability (1). An estimated 50–60 million people worldwide sustain a TBI each year (1). Increased knowledge of long-term implications has changed the perception of TBI from an isolated event to a chronic disease process (2). This is especially true for more severe injuries, but even mild injuries may be associated with longer-term limitations in functioning and participation (3-5).

Employment participation is considered a key goal for rehabilitation after TBI (6,7) and an important indicator of real-world functioning (8). To return to work (RTW) and maintain stable employment is one of the main challenges following TBI (9,10). Failure to RTW can have profound economic and psychosocial consequences for individuals, their families and society (9). Across all TBI severities, approximately 40% can RTW 1–2 years post injury (10). While physical, cognitive, emotional and behavioural problems may lead to difficulty coping with work demands (11), barriers to RTW exist in several domains, including social, environmental, and systemic or organisational (12).

Traditionally, health and vocational services have been provided separately in Norway, and collaboration between the sectors providing these services has been weak (13,14). More recently, literature reviews have indicated a need for early, tailored interventions targeting employers, employees and the workplace (5,15,16), leading to a shift towards the concept of providing vocational interventions as an integral part of rehabilitation efforts. Still, limited knowledge exists regarding long-term work outcomes and the most effective approaches to improve vocational outcomes after TBI.

## 1.1 Definition and classification of traumatic brain injury

TBI is defined as “*an alteration in brain function, or other evidence of brain pathology, caused by an external force*” (17). TBI is considered an umbrella term encompassing a wide range of injury mechanisms, severities, symptoms and clinical outcomes (17).

Diagnostic criteria for injuries at the mild end of the TBI spectrum have been debated (18), and several definitions of mild TBI (mTBI) have been proposed. In this thesis, the definition proposed by the American Congress of Rehabilitation Medicine (ACRM) is

used. The ACRM defines mTBI as a traumatically induced physiological disruption of brain function, manifested by at least one of the following: (1) loss of consciousness (LOC) not exceeding 30 minutes, (2) posttraumatic amnesia (PTA) of no more than 24 hours, (3) any alteration in mental state at the time of the accident (e.g. feeling dazed, disoriented or confused), (4) focal neurological deficit(s) that may or may not be transient and (5) a Glasgow Coma Scale (GCS) score of 13–15 after 30 minutes (19).

Due to the large heterogeneity in symptomatology and outcomes of TBI, it is necessary to describe and categorise subgroups of patients to provide appropriate management, to guide treatment and prognosis, and for comparative purposes. Indices of injury severity are frequently used in clinical research to compare patients between centres (20). The GCS (21) is used to assess a person's level of consciousness on a scale of 3–15 and is one of the most frequently applied measures of injury severity. The GCS is scored by assessing eye, verbal and motor responses in the acute phase, with a score of 13–15 usually considered mTBI, 9–12 moderate TBI, and 3–8 severe TBI. The GCS is easy to perform and of prognostic value (22), but does not take into account the presence of extracranial injuries and is a poor discriminator for less severe TBI (20). In addition, the level of consciousness may be obscured in acute settings due to substance use at the time of injury, medical sedation or paralysis (23).

The duration of PTA is another measure of injury severity. Defined as the period from injury to resumption of the ability to store new memories (24), it ranges from seconds to months. Longer duration of PTA is generally associated with more severe injury and poorer outcomes both in the early and later phases after injury (24). In recent years, the term posttraumatic confusion has been proposed (25), recognising the range of cognitive and neurobehavioral disturbances that may be present in the acute period of recovery following TBI.

The Abbreviated Injury Scale (AIS) (26) is an anatomically based coding system created to classify the severity of injury to multiple body regions on a six-point scale (1 = minor, 6 = maximal). The AIS–Head is part of the AIS and reflects intracranial pathology, level of consciousness and neurological signs. The scale has good prognostic value regarding mortality and functional outcome (27,28). The Injury Severity Score (ISS), a scale assessing overall trauma severity, is based on AIS codes for the three most severely

injured body regions. The ISS ranges from 1–75 (higher score indicating more severe trauma) and is associated with mortality, morbidity and length of hospital stay (29,30).

Classification by pathoanatomic type describes the location and anatomical features of the injury and is most often used to describe TBI for acute management (20).

Pathoanatomical classification relies on imaging techniques such as computed tomography (CT) and magnetic resonance imaging (MRI). The Marshall (31) and Rotterdam (32) classification systems are used to grade injury severity into one of six categories based on morphological abnormalities (i.e. basal cisterns, midline shift, epidural mass lesion, and intraventricular blood or traumatic subarachnoid haemorrhage) shown on CT scans. Higher scores on both scales (indicating more severe injury) have been shown to predict mortality and more severe disability after TBI (32,33).

Classification by physical mechanism (i.e. causative factors associated with the injury) relates to how specific forces result in predictable patterns of injury (20). Some degree of correlation exists between the physical mechanism of injury and pathoanatomical injury type (20). For instance, traumatic axonal injury (TAI), damage of the brain's white matter tracts, is more common after motor vehicle accidents or falls where the head is subject to high-velocity translational or rotational forces (34,35). The TAI classification was first proposed by Adams et al. in 1989 (36) as diffuse axonal injury (DAI) divided into three grades. Grade I involves the grey–white matter interfaces, grade II involves the corpus callosum in addition to grade I locations, and grade III involves the brainstem in addition to grade I and II locations. A recent study found that the current TAI classification on MRI did not correlate well with neurological outcome, and that age above 30 years and TAI involvement of the substantia nigra and tegmentum of the midbrain were the most important predictors of poor neurological recovery (37).

In 2013, the Scandinavian Neurotrauma Committee published updated guidelines for the acute management of minimal, mild and moderate TBI (38). Increased knowledge of the potentially harmful effects of CT radiation and advances in identifying serum biomarkers led to the recommendation to assess the biomarker S100B when triaging persons with mTBI for CT scans. Elevated levels of S100B, a calcium-binding protein found in glial cells, indicates the presence of neuropathology on CT (39). Recently, glial fibrillary acidic protein has been reported to be predictive of traumatic abnormalities on CT (40). A

range of other biomarkers are near the stage of validation of their diagnostic and prognostic values in TBI management (41).

Unidimensional classification systems have, however, been criticised for not being able to capture the heterogeneity of TBI (20). Consequently, multidimensional classification systems using several clinical, neuroimaging, physiological and biochemical variables to describe clinical care pathways and characterise different functional outcomes have been proposed (42), but need to be validated in future studies.

## **1.2 Epidemiology**

The reported incidence (new cases during a defined period) of TBI varies greatly between geographical regions due to lack of robust data, methodological variations and different reporting standards (1). Additionally, many patients who sustain mTBI do not seek emergency medical care and thus are not represented in hospital-based estimates of incidence (43). Using results from the 2016 Global Burden of Diseases, Injuries, and Risk Factors Study, James et al. (44) found global age-standardised incidence and prevalence (individuals living with the consequences of TBI) rates of 369 and 759 per 100 000 population, respectively. In Europe, the reported incidence of TBI based on hospital admission rates has varied from 235–287 per 100 000 (45-47). Previous estimates of the annual incidence of both hospitalised and non-hospitalised patients in Norway and Sweden have ranged from 229–546 per 100 000 persons (48-50). The annual incidence of hospital-admitted TBI in Oslo in 2005–2006 was 83.3 per 100 000 individuals (51), reflecting approximately 4 000 hospital admissions per year.

Incidence of TBI is higher in males compared to females, with European studies showing ratios ranging from 1.2:1.0 to 4.6:1.0 (45,46). However, among elderly and paediatric subpopulations, the gender pattern diverges, with more females sustaining TBI than males (44,45). Falls are the most frequent cause of TBI in high-income countries, including Norway, followed by motor vehicle accidents (44,51).

Approximately 70–90% of all TBIs are classified as mild (52). A Norwegian study used the GCS to assess TBI severity and found that 86% of hospital-treated TBIs were classified as mild, 8% moderate and 6% severe (51). The highest incidence of TBI is in

older adults (44,51), likely due to increased life expectancy and greater mobility (18). Still, TBI is the most common cause of brain damage in young adults, and a leading cause of disability in young individuals of working age (9,18).

### **1.3 Sequelae and recovery**

TBI may result in a range of short- and long-term physical, cognitive, emotional and behavioural disabilities, affecting the lives of individuals and their families and posing substantial direct and indirect financial costs (1,53). Patients who sustain more severe TBI often require prolonged hospitalisation and rehabilitation efforts, while many individuals who acquire mTBI never seek medical care (43) or only present to primary care (54).

Recovery usually occurs during the first 12 weeks in the majority of patients who sustain mTBI (55). However, a subset reports persisting problems, referred to as post-concussion symptoms, beyond this point (56). Post-concussion symptoms may manifest as somatic (headache, sleep problems, fatigue, dizziness, nausea, or visual or auditory disturbances), emotional (irritability, restlessness or emotional lability) or cognitive (memory, attention or executive dysfunction) problems (19,57,58). The term post-concussion syndrome (PCS) is used to describe persistent problems; PCS can be diagnosed according to the International Classification of Diseases (ICD)-10 (58) or Diagnostic and Statistical Manual of Mental Disorders (DSM)-IV (57) criteria. However, controversy exists regarding whether PCS actually reflects a distinct syndrome, as these symptoms are also present in trauma populations without brain injury (56) and the general population (59). Recent publications have suggested using the terms posttraumatic symptoms (56) or persistent post-concussion symptoms (60) when problems last more than 3 months.

The reported prevalence of post-concussion symptoms varies (60). A study from Norway (61) examined the presence of PCS in a sample with hospitalised mild, moderate and severe TBI using the Rivermead Post Concussion Symptoms Questionnaire (RPQ) (62). The RPQ is a 16-item questionnaire assessing post-concussion symptoms on a five-point Likert scale (0 = not experienced at all, 1 = no more of a problem, 2 = a mild problem, 3 = a moderate problem, 4 = a severe problem). By applying a conservative cut-off score (>3), the researchers found PCS present in 40%, 29% and 16% of patients with mild, moderate and severe TBI, respectively, at 3 months, and in 27%, 15% and 14% at 12

months post injury. The presence of post-concussion symptoms in mTBI is associated with psychosocial factors such as emotional disturbances, negative injury perceptions and negative expectations for recovery (56). A greater understanding of the many non-injury-related factors associated with the persistence of symptoms has led to support for a biopsychosocial conceptualisation of poor outcomes after mTBI (63,64). This perspective proposes that a multitude of interacting pre- and post-injury biological, social and psychological factors contribute to how symptoms are perceived, experienced and reported (63,64).

Moderate and severe TBI are associated with reduced life expectancy, long-term disability and functional impairments (27,53). The Glasgow Outcome Scale (GOS) (65), or its extended version (GOSE) (66), is a frequently applied measure of functional outcome after TBI. The GOS consists of five categories (1 = death, 5 = low disability), while the GOSE has eight categories (1 = death, 8 = upper good recovery), allowing for assessment of disability and social participation. GOSE categories 8 and 7 (upper and lower good recovery) indicate full recovery or minor physical or mental deficits and ability to resume work. Category 6 (upper moderate disability) indicates some disability, but patients can look after themselves and can partly resume work. Categories 5 and lower (lower moderate disability or worse) indicate continued dependence, impaired ability to participate in social activities, and reduced or no work capacity. Studies applying the GOSE have found functional limitations in the short and longer term after moderate and severe TBI (67-69). A longitudinal observational study from Norway (68) found moderate disability or worse in 60%, 58%, 58% and 69% of participants at 1, 2, 5 and 10 years, respectively, after moderate and severe TBI. In comparison, Andelic et al. (67) identified moderate disability or worse in 52% of participants 10 years after moderate and severe TBI. A recent publication that used GOSE to specifically assess outcomes in patients with moderate TBI admitted to two hospitals in Norway and the Netherlands reported that 44% were moderately disabled or worse 12 months after the injury (69). However, a Norwegian study found improved community integration despite stable functional limitations 20 years after moderate and severe TBI (70).

Capturing the many areas affected by TBI is not possible using a single outcome measure such as the GOSE, and accounting for these is beyond the scope of this thesis. In line with

the thesis theme, the following sections will focus on the working-age population and employment after TBI.

#### **1.4 Return to work following traumatic brain injury**

Reported rates of RTW after TBI vary widely according to differences in sample characteristics, measures of employment outcomes and length of follow-up (9,10). The overall RTW rate across all severities has been estimated at 40.7% at 1 year and 40.8% at 2 years post injury (10). A meta-analysis of adult patients with mTBI (71) found pooled RTW proportions (defined as RTW at any capacity) of 56% at 1 month, 81% at 6 months, and 88% at 12 months post injury, with an average of 13–93 days until RTW. A literature review by Cancelliere et al. (5) found that although most employees with mTBI were able to RTW within 3 to 6 months post injury, 5–20% experienced persistent symptoms affecting work participation 1–2 years post injury. Regarding moderate and severe TBI, Gormley et al. (72) reported pooled estimates of employment prevalence (proportion working full- or part-time) at approximately 35%, 42%, and 50% at 1, up to 5, and beyond 5 years post injury, respectively. Regardless of the follow-up interval, 33% were able to return to their pre-injury level of employment.

Even when achieving successful RTW, remaining stably employed and maintaining pre-injury levels of productivity may be an issue. Ponsford et al. (73) followed a sample that had sustained moderate and severe TBI at 1, 2 and 3 years post injury and found that only 44% remained employed at each follow-up interval. Cuthbert et al. (74) reported a decline in employment probability from 5 to 10 years after moderate to severe TBI. A longitudinal follow-up of patients with mild, moderate and severe TBI reported that 27% were unstably employed over 4 years post injury (75). Regarding productivity, Silverberg et al. (76) found that more than half of a sample with mTBI reported completing less work 8 months post injury, despite having successfully returned to work. Moreover, a longitudinal follow-up of 245 individuals with a history of mTBI found that approximately 15% experienced injury-related limitations at work 4 years post injury (77).

## **1.5 Associated factors and predictors for employment outcomes**

Identifying individuals at risk of failure to RTW is important for prognostication, understanding barriers to work, and providing targeted interventions. A number of studies have assessed factors that are associated with and predictive for vocational outcomes after TBI, mostly in terms of individual pre- or post-injury characteristics. In line with current recommendations (60,78) and for the purpose of this thesis, the main findings from longitudinal observational studies that have each assessed predictors of vocational outcomes in more than 500 individuals are presented in Table 1.



**Table 1.** Predictors for employment outcomes.

	Arango-Lasprilla et al. (79)	Corrigan et al. (80)	Cuthbert et al. (81)	Cuthbert et al. (74)	DiSanto et al. (82)	Gary et al. (83)	Klyce et al. (84)	Lau et al. (85)	Odgaard et al. (86)	Schönberger et al. (87)	Walker et al. (88)
Demographic factors											
Education	X	X	X	X	X	X	X	X	X	X	X
Age	X	X	X	X	X	X	X	X	X	X	
Gender	X	X	X	X	X	X		X			X
Ethnicity	X	X	X	X	X	X					
Pre-injury employment status	X		X		X	X	X			X	
Marital status	X		X			X					X
Injury characteristics, functional capacity and disability level											
Injury severity	X			X	X		X	X		X	
LOS acute	X	X				X			X		X
Disability level	X		X			X		X			
LOS rehabilitation	X		X			X					
Functional status	X								X		X
Cause of injury	X					X					
Time of injury				X					X		
Extracranial injury								X		X	
Pre- and post-injury emotional and psychosocial factors											
Insurance status		X	X	X							
Pre-injury substance use or psychiatric problems				X				X			
Emotional status					X		X				
Pre-injury public assistance benefits									X		
Transportation independence					X						
Occupational factors											
Pre-injury employment type				X				X			X
Higher annual earnings					X						

*Abbreviations:* LOS, length of stay.

### **1.5.1 Demographic factors**

The demographic factors most consistently found to predict poorer vocational outcomes after TBI have been lower educational level (74,79-88), older age (74,79-84,87), non-white ethnicity (74,79-83) and being unemployed at the time of injury (79,81-88). Being married at the time of injury has been reported to predict competitive employment after TBI (88), while being unmarried (including previously married) has been shown to predict less favourable work outcomes (79,81,83). Most studies have reported that female gender predicts unemployment and decreased work stability (74,79-83,85), but some have found that women were more likely to be competitively employed post injury (88). These findings are in line with systematic reviews that have also included studies with smaller sample sizes (16,89).

### **1.5.2 Injury characteristics, functional capacity and disability level**

More severe injury, as measured by lower GCS score (79), higher ISS (85), longer PTA (74,82,84,87), and longer acute and rehabilitation hospitalisation (79-81,83,86,88), has been found to predict poorer vocational outcomes after TBI. Additionally, lower functional capacity and higher disability level at discharge (79,81,83,86,88) has been reported to negatively predict post-injury employment status. Other injury-related variables include cause and timing, where violent aetiologies (79,83) and injuries sustained during specific periods (74,86) are associated with decreased employment probability. The presence of extracranial injuries, such as spinal cord (85) and limb injuries (87), also negatively predicts post-injury work participation.

### **1.5.3 Pre- and post-injury emotional and psychosocial factors**

Pre-injury substance use and mental health issues have been reported as negative prognostic factors for employment post injury (74,85). Additionally, the presence of emotional problems after injury, including anxiety and depression (82,84), is associated with decreased employment stability and participation. Receiving public assistance benefits shortly before the injury (86) and residence in neighbourhoods with higher levels of socioeconomic disadvantage (85) are also reported to be negatively associated with employment outcomes. Systematic reviews have highlighted the impact of behavioural problems after injury (7,90), in addition to access to social support as an important

facilitator for RTW (7). Additionally, transportation independence has been identified as important for employment participation post TBI (75,82,91,92). Other studies have indicated the impact of motivation for RTW, coping styles and personality factors (7,90).

#### **1.5.4 Neurocognitive function**

Cognitive impairment is associated with work-related difficulties across all injury severities (6,11,16,90,93). Evidence exists for a negative impact of problems with global cognitive functioning (90), executive dysfunction (11,90,92,93), memory problems (92,93) attention deficits, processing speed and verbal skills (93). Additionally, studies have found an association between metacognitive abilities (i.e. self-awareness) and vocational outcomes, with impaired self-awareness associated with a lower probability of employment (94).

#### **1.5.5 Occupational factors**

Pre-injury occupation is associated with employment after TBI, with studies reporting that individuals in blue-collar or manual labour occupations have poorer vocational outcomes compared to those in professional, managerial or white-collar occupations (74,85,88). Systematic reviews have also found evidence for an association between being stably employed pre injury and better work outcomes post injury (7). Other studies have highlighted workplace-specific factors, such as enterprise size (95), access to workplace support and accommodations (7,96), and independence and decision-making latitude (5).

These factors are, however, not specific to TBI. Cancelliere et al. (8) performed a best-evidence synthesis of 56 systematic reviews on prognostic factors for work outcomes across several health conditions, including TBI. Among the factors associated with negative work outcomes were older age, female gender, greater pain or disability, higher physical work demands, previous sick leave, and unemployment. The factors most consistently linked to positive work outcomes were higher education and socioeconomic status, higher self-efficacy and optimistic expectations regarding RTW, less severe injury or illness, coordinated RTW efforts, and multidisciplinary interventions that include the workplace and different stakeholders.

In sum, RTW is a challenge across all TBI severities. Although most individuals with mTBI are able to RTW within days to weeks following the injury, up to 20% experience persisting symptoms affecting RTW and work stability. Considering that most TBIs are classified as mild, this represents a substantial number of individuals.

Several predictors for work participation, including factors beyond specific features of the injury, have been identified. A complex interrelationship between personal and environmental factors influences vocational outcomes and makes prediction difficult. Moreover, predictors for short- and long-term work outcomes may differ (11,97,98). While physical limitations may be more prominent in the acute phase, the impact of cognitive and behavioural sequelae becomes more apparent in the longer term (11).

## **1.6 The association between work and health**

The broad consensus is that individuals with disabilities should RTW when possible due to the social, economic and health benefits derived from working (99). This goal is reflected in rehabilitation guidelines and government policies (100,101).

Employment provides financial independence but may also serve as an important arena for personal growth, social relationships, and structure in daily life (7,102). Meaningful productive employment can provide motivation to leave the house, a sense of purpose and achievement, and improved self-esteem (7,9,103). Employment following TBI is associated with increased quality of life and greater life satisfaction (104-106). Conversely, unemployment is associated with poorer psychosocial outcomes and an increased risk of mental health problems (106,107).

Qualitative studies have explored the perceived meaning of work and individual experiences of RTW after TBI. While resuming employment can be viewed as indicative of community re-integration and returning to normality (108), failure to do so may result in a grief reaction (109). Support from employers and vocational rehabilitation (VR) and health professionals, in addition to work modifications and gradual increase of workload, is perceived as important in facilitating successful RTW after brain injury (96,108,110,111). Conversely, challenges identified in RTW include managing persisting symptoms, poorly coordinated and managed RTW support systems, employers' and

colleagues' lack of information about the effects of brain injury in relation to work, and the perceived invisibility of the consequences of the injury (96,109-111).

## **1.7 Vocational rehabilitation**

The World Health Organization (WHO) defines rehabilitation as *“a set of measures that assist individuals, who experience or are likely to experience disability, to achieve and maintain optimal functioning in interaction with their environments”* (112).

Rehabilitation aims to reduce the impact of a TBI and focuses on improving health and functioning. The International Classification of Functioning, Disability, and Health (ICF) (113) provides a framework that can be used for all aspects of rehabilitation. VR is an important component of the rehabilitation process, specifically targeting employment. In a conceptual definition based on the ICF, VR is a *“multi-professional evidence-based approach that is provided in different settings, services, and activities to working age individuals with health-related impairments, limitations, or restrictions with work functioning, and whose primary aim is to optimize work participation”* (114, p. 130).

Three main approaches to VR after TBI have been identified (115): the program-based VR model (116), the case coordination model (117), and the individual placement model of supported employment (118).

Program-based VR approaches – brain injury rehabilitation programs with integrated or additional VR services – are generally based on the New York University Head Trauma Rehabilitation Program developed by Ben-Yishay et al. (116). The original program was designed to provide rehabilitation to young adults with a history of TBI who had failed to benefit from conventional rehabilitation efforts and were deemed unemployable at the time of program entry. The program involved three phases: (1) intensive and systematic holistic remediation interventions targeting cognitive and interpersonal skills, (2) individualised, guided occupational trials and work placement within the program, and (3) actual work placement and follow-up. Ben-Yishay et al. reported employment status in 94 individuals with severe TBI up to 3 years following program completion (116). They noted that 63% were able to engage in competitive employment following program completion, while 50% of the 38 individuals who had reached the 3-year follow-up before the time of publication were employed.

The case coordination approach to VR, first described by Malec et al. in 1995 (117,119), was developed in the United States as a method of bridging the gap between medical and community-based services. Patients who state a vocational goal, are of working age and have a medical diagnosis of acquired brain injury with confirmed neuropsychological impairment are eligible for the program. A brain injury nurse coordinator directs the patients through medical services and refers those with vocational needs to a vocational coordinator. The vocational case coordinator oversees the RTW process and can refer patients to available VR services when necessary. Key elements of the case coordination approach include early assessment of vocational readiness and identification of VR needs, vocational counselling and evaluation, continuity of follow-up, and coordination of VR with other rehabilitation services (119). A study showed that of 114 participants in the program, 81% were in community-based employment 1 year after initial placement (120).

Individual Placement and Support (IPS) (121) was developed in the United States in the 1980s as a model of SE for persons with severe mental illness. It aims to help individuals with disabilities attain competitive employment in the ordinary labour market. The program was adapted to people with brain injury by Wehman et al. in the 1980s (118). The IPS approach represented a shift from a train-and-place philosophy (i.e. pre-employment training) to a place-and-train approach, acknowledging a need to gain work training and experience in real-world settings to maximise the chance of attaining and maintaining competitive employment. IPS is based on eight principles: (1) the goal of competitive employment, (2) eligibility based on client choice, (3) attention to client preferences, (4) rapid job search, (5) integration of rehabilitation and healthcare services, (6) personalised benefits counselling, (7) targeted job development and (8) time-unlimited and individualised support. Wehman et al. (122-124) have reported cost-effectiveness and improved rates of competitive employment in persons with a history of severe TBI. Randomised controlled trials (RCTs) performed in the Norwegian context have demonstrated positive effects of the IPS approach on attaining and maintaining competitive employment and improved measures of psychological distress, subjective health complaints and health-related quality of life in individuals with mental illness (125,126).

Some key differences exist between the different VR approaches. Most notable is the place-and-train method characterising the IPS model of SE, as opposed to the train-and-place method applied in the program-based approach. The approaches additionally differ in terms of stating a clear goal of competitive employment, or employment that may also include sheltered work without pay. Lastly, the VR approaches differ with regard to more or less strict eligibility criteria and the duration and extent of follow-up.

## **1.8 Cognitive rehabilitation**

Cognitive function is considered a potentially modifiable factor (16) with an important relationship to employment post TBI (11,90). Cognitive rehabilitation (CR) is defined as a *“systematic, functionally oriented service of therapeutic cognitive activities, based on an assessment and understanding of the person's brain-behavioural deficits”* (127, p. 63). It refers to the process of enhancing a person's capacity to process and interpret information and to improve functioning in everyday life (128).

CR after TBI may be directed toward many areas of cognition, including memory, attention, perception, comprehension, communication, reasoning, problem solving, judgment, initiation, planning, self-monitoring and self-awareness (129). Specific approaches may include *“(1) reinforcing, strengthening or re-establishing previously learned patterns of behaviour; (2) establishing new patterns of cognitive activity through compensatory cognitive mechanisms for impaired neurologic systems; (3) establishing new patterns of activity through external compensatory mechanisms such as personal orthoses or environmental structuring and support; and (4) enabling persons to adapt to their cognitive disability, even though it may not be possible to directly modify or compensate for cognitive impairments, to improve their overall level of functioning and quality of life”* (129, p. 1597).

During the past 20 years, several evidence-based guidelines for CR after brain injury have been published. Among these are the INCOG recommendations (130-135) and recommendations by Cicerone et al. (129,136-138) synthesised in a CR manual published by the ACRM (139). The guidelines provide recommendations based on different levels of empirical evidence established from evaluating the methodological quality of various study designs. The highest level of evidence for CR after TBI has been found for direct

training and compensatory strategies for attention deficits, interventions for functional communication deficits, internal and external compensatory strategies for memory impairments, metacognitive strategy training for deficits in executive functioning, direct corrective feedback for impaired self-awareness, and comprehensive holistic neuropsychologic rehabilitation to reduce cognitive and functional disability for persons with TBI (131,133-135,138). Importantly, none of the guidelines provide recommendations for CR specifically in the context of VR.

### **1.9 Randomised controlled trials aimed at improving vocational outcomes after TBI**

A combination of VR, CR and other treatment approaches have been applied in RCTs aimed at improving vocational outcomes after TBI (see Table 2). As the table shows, large methodological variations exist between the trials regarding characteristics of the studied samples (e.g. injury severity, time since injury, and veterans or civilians), definitions of employment outcomes, study settings, characteristics of the intervention and control conditions (e.g. content, duration and intensity), and duration of follow-up.

Although these RCTs found limited evidence for effectiveness on vocational outcomes, they demonstrated positive effects on outcomes including post-concussive symptoms (140-142), measures of cognitive functioning (140,141,143,144), community functioning (145), functional status (146), and quality of life and wellbeing (141,145,146).

While general recommendations exist regarding CR and elements that should be included in VR after TBI, knowledge regarding the most effective approaches to improve vocational outcomes after TBI is still lacking.



**Table 2.** Characteristics of randomised controlled trials aimed at improving vocational outcomes after traumatic brain injury.

Author, country, year	Study population, age (years), n	Time point of inclusion	Employment outcomes	Interventions	Intervention duration	Follow-up	Results (employment outcomes)
Scheenen et al. (147), Netherlands, 2017	Mild TBI, age 18–65, n = 84	4–6 weeks post injury	Self-reported RTW (successful, i.e. full RTW, or unsuccessful, i.e. partial/lower level or no RTW)	Adapted cognitive behavioural therapy vs telephonic counselling	5 weeks	6 and 12 months post injury	No significant between-group differences regarding RTW
Vikane et al. (142), Norway, 2017	Mild TBI, age 16–56, n = 156	8 weeks post injury	Days to sustainable employment (defined as not receiving sick-leave benefits from the NAV for a period of 5 weeks post injury)	Multidisciplinary evaluation followed by individualised multidisciplinary outpatient treatment (including educational group) vs follow-up by GPs	Median of two individual follow-ups during first year in addition to educational group (intervention group)	6 and 12 months post injury	No significant between-group differences regarding days to sustainable employment
Twamley et al. (141), USA, 2015	Veterans with mild–moderate TBI, mean age 32, n = 50	On average 4.5 years since most recent TBI	Work attainment, hours worked, wages earned	SE and CogSMART or enhanced SE	SE for 1 year (CogSMART or enhanced SE for 12 weeks)	3, 6 and 12 months following inclusion	No significant between-group differences regarding work attainment, weeks worked, hours worked or wages earned
Twamley et al. (140), USA, 2014	Veterans with mild–moderate TBI, mean age 32, n = 34	On average 4.5 years since most recent TBI	Work attainment, hours worked, wages earned	SE and CogSMART or enhanced SE	SE for 1 year (CogSMART or enhanced SE for 12 weeks)	3 months following inclusion	No significant between-group differences regarding work attainment, weeks worked, hours worked or wages earned

Man et al. (143), China, 2013	Mild–moderate TBI, age 18–55, n = 40	Not specified	Employment status (full-time, supported, sheltered, unemployed or unable to work)	Artificially intelligent virtual reality–based problem-solving skill training program vs psychoeducational vocational training	12 sessions	1, 3 and 6 months	No significant between-group differences regarding proportions in each of the employment categories
Bell et al. (148), USA, 2011	Moderate–severe TBI, age >16, n = 433	Within 72 hours after discharge from acute care	Vocational composite including occupational status, time until RTW, weeks of competitive employment during the past year, and average hours per week worked during the past month	Scheduled telephone intervention vs usual care	Received telephone calls 3–4 days; 2, 4, 8 and 12 weeks; and 5, 7, 9, 12, 15, 18 and 21 months post injury	12 and 24 months post injury	No significant between-group differences in the vocational composite
Cicerone et al. (145), USA, 2008	Mild–severe TBI, age 18–62, n = 68	On average 43 months post injury	Vocational activity (engaged in community-based employment vs unemployed)	Comprehensive holistic neuropsychological rehabilitation vs standard neurorehabilitation program	15 hours per week for 16 weeks	Post treatment and 6 months	Significantly larger proportion of participants in comprehensive neuropsychological rehabilitation program engaged in community-based employment post treatment; no significant difference at 6 months
Vanderploeg et al. (144), USA, 2008	Veterans with moderate–severe TBI, mean age 32, n = 360	On average 50 days post injury	RTW or school (i.e. current status of paid employment or school enrolment, either full- or part-time)	Cognitive didactic vs functional experiential rehabilitation therapy	1.5 to 2.5 hours daily of protocol-specific therapy plus another 2 to 2.5 hours daily of occupational and physical therapy for a total of 20 to 60 days	12 months	No significant between-group difference regarding RTW or school at 12 months

Bell et al. (146), USA, 2005	Mild-severe TBI, age 18– 70, n = 171	Within 24 hours after discharge from inpatient rehabilitation unit	A vocational status composite that included time to RTW, hours of paid employment, income, monthly employment ratio, and the work domain of the FSE	Scheduled telephone intervention vs standard follow-up	Received telephone calls at 2 and 4 weeks and 2, 3, 5, 7 and 9 months after discharge	12 months post injury	No significant between- group difference in the vocational composite
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*Abbreviations:* TBI, traumatic brain injury; RTW, return to work; NAV, Norwegian Labour and Welfare Administration; GP, general practitioner; SE, supported employment; CogSMART, Cognitive Symptom Management and Rehabilitation Therapy; FSE, Functional Status Examination.

## **2 Rationale for the thesis study**

Long-lasting debate has concerned weak collaboration between health sectors and vocational services in Norway in general. During the last decades, two important reform strategies have been introduced: the Coordination Reform and the Norwegian Labour and Welfare Administration (NAV) Reform. The Coordination Reform aimed to enhance coordination between two main health sectors: primary health and long-term care, and hospitals and specialist services. The NAV Reform aimed to make welfare services more user-friendly, holistic and efficient, and to include more people in the workforce (13). The Work, Welfare and Inclusion report (101) highlighted a need to coordinate medical and vocational services to help individuals receiving temporary sickness benefits RTW. Measures such as the Inclusive Working Life agreement (100), graded sick leave (149), activation requirements, and the New Model for Earlier Follow-up of Employees on Sick Leave (150) have been implemented to prevent lengthy absenteeism and continued social security dependence (151). Still, Norway has a high rate of long-term sickness absence compared to other Nordic and OECD countries (152,153). To aid RTW and reduce absenteeism among people with long-term functional disability, it is necessary to further explore effective RTW models.

The current evidence base for VR in chronic conditions is still limited. Additional clinical trials and practice-based studies with more detailed descriptions of program content are warranted to establish evidence of the effectiveness of specific programs.

The present thesis focuses on TBI, RTW after injury, and the development and trial of a combined CR and VR program (SE) based on cross-sectoral collaboration between health and vocational services. This kind of treatment model has not been evaluated previously in individuals with TBI in the Norwegian context.

In the early phase of this work, few studies had addressed long-term employment probability after moderate and severe TBI. Studies from different countries were required to provide a better understanding of how sociodemographic and injury-related characteristics, differences in governmental policies, healthcare and welfare systems may influence employment probability several years after TBI. Such knowledge may encourage cross-sectoral collaboration between healthcare services and the welfare

system to develop new individualised work-related interventions to improve both short- and long-term employment outcomes following TBI. The last paper of this thesis serves as a contribution to this research knowledge.

## **2.1 Aims and hypotheses**

The specific aims of each of the papers were as follows.

### Paper I

To present the study protocol for a pragmatic RCT aimed at exploring the effectiveness of combining a manualised cognitive intervention (Compensatory Cognitive Training, CCT) and SE in real-life competitive work settings on RTW and related outcomes in participants with mild to moderate TBI.

### Paper II

To assess the feasibility of a manualised compensatory cognitive training intervention in a Norwegian civilian sample with mild to moderate TBI. The primary outcomes were participants' satisfaction with and ability to engage with the intervention.

### Paper III

To evaluate the effectiveness of a combined cognitive and vocational intervention by comparing it to treatment as usual (TAU) consisting of multidisciplinary outpatient follow-up. The primary outcome was the proportion of participants who had returned to work 3 and 6 months following study inclusion. Secondary outcomes were work percentage, work stability and work productivity at 3 and 6 months. We hypothesised that individuals who received the combined cognitive and vocational intervention would show greater gains on the outcome measures compared to those receiving TAU.

## Paper IV

To examine employment probability up to 10 years after moderate and severe TBI, and to identify significant predictors of employment probability from baseline sociodemographic and injury characteristics. We hypothesised that employment probability would decrease from 5 to 10 years post injury.

## 3 Materials and methods

### 3.1 Study design

The studies included in this thesis had different designs and were part of two larger research projects. Papers I–III were part of a research project involving collaboration between clinicians and researchers at Oslo University Hospital (OUH), Sunnaas Rehabilitation Hospital (SRH), NAV, and the Work Research Institute (Arbeidsforskningsinstituttet, AFI). The project encompasses a complex intervention that combines perspectives from rehabilitation and vocational sciences, developed based on studies on employment after TBI, the existing evidence and guidelines for CR after TBI, and a novel approach to VR. In this thesis, the effectiveness of the intervention on vocational outcomes was assessed up to 6 months following study inclusion. Subsequent publications will assess the effectiveness of the intervention on vocational outcomes and clinical functioning up to 12 months after study inclusion.

Paper IV is part of a TBI research project developed to explore short- and long-term outcomes in several functional domains after moderate and severe TBI. In this thesis, outcomes are assessed 10 years after injury.

The specific designs of each paper included in this thesis are as follows.

**Paper I** was a description of the study protocol.

**Paper II** was a feasibility study designed to test whether the CCT intervention that was part of the subsequent RCT was applicable to a convenience sample of Norwegian patients, with limited statistical power and follow-up at baseline and post intervention (i.e. 3 months after study inclusion).

**Paper III** was an RCT with follow-up at baseline and 3 and 6 months following study inclusion.

**Paper IV** was a longitudinal observational study including data from baseline and 1, 2, 5 and 10 years post injury.

## **3.2 Study participants and setting**

Papers II and III are based on a sample of patients who sustained mild and moderate TBI between 2017 and 2019. Paper IV is based on data from a sample of patients who sustained moderate and severe TBI between 2005 and 2007. All patients were recruited from the south-eastern region of Norway. The studies were conducted at OUH, the primary trauma hospital for inhabitants of Oslo and the Trauma Referral Centre for the south-eastern region of Norway, serving a population base of 3 million as of 2020, more than half of the Norwegian population.

### **3.2.1 Papers II and III**

#### ***3.2.1.1 Inclusion and exclusion criteria***

The study population consisted of patients with mild to moderate TBI, as assessed by a GCS score of 10–15, LOC for <24 hours and PTA for <7 days. Patients with a GCS score of 9 were excluded to avoid the most severe of the moderate injuries and include individuals where RTW could reasonably be expected. The criteria for diagnosing mTBI developed by the ACRM were used to establish the presence of mTBI, either extracted from medical records or while screening for study eligibility. Patients were considered for inclusion if they were employed in a minimum 50% position at the time of injury, but sick-listed 50% or more due to post-concussive symptoms, as assessed by the RPQ 2–3 months post injury. Sick-listing refers to sick leave certified by a medical doctor (MD). Participants were aged 18–60 years, and residents of Oslo or the former Akershus County (as of January 1<sup>st</sup>, 2020, Akershus was merged with two other counties and is now called Viken). Patients with a history of severe psychiatric or neurological illness, active substance use or inability to speak and read Norwegian were excluded.

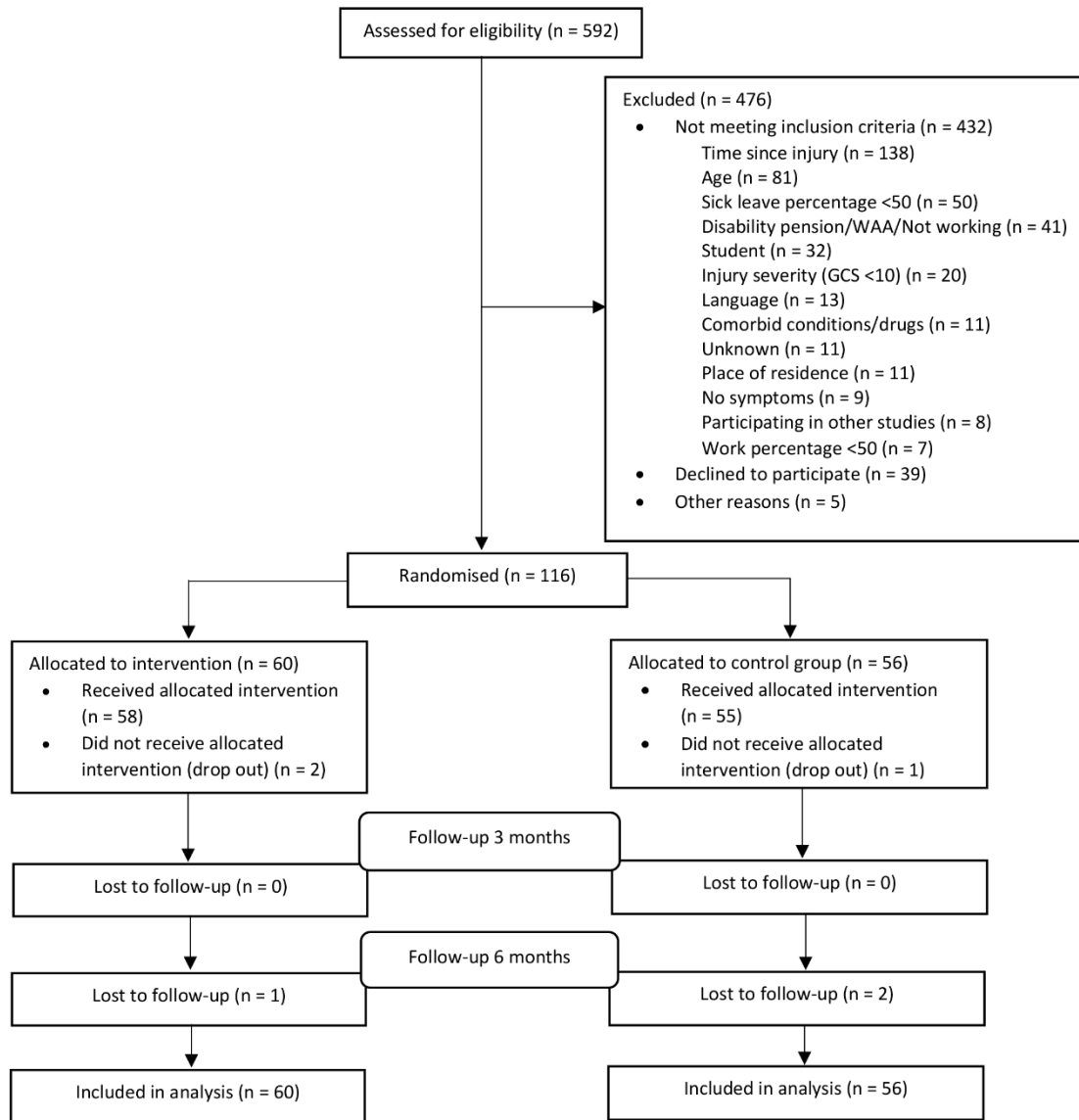
### ***3.2.1.2 Recruitment procedures***

Potentially eligible patients were referred from the emergency department (ED), neurosurgical department and general practitioners (GPs) to an outpatient clinic at the Department of Physical Medicine and Rehabilitation (PM&R), OUH, Norway. The outpatient clinic at PM&R provides specialised rehabilitation and follow-up services to patients with TBI.

Recruitment to the feasibility study (paper II) took place in March and April 2017. Fourteen patients were assessed for eligibility, of whom five were excluded due to not meeting the inclusion criteria. Reasons for exclusion were place of residency, low symptom burden and unemployment at the time of injury. All remaining patients were asked to participate, of whom eight consented and one declined. Two participants dropped out before or shortly after starting the intervention. One dropped out due to low symptom burden and one preferred another treatment option. A total of six participants (three quarters of those who consented) completed the feasibility study. All six participants completed the follow-up 3 months after study inclusion.

Recruitment to the RCT (Paper III) commenced in July 2017 and continued until April 2019. Figure 1 shows the patient flow. Of the 592 patients who were assessed for eligibility, 476 (80%) did not meet inclusion criteria. The main reasons were time since injury (29%), age (17%), sick leave percentage below 50% (11%), and receiving a disability pension, work assessment allowance or unemployment (9%). Thirty-nine (25%) of the 155 patients who were asked to participate declined, leaving a total of 116 patients included in the study. No significant differences existed between the study participants and patients who declined to participate in the median GCS score (15 in both groups). However, there was a statistically significant higher proportion of men (61.5% vs 40.5%) and lower mean age (38 vs 42 years) among the patients who declined to participate compared to study participants.





**Figure 1.** Flow chart of recruitment to the randomised controlled trial (paper III).

### 3.2.1.3 Participants

Participants in the feasibility study (paper II) consisted of three men and three women with a median age of 40 (range 28–51) years, and median education of 16 (range 13–17) years. Four (67%) were married. All had a GCS score of 15, two (33%) were injured in falls, four (67%) experienced blows to the head, and none had trauma-related intracranial injuries on CT or MRI scans. Four (67%) had sustained work-related injuries. Four were sick-listed 100% at the time of inclusion, one 80% and one 70%.

Table 3 provides the baseline characteristics of participants in the RCT (paper III) by treatment group. No statistically significant differences existed between the groups at baseline, except for intoxication at the time of injury and having sustained a previous TBI.

**Table 3.** Baseline characteristics of participants in the randomised controlled trial (paper III).

Variable	Statistic	All (n = 116)	CCT-SE (n = 60)	TAU (n = 56)
<b>Demographic information</b>				
Age (years)	Mean (SD)	42 (10)	41 (10)	44 (9)
Gender (female)	n (%)	69 (59.5)	33 (55)	36 (64)
Education	Mean (SD)	16 (2.5)	16 (2)	16 (3)
Marital status	n (%)			
Married or cohabiting		77 (66)	43 (72)	34 (61)
Single		39 (34)	17 (28)	22 (39)
<b>Injury characteristics</b>				
Time since injury (days)	Mean (SD)	72 (24)	77 (25)	68 (22)
Injury cause (n = 115)	n (%)			
Falls		49 (43)	19 (32)	30 (54)
Transport		23 (20)	12 (20.5)	11 (20)
Exposure to inanimate mechanical forces		23 (20)	15 (25.5)	8 (14)
Sport		14 (12)	10 (17)	4 (7)
Violence		6 (5)	3 (5)	3 (5)
GCS (n = 114)	Median (range)	15 (10–15)	15 (10–15)	15 (11–15)
Mild (13–15)	n (%)	109 (94)	58 (97)	51 (91)
Moderate (10–12)	n (%)	7 (6)	2 (3)	5 (9)
LOC (n = 115)	n (%)			
None		61 (53)	31 (51.5)	30 (54.5)
<30 minutes		37 (32)	21 (35)	16 (29)
<24 hours		3 (3)	1 (2)	2 (4)
Not registered		14 (12)	7 (11.5)	7 (12.5)
PTA (n = 115)	n (%)			
None		51 (44)	25 (42)	26 (47)
<1 hour		35 (30)	18 (30)	17 (40)
<24 hours		16 (14)	7 (11.5)	9 (16)
<7 days		2 (2)	0 (0)	2 (4)
Not registered		11 (10)	10 (16.5)	1 (2)
Trauma-related CT or MRI findings	n (%)			
Yes		27 (23)	11 (18)	16 (29)
No		80 (69)	45 (75)	35 (62)

No CT or MRI		9 (8)	4 (7)	5 (9)
AIS–Head score	n (%)			
Minor		59 (51)	34 (57)	25 (44.5)
Moderate		34 (29)	18 (30)	16 (28.5)
Serious		15 (13)	5 (8)	10 (18)
Severe		8 (7)	3 (5)	5 (9)
Extracranial injuries (yes)	n (%)	53 (46)	28 (47)	25 (45)
Hospital stay (days)	Median (range)	0 (0–22)	0 (0–22)	0 (0–18)
Intoxicated at time of injury (yes) (n = 115)	n (%)	17 (15)	5 (9)	12 (21)
Injured at the workplace (yes) (n = 114)	n (%)	16 (14)	9 (15)	7 (13)
<b>Self-reported history of diseases</b>				
Anxiety	n (%)	6 (5)	3 (5)	3 (5)
Depression	n (%)	17 (15)	11 (18)	6 (11)
TBI	n (%)	50 (43)	32 (53)	18 (32)
Migraine or headache	n (%)	23 (20)	12 (20)	11 (20)
<b>Work factors</b>				
Occupation type (white-collar)	n (%)	103 (89)	53 (88)	50 (89)
Occupation category	n (%)			
Military or academic professions		58 (50)	30 (50)	28 (50)
Leaders		28 (24)	15 (25)	13 (23)
Office sales		19 (16.5)	10 (17)	9 (16)
Craft or machine operators, transportation or cleaning		11 (9.5)	5 (8)	6 (11)
Employment duration (months) (n = 114)	Median (IQR)	51 (112)	54 (114)	42 (108)
Permanent position (yes)	n (%)	105 (90.5)	56 (93)	49 (87.5)
Full-time position (yes)	n (%)	103 (89)	55 (92)	48 (86)
Enterprise size	n (%)			
Micro (1–9 employees)		9 (8)	4 (7)	5 (9)
Small (10–49 employees)		36 (31)	17 (28)	19 (34)
Medium (50–249 employees)		28 (24)	12 (20)	16 (28.5)
Large (>250 employees)		43 (37)	27 (45)	16 (28.5)
Employed in private sector	n (%)	64 (55)	36 (60)	28 (50)
Sick-listed				
80–100%		94 (81)	48 (80)	46 (82)
50–79%		22 (19)	12 (20)	10 (18)
Work hours per week (n = 110)	Median (IQR)	0 (8)	0 (8)	0 (8)

*Abbreviations:* CCT-SE, Compensatory Cognitive Training and Supported Employment; TAU, treatment as usual; GCS, Glasgow Coma Scale; PTA, posttraumatic amnesia; CT, computed tomography; MRI, magnetic resonance imaging; AIS, Abbreviated Injury Scale; TBI, traumatic brain injury.

### **3.2.2 Paper IV**

#### ***3.2.2.1 Inclusion and exclusion criteria***

The study population consisted of patients with moderate to severe TBI, as assessed by a GCS score of 3–12 at emergency admission or before intubation at the site of injury; admission with ICD-10 diagnoses S06.0–S06.9 within 24 hours of injury; age 16–55 years at the time of injury; and residence in eastern Norway. Patients with a previous neurological disorder or injury, associated spinal cord injuries, previously diagnosed severe psychiatric or substance use disorders, unknown address or incarceration were excluded.

#### ***3.2.2.2 Recruitment procedures***

Participants were recruited to a larger TBI project conducted in eastern Norway, comprising patients with acute TBI who were admitted to OUH over a 2-year period from May 2005 to 2007. Follow-ups were provided at 1, 2, 5 and 10 years after the injury. During the inclusion period, 160 patients were identified as eligible for the study. Twenty-seven patients declined participation. Thus, 133 participants were included in the study. Of these, 32 individuals died in the acute or post-acute phase, and four individuals withdrew before the 1-year follow-up. One patient died and four dropped out of the study between 1 and 2 years. Between the 2- and 5-year follow-ups, two individuals died and four dropped out. Between the 5- and 10-year follow-ups, five individuals died and 12 dropped out, leaving 77 individuals at the last follow-up. The present study analysed data from the surviving population ( $n = 97$ ), with an attrition rate of 21% from the 1- to 10-year follow-ups.

#### ***3.2.2.3 Participants***

Table 4 provides the baseline characteristics of the participants in the longitudinal observational study (paper IV).

**Table 4.** Baseline characteristics of participants in the longitudinal observational study (paper IV).

Variable	n (%)	Mean (SD)	Total n
Age at injury in years		30.3 (10.8)	97
Gender			97
Male	76 (78.4)		
Female	21 (21.6)		
Relationship status			97
Partnered	28 (28.9)		
Single	69 (71.1)		
Education level			96*
≤12 years	54 (56.3)		
>12 years	42 (43.8)		
Employment status			97
Yes	80 (82.5)		
No	17 (17.5)		
Occupational status			97
Blue-collar	46 (47.4)		
White-collar	51 (52.6)		
Disability pension	4 (4.0)		
Injury cause			97
Traffic accident	58 (59.8)		
Other	39 (40.2)		
GCS		7.2 (3.2)	97
Moderate (9–12)	32 (33.0)		
Severe (3–8)	65 (67.0)		
PTA in days		26.0 (30.0)	91**
CT head Marshall score		2.6 (1.1)	97
1–2	46 (47.4)		
3+	51 (52.6)		
ISS		30 (13.6)	97
Total acute length of stay in days		29.0 (25.0)	97
Inpatient rehabilitation length of stay in days		59.0 (37.0)	71***

\*Missing data on one individual. \*\*Missing data on six individuals. \*\*\*Only 71 individuals received inpatient rehabilitation (length of stay and mean stay are only calculated for those actually receiving it rather than the whole population). *Abbreviations:* GCS, Glasgow Coma Scale; PTA, posttraumatic amnesia; CT, computed tomography; ISS, Injury Severity Score.

### **3.3 Data collection and procedures**

For paper II, data were collected at baseline and 3 months after inclusion. For paper III, data were collected at baseline and 3 and 6 months post-inclusion. For Paper IV, data were collected during the acute hospital stay and 1, 2, 5 and 10 years post injury. Patient outcomes were assessed by structured interviews, standardised tests, and self-report questionnaires.

The assessments for papers II–IV were performed at the outpatient clinic at PM&R. Assessment at baseline and 3 months (paper II) were performed by the PhD candidates in the project. Independent and blinded assessors performed outcome assessments for paper III at 3 and 6. For paper IV, a physiatrist performed the assessments and interviews of patients at follow-up at 1, 2, 5 and 10 years.

### **3.4 Randomisation and blinding**

For paper III, participants were randomly assigned with a 1:1 allocation ratio to the combined cognitive and vocational intervention (CCT-SE) or treatment as usual (TAU). Allocation followed a computer-generated list using randomised block sizes of 2, 4, 6 or 8, prepared by an independent statistician before initiating the study. The allocation sequence was concealed from the interventionists. Following baseline assessment, the participants were randomised by an independent investigator who was not involved in the intervention or follow-ups. Participants and interventionists providing CCT-SE or TAU were not blinded to group allocation. As the baseline assessment was performed before randomisation, assessors were not aware of group allocation at the time. Outcome assessments at 3 and 6 months were performed by independent assessors. To ensure blinding, participants were instructed to not reveal group allocation. The collected data were entered into the database by independent study personnel who were unfamiliar with the study. Prior to analyses, an independent statistician converted the participant's original identification numbers to fake identification numbers to avoid revealing group allocation.

### **3.5 Measures and instruments**

#### **3.5.1 Sociodemographic information and injury characteristics**

Table 5 provides an overview of the sociodemographic and injury characteristics collected at baseline for papers II–IV. Clinical and demographic information was obtained from medical records and/or structured interviews performed at baseline.

**Table 5.** Overview of collected sociodemographic and injury characteristics at baseline (papers II–IV).

	Paper II	Paper III	Paper IV
Sociodemographic information			
Age	X	X	X
Gender	X	X	X
Education	X	X	X
Marital status	X	X	X
Injury characteristics			
Injury mechanism	X	X	X
Time since injury		X	X
GCS	X	X	X
LOC		X	
PTA		X	X
Extracranial injury (yes/no)		X	
CT/MRI findings (yes/no)	X	X	
CT Marshall score			X
AIS–Head		X	
ISS			X
LOS acute hospital		X	X
LOS rehabilitation			X
Intoxication at time of injury		X	
Injured at workplace or not	X	X	
Work information			
Employment status	X	X	X
Employment duration	X	X	
Occupation type		X	X
Occupation category		X	

*Abbreviations:* GCS, Glasgow Coma Scale; LOC, loss of consciousness; PTA, posttraumatic amnesia; CT, computed tomography; MRI, magnetic resonance imaging; AIS, Abbreviated Injury Scale; ISS, Injury Severity Score; LOS, length of stay.

### 3.5.2 Measurements

#### Paper II

To assess whether the CCT intervention was feasible and recruitment procedures were appropriate, pre-defined success criteria were determined based on a previous pilot study



by Twamley et al. (140) and studies that have been performed at PM&R, OUH (154). Regarding recruitment and assessment procedures, we anticipated that three quarters of the patients who were asked to participate would agree, that less than 30% would drop out, and that participants would tolerate the burden of follow-up procedures. Regarding attendance and satisfaction with the CCT intervention, we anticipated 90% attendance across sessions, and that subjective satisfaction with the intervention would be comparable to that reported in the pilot study by Twamley et al. (140).

#### *Work participation*

Information about percentage sick leave and hours worked per week was collected at baseline and post-treatment follow-up.

#### *Neurocognitive function*

A neuropsychological evaluation was performed at baseline for descriptive purposes. All tests were administered according to standardised procedures and in the same order for all participants. Four subtests from the Wechsler Adult Intelligence Scale – Fourth Edition (WAIS-IV) (155) were used to estimate general mental ability: (1) *Vocabulary*, a test of semantic knowledge and word comprehension; (2) *Similarities*, a test of abstract verbal reasoning; (3) *Matrix Reasoning*, assessing non-verbal abstract problem solving; and (4) *Block Design*, a test of visual–spatial abilities and problem solving. The California Verbal Learning Test – Second Edition (156) was used as a measure of verbal learning and memory. The Memory for Intentions Screening Test (157) was used to assess prospective memory. The Color Word Interference Test and Trail Making Test from the Delis–Kaplan Executive Function System (158) were used as measures of executive function. Processing speed and attention were assessed with *Coding* from the WAIS-IV and the Ruff 2 & 7 Selective Attention Test (159).

#### *Emotional status and fatigue*

The Patient Health Questionnaire – 9-item (PHQ-9) scale (160) was used as a self-report measure of depressive symptoms. The patient is asked to rate the frequency of depressive symptoms during the past 2 weeks on a scale ranging from 0 (not at all) to 3 (nearly every day). The PHQ-9 has a score range from 0–27, with scores of 5, 10, 15 and 20

representing cut-off values for mild, moderate, moderately severe and severe symptoms of depression, respectively. The PHQ-9 has demonstrated good psychometric properties as a measure of depression severity (160) and is a reliable and valid measure for detecting depression in patients with TBI (161).

The General Anxiety Disorder – 7-item (GAD-7) scale (162) was used as a self-report measure of symptoms of anxiety. The frequency of symptoms of anxiety is assessed on a four-point Likert scale from 0 (not at all) to 3 (nearly every day). The GAD-7 has a score range from 0–21, with scores of 5, 10 and 15 representing cut-off values for mild, moderate and severe symptoms, respectively. The GAD-7 has shown good psychometric properties in detecting symptoms of anxiety (162) and is a frequently applied measure in the TBI population (163).

The Fatigue Severity Scale (FSS) (164) is a self-reported measure of the frequency and impact of fatigue on daily functioning. The FSS consists of nine items scored on a seven-point Likert scale from 1 (strongly disagree) to 7 (strongly agree), with higher scores indicating higher fatigue levels. The mean score was calculated and the cut-off values recommended by Lerdal et al. (165) were applied: 0–3.9 = no fatigue, 4–4.9 = moderate fatigue, and 5–7 = severe fatigue.

#### *Post-concussive symptoms*

The RPQ (62) is a 16-item self-report measure of the presence and frequency of post-concussion symptoms. The items are divided into three symptom categories: somatic (headache, dizziness, nausea, noise sensitivity, sleep disturbance, fatigue, blurred vision, light sensitivity), emotional (irritability, depression, frustration, restlessness), and cognitive (poor memory, poor concentration, taking longer to think). Individuals are asked to rate to what degree they have experienced symptoms during the past 7 days on a five-point Likert scale ranging from 0–4 (0 = not experienced at all, 4 = a severe problem). As advised by King et al. (62), all scores of 1 (indicating that the problem was the same as before the injury) were removed. The total score, ranging from 0–64, was used. The RPQ has been validated in the Norwegian context (166).

The Therapist Checklist was developed to rate participants' level of skill acquisition and generalisation of target skills to everyday function in a day treatment program for patients with TBI (167,168). It is a modified five-item checklist where participants are rated as perceived by the therapist on a four-point scale (0–3) according to level of participation (participated fully, moderately, or minimally, or was inattentive and unresponsive), homework completion (completed, did not complete for legitimate reasons, did not complete with no legitimate reason, or was not aware that homework was assigned), interaction with the therapist and other participants (interacts well with others and therapist, interacts well with therapist only, interacts minimally with therapist and others, or interacts negatively), ability to learn and apply skills and strategies (exceptional, good, modest, or minimal), and generalisation of skills (applies skills exceptionally well to real-life situations, attempts to apply skills to real-life situations, attempts to apply skills to hypothetical real-life situations, or minimal or no use of skills). Additionally, attendance across each of the 10 CCT sessions was recorded.

The CCT Feedback Form was designed specifically to assess participants' satisfaction with the compensatory cognitive intervention (140). It consists of two parts: in the first, participants are asked to rate the perceived usefulness of the information and strategies provided in each of the sessions on a five-point scale ranging from 1 (not helpful) to 5 (extremely helpful); in the second, participants are asked what topic or strategy they found most useful, what strategies they are using regularly now that they were not before, whether the strategies have helped them in their daily life, and what topic or strategy was least helpful. The scale also contains a final question of whether participants would recommend the intervention to others with similar problems.

### Paper III

All measures applied in the feasibility study were also used in the RCT, with exception of the Therapist Checklist. Subsequent publications will report on these measures, as the outcome measures reported in paper III were related to employment participation.

The primary outcome in paper III was *RTW* at 3 and 6 months following study inclusion. Secondary outcomes were *work percentage*, *work stability* and *productivity* at 3 and 6 months following study inclusion. RTW was defined as the proportion of participants who had returned to full- or part-time work (categorical variable, yes or no). Work percentage was divided into four categories reflecting the quantity of resumed work at 3 and 6 months (relative to the participants' pre-injury work percentage) (0 = not working at all; 1 = working <50%; 2 = working 50–79%; 3 = working 80–100%, i.e. full-time). Work stability was defined as stable (working at the same or increased level as the previous follow-up time point, i.e. baseline to 3 months or 3 months to 6 months follow-up) or unstable employment (working at a decreased level in % compared to the previous follow-up). Work productivity was operationalised by the number of hours worked per week and whether there had been any work accommodations (yes or no). The number of hours worked per week was calculated by dividing 37.5 (i.e. standard full-time work in Norway) by 100 and multiplying by the work percentage relative to the pre-injury work level at 3 and 6 months. Participants were also asked to describe the type of work accommodations that had been made.

### Paper IV

The dependent variable was *employment status* 1, 2, 5 and 10 years post injury. Employment was dichotomised into employed (working full- or part-time, including students) and unemployed (seeking work, on sick leave, or receiving work assessment allowance or disability pension) at each follow-up. Students denoted persons who were studying at a high school, college or university. Full-time work was defined as 37.5 hours of productive activity per week and part-time work as less than 37.5 hours weekly.

Independent variables were *gender* (male vs female), *age at time of injury* (years), *relationship status at hospital admission* (partnered [married or cohabitating] vs single),

*education* ( $\leq 12$  years vs  $> 12$  years), *employment status at time of injury* (employed vs unemployed), *occupation prior to admission* (blue-collar [physical work] vs white-collar [nonphysical work or study]), *acute GCS score* (continuous), *cause of injury* (traffic accident vs other), *duration of PTA* (number of days), *ISS* (continuous) and *CT severity score* (assessed by the Marshall classification system).

### **3.6 Interventions**

This section describes the combined cognitive and vocational intervention and TAU. In addition to the study interventions, all participants received standard Norwegian statutory sick leave follow-up.

#### **3.6.1 Combined cognitive and vocational intervention**

The cognitive and vocational intervention comprised CCT and SE CCT-SE (169). CCT is a further development of Cognitive Symptom Management and Rehabilitation Therapy (CogSMART), developed in the US by Twamley et al. (140,141). CCT is a manualised intervention targeting post-concussive symptom management and cognitive symptoms in individuals with mild and moderate TBI. The intervention was provided in groups of two to five participants for 2 hours weekly over 10 weeks. Each session covered the topics through a combination of psychoeducation and compensatory strategy training. The participants received an information leaflet about TBI in addition to the intervention manual. They were also provided audio files containing relaxation exercises. After each session, the participants were assigned homework to increase the chance of automating and generalising the skills. Table 6 provides an overview of the topics covered in the intervention.

**Table 6.** Topics covered in the CCT intervention.

Session	Topic	Examples of strategies
1	Course introduction and information about traumatic brain injury	Finding a 'home' for important personal items
2	Managing fatigue, sleep problems, headaches and tension	Sleep hygiene and relaxation techniques
3	Organisation and prospective memory	Time management and establishing routines
4	Organisation and prospective memory (continued)	Calendar use and to-do lists
5	Attention and concentration	Paying attention during conversations
6	Learning and memory	Internal and external memory strategies
7	Learning and memory (continued)	Overlearning and name learning strategies
8	Planning and goal setting	Plan to meet goals and deadlines
9	Problem solving and cognitive flexibility	Six-step problem-solving method and self-monitoring
10	Skills integration, review and next steps	Application of strategies to everyday life and progress toward goals

The CCT intervention was administered by the PhD candidates in the study, supervised by senior researchers. Before commencing the feasibility trial, the CCT intervention manual and accompanying information leaflet were translated and adapted to the Norwegian setting. The relaxation exercises were also translated to Norwegian and audio-recorded. Adaptations included minor language adjustments, downscaling information about posttraumatic stress, and removing content related to injuries sustained in war settings. The translation was performed by researchers at PM&R and SRH with permission from the developer (EW Twamley). Our collaborating user organisation, The National Association for the Traumatically Injured (Personskadeforbundet LTN), requested and received comments on the material from some of their members to ensure the appropriateness of the content.

The vocational part of the intervention was based on the IPS model of SE. Because all participants were employed at the time of injury, the main efforts were on stages 1 (client engagement), 4 (employer engagement) and 5 (on- and off-the-job support). The initial contact with the participant focused on establishing a trustful relationship between the employment specialist and the participant. The next step involved mapping the patient's

resources, limitations and work tasks, as well as establishing common goals between the employment specialist and the participant. The following sessions were customised to the employee's needs and included consultations, guidance and advice, learning and training, work task adaptations, and assistive technology. When deemed beneficial by the participant and employment specialist, the employer and supervisor at the local NAV office were included in the process. For the purpose of the study, SE was provided for a maximum of 6 months.

SE was provided by three employment specialists employed at the NAV. The employment specialists had longstanding experience in working with individuals with acquired brain injury, and they completed formalised postgraduate SE education before initiating the study. The employment specialists each followed one CCT group program to become acquainted with the CCT content and ensure the implementation of strategies and compensatory techniques at the workplace. The CCT team and employment specialists met regularly to discuss individual patient cases and potential issues related to their RTW process.

The total number of face-to-face meetings between the employment specialists and participants was 178, with an average of three meetings per participant (approximately one meeting per participant was at the workplace). The mean number of contacts by email or telephone was 10 per participant.

### **3.6.2 Treatment as usual**

TAU consisted of assessment and treatment provided by a multidisciplinary team at the outpatient clinic at PM&R. The specific follow-up consisted of individual contacts and an educational group. Follow-up was tailored to the individual patient's needs and was provided by an MD, a neuropsychologist, a physiotherapist, an occupational therapist, and a social worker. The educational group consisted of four weekly meetings of 2 hours, each led by a different professional (MD, neuropsychologist, occupational therapist or physiotherapist). The participants in the educational group received nonspecific education about brain injury, shared their experiences and discussed common problems in daily life following TBI. Patients received TAU for a maximum of 6 months.

The mean (standard deviation, SD) number of individual contacts in the TAU group was 9 (5), and the mean (SD) duration of follow-up was 199 (123) days. Of the 55 patients who received TAU, all were consulted by an MD, 50 (91%) received occupational therapy, 39 (71%) participated in the educational group, 31 (56%) received physical therapy, 21 (38%) were referred to a neuropsychologist, and 20 (36%) received advice from a social worker.

### **3.7 Treatment fidelity**

A six-item fidelity checklist was completed by a senior researcher to evaluate the therapist's adherence and competence in administering the CCT intervention. The items, chosen from a previous publication by Winter et al. (170), were (1) explained content of each CCT session clearly, (2) used appropriate pace and language, (3) showed sensitivity to participants' responses, (4) responded clearly to participants' questions, (5) demonstrated overall fidelity to the CCT manual, and (6) explained next step of the CCT intervention. The rating levels were poor, good and excellent. Treatment fidelity was assessed for 30 (5%) CCT sessions. Items 2, 3 and 6 were rated as excellent, and the remaining items were rated as good.

### **3.8 Statistical considerations and analyses**

All statistical analyses were performed using IBM SPSS v. 22 (171) and 25 (172) or Stata v. 16 (173). A p-value below 0.05 was considered statistically significant.

#### **3.8.1 Sample size**

The estimated sample size for the RCT (paper III) was based on the RTW proportion at 12 months. To detect an odds ratio (OR) of 2.0, considered the smallest clinically and societally relevant ratio, between CCT-SE and TAU, required a sample size of 110 (i.e. 55 in each group, alpha 0.05, power 0.80). To account for a loss to follow-up of 15%, we estimated a total of 125 participants. Based on another ongoing TBI study (174), we assumed that this would be achievable within 12–18 months. However, because of time constraints caused by almost 3 months' delay in commencement due to waiting for ethical approval, the limited timeframe of the project, and low loss to follow-up (2.5%) at 6 months, we completed recruitment at 116 participants.



### 3.8.2 Statistical analyses

In **paper II**, descriptive statistics with median and IQR were reported for sociodemographic variables and self-reported symptoms. For neuropsychological test results at baseline, the participants' performance was characterised as deviance from the normative mean (in SD). Descriptive statistics with proportions and percentages were reported for the CCT Feedback Form and the Therapist Checklist. The Wilcoxon signed-rank test was applied to assess changes in post-concussive symptoms from baseline to post-treatment follow-up 3 months after inclusion. The analyses were performed by the first author.

In **paper III**, descriptive statistics were presented with mean and SD or median and IQR for continuous variables or median and percentages or range for categorical variables. We assessed whether the two variables that were significantly different between the groups at baseline, intoxication at time of injury and previous TBI, were associated with the outcomes. Neither variable were associated with any of the outcomes, thus were not controlled for in the main analyses. Differences in primary (RTW proportion) and secondary (work stability, productivity and accommodations) outcomes between the CCT-SE and TAU groups at each follow-up (3 and 6 months) were analysed using independent samples t-tests for continuous and chi-square tests for categorical variables. Mixed effect models were fitted to all outcome variables to account for the repeated measures by patients. Continuous endpoints were analysed using linear mixed models with random intercept and slope. Time and time-by-treatment interaction were fixed effects in all models. Based on the linear mixed model, we estimated mean values with 95% confidence intervals (CI) for the three time points (baseline, 3 months and 6 months) for each treatment group. We also estimated the mean between-group changes from baseline to 6 months. Dichotomous endpoints were analysed using mixed-effects logistic regression with treatment and time-by-treatment as fixed effects. Based on the mixed-effects logistic regression, we estimated risk differences with 95% CI from baseline to 3 and 6 months using the delta method. Analyses were conducted according to the intention-to-treat principle, leaving all patients randomised to CCT-SE or TAU included in the analyses. The statistical analyses were performed by co-author and statistician Cathrine Brunborg together with the first author.

In **paper IV**, descriptive statistics with proportions and percentages and means with SD were used to present demographics and injury-related variables, as appropriate.

Hierarchical linear modelling (HLM) was used to examine the trajectories of employment probability across 1, 2, 5 and 10 years after injury and identify baseline predictors. HLM was selected so that a full trajectory across all four time points could be analysed and predicted, as opposed to separate and limited predictions of employment probability at each independent time point. Predictors were entered simultaneously as fixed effects after being centred or given a reference point of 0, along with time. The HLM determined whether linear trajectories of employment probabilities across the four time points could be predicted by the demographic and injury characteristics of time (coded as 0 [1 year], 1 [2 years], 4 [5 years], or 9 [10 years] to reflect actual spacing between time points), gender (1 = female, 0 = male), age, relationship status (1 = partnered, 0 = single), education (1 = >12 years, 0 = ≤12 years), employment at admission (1 = employed, 0 = unemployed), occupational status (1 = white-collar, 0 = blue-collar), continuous GCS score, cause of injury (1 = motor vehicle, 0 = not motor vehicle), length of PTA (days), CT severity score, and ISS. A second HLM included the significant predictors identified from the full HLM, the variable of time, and interaction terms between the variable of time and the significant predictors. Statistical analyses were performed by co-author Paul Perrin and the two first authors.

### **3.9 Ethics**

All study participants received written and verbal information, and written informed consent was obtained on agreement to participate. The trials were performed in accordance with the principles of the Declaration of Helsinki and approved by the Norwegian Regional Committees for Medical and Health Research Ethics (papers I–III approval number 2016/2038; paper IV approval number 2015/1589) and the Norwegian Data Inspectorate. The RCT was registered at the US National Institutes of Health (ClinicalTrials.gov, #NCT03092713).

## **4 Summary of papers**

### **4.1 Paper I**

#### **Background**

A considerable proportion of patients with mild to moderate TBI experience long-lasting somatic, cognitive and emotional symptoms that may hamper their capacity to RTW.

Although several earlier studies have described medical, psychological and work-related factors that predict RTW after TBI, well-controlled intervention studies regarding RTW are scarce. Furthermore, there has traditionally been weak collaboration among health-related rehabilitation services, the labour and welfare sector, and workplaces.

#### **Methods**

This study protocol described an RCT aimed at exploring the effectiveness of combining manualised CR (CCT) and SE on RTW and related outcomes for patients with mild to moderate TBI in real-life competitive work settings. The study was carried out within the Norwegian welfare system. Patients aged 18–60 years with mild to moderate TBI, employed in a minimum 50% position at the time of injury and sick-listed 50% or more for post-concussive symptoms 2 months post injury, were included in the study.

Outcomes were assessed immediately after CCT (3 months after inclusion), following the end of SE (6 months after inclusion), and 12 months following study inclusion. The primary outcome measures were the proportion of participants who had returned to work at 12-month follow-up and time until RTW, in addition to work stability and productivity over the first year following the intervention. Secondary outcomes included changes in self-reported symptoms, emotional and cognitive function, and quality of life.

Additionally, a qualitative RTW process evaluation focused on organisational challenges in the workplace.

#### **Discussion**

The study proposed to combine CR and VR and explore the effectiveness of increased cross-sectoral collaboration between specialised healthcare services and the labour and welfare system. If the intervention proved effective, the project would describe the cost-

effectiveness and utility of the program and thereby provide important information for policymakers. In addition, it provided knowledge about the RTW process for persons with TBI and their workplaces.

## **4.2 Paper II**

### **Background**

This study aimed to assess the feasibility of recruitment procedures and delivery of a Norwegian adaptation of a manualised cognitive intervention to a civilian sample with TBI.

### **Methods**

Six individuals received a 10-week group-based intervention (CCT) targeting post-concussive symptom management and cognitive symptoms. Participant engagement (i.e. attendance, level of participation, ability to learn and apply strategies, and homework completion) and satisfaction were assessed with the Therapist Checklist and CCT Feedback Form.

### **Results**

All participants had a diagnosis of concussion, were enrolled on average 4 months post injury, and were sick-listed at a range of 70–100% at the time of inclusion. Attendance across CCT sessions was 97%. Eight out of nine topics in the CCT intervention received a rating above 3.5 on a five-point scale (i.e., towards very helpful). The items that received the highest mean ratings were information about TBI and post-concussive symptoms, and strategies targeting fatigue, prospective memory, and memory and learning. All participants were rated as participating fully (3/6) or moderately (3/6), and most (5/6) attempted to apply the trained skills to real-life situations.

### **Conclusions**

The results support the feasibility of a Norwegian adaptation of the intervention for a civilian sample with TBI.

### **4.3 Paper III**

#### **Background**

Employment participation is a key rehabilitation goal after TBI. The objective of this RCT was to compare the effectiveness of a combined cognitive and vocational intervention to TAU on RTW and work stability after TBI.

#### **Methods**

Patients with a history of mild to moderate TBI ( $n = 116$ ) who were referred to a specialised outpatient clinic at OUH, Norway, were randomised to receive both group-based CCT and SE ( $n = 60$ ) or TAU consisting of individualised multidisciplinary treatment ( $n = 56$ ). Participants were enrolled 2–3 months post injury. Work participation, stability and productivity were assessed at baseline and 3 and 6 months following inclusion.

#### **Results**

Mixed-effects models showed a statistically significant within-group increase in the proportion of participants who had returned to work, work percentage, and hours worked in both the CCT-SE and TAU groups from baseline to 6 months, but no between-group differences. Adjusting for baseline differences, results showed that a higher proportion of participants in the CCT-SE group had returned to work at 3 months. The majority of participants who were employed at 3 and 6 months were stably employed.

#### **Conclusions**

The findings suggest that CCT-SE can accelerate early RTW for individuals following mild to moderate TBI.

## 4.4 Paper IV

### Background

This study aimed to examine employment probability up to 10 years following moderate to severe TBI and identify significant predictors from baseline sociodemographic and injury characteristics.

### Methods

A longitudinal observational study followed 97 individuals with moderate to severe TBI for their employment status up to 10 years post injury. Participants were enrolled at the Trauma Referral Center in south-eastern Norway between 2005 and 2007.

Sociodemographic and injury characteristics were recorded at baseline. Employment outcomes were assessed at 1, 2, 5 and 10 years. HLM was used to examine employment status over time and assess the predictors of time, gender, age, relationship status, education, employment pre injury, occupation, cause of injury, acute GCS score, duration of PTA, CT findings, and ISS, as well as the interaction terms between significant predictors and time.

### Results

The employment probability for the full sample remained at ~50% across 1, 2, 5 and 10 years post injury. Gender ( $p = 0.016$ ), relationship status ( $p = 0.002$ ), pre injury employment ( $p < 0.001$ ) and occupational status at injury ( $p = 0.005$ ), and GCS ( $p = 0.006$ ) yielded statistically significant effects on employment probability. Men, individuals in a partnered relationship at the time of injury, those who had been employed at the time of injury, those in a white-collar profession, and those with a higher acute GCS score had significantly higher overall employment probability across the four time points. The time\*gender interaction term was statistically significant ( $p = 0.002$ ), suggesting that employment probabilities remained fairly stable over time for men, but showed a downward trend for women. The time\*employment at injury interaction term was statistically significant ( $p = 0.003$ ), suggesting that employment probability was fairly level over time for those who were employed at injury, but showed an upward trend over time for those who had been unemployed at injury.

## **Conclusions**

Overall employment probability remained relatively stable between 1 and 10 years. Baseline sociodemographic and injury characteristics were predictive of employment probability. Regular follow-up is recommended for patients at risk of long-term unemployment.

## **5 Discussion**

The discussion is divided into two main sections. The first section contains a discussion of the main results from papers II–IV in light of recent publications. The second section contains a discussion of methodological aspects concerning the internal and external validity of the studies.

### **5.1 Feasibility of the CCT intervention**

The objective of paper II was to assess the feasibility of recruitment procedures and delivery of a Norwegian adaptation of the CCT intervention in preparation for a larger-scale RCT. Feasibility studies have been broadly defined as studies that *asks whether something can be done, should we proceed with it, and if so, how* (175, p. 8). They are increasingly recognised as an important step when designing complex interventions. The larger-scale RCT had several characteristics of a complex intervention, involving multiple interacting components (176). Evaluating the effectiveness of interventions may be undermined by problems with recruitment and retention, delivery of the intervention, acceptability and compliance (177). Thus, determining the appropriateness of an intervention within a specific context and tailoring interventions to fit the target population are important prior to assessing treatment effectiveness.

The CCT intervention was developed in the US, where it has been administered to veterans with a history of mild to moderate TBI (140,141,169). Due to the considerable differences between the US and Norway in welfare systems and access to healthcare services, it was considered important to assess the acceptability of the CCT intervention in the Norwegian context before initiating the larger-scale RCT. Moreover, several key differences existed between the samples who received CogSMART or CCT in the US and

patients referred to follow-up at PM&R. Most importantly, the US samples consisted of veterans, who were mostly male. Military TBI differs from civilian TBI in several important ways, including injury mechanisms, prevalence of posttraumatic stress symptoms, and psychiatric comorbidities (178). Indeed, Twamley et al. (140,141) documented posttraumatic stress disorder–related symptomatology in 75% of their sample. Furthermore, all participants in the US studies were unemployed at the time of study inclusion, while our inclusion criteria pre-defined minimum 50% employment at the time of study inclusion.

Nine participants were asked to participate, of whom eight (89%) initially consented. However, one participant withdrew before receiving the intervention, and another dropped out after receiving one CCT session. These proportions were below our pre-defined success criteria, anticipating that 75% of those asked to participate would agree and that fewer than 30% would drop out. Moreover, there was no loss to follow-up, with all six participants completing the post-treatment follow-up at 3 months.

Attendance across the 10 CCT sessions was high. Five out of the six participants completed all CCT sessions, while one participant missed two sessions for personal reasons. The attendance rate was comparable to the pilot study performed by Twamley et al. (140), in which 15 out of 16 participants attended all CogSMART sessions, while one participant missed four sessions.

Results from the CCT Feedback Form indicated that the participants perceived most topics as useful. The mean rating across all 10 items was 3.6 (i.e. moderately to very helpful). The topics found most useful were information about post-concussive symptoms and TBI, strategies to deal with fatigue, prospective memory, and memory and learning, all rated as very useful. In comparison, the topic that received the highest rating in the pilot study of Twamley et al. was prospective memory strategies, also rated as very useful. The topic that received the lowest mean rating in our study was information about additional services. Five of the six participants stated that they would recommend the program to others with similar problems, while one responded “I don’t know”. This was slightly lower than in the pilot study of Twamley et al., in which all participants reported that they would recommend the program to other veterans.



To increase the chance of integrating the strategies into their daily life, the participants were provided with homework assignments between the CCT sessions. Reported rates of compliance with homework assignments in clinical trials range from 49% to 94% (179). Four (67%) out of the six participants completed the assignments to a satisfactory degree, while two did not. Although one participant was considered to have an acceptable reason, failing to complete the homework may have limited the generalisation of skills, thus limiting the potential therapeutic effect of the CCT intervention. Motivating the participants to complete home assignments and underlining the importance of practice to automate skills was identified as an area for improvement in the RCT.

## **5.2 Effectiveness of the combined cognitive and vocational intervention on employment outcomes at 6 months**

Results from the RCT (paper III) showed that a higher proportion of participants who received the CCT-SE intervention had returned to work at 3 months compared to the TAU group. This finding may indicate that the CCT-SE intervention accelerated RTW. Evidence-based guidelines recommend compensatory cognitive strategies for CR after TBI (137). Regarding VR, recommendations regarding specific approaches are lacking, although systematic reviews have found support for early interventions that involve multiple stakeholders: the employee, employer, and healthcare and employment service providers (8,15). The CCT-SE intervention consists of individualised work support and a combination of compensatory cognitive strategies, strategies to manage common symptoms and psychoeducation. Studies applying the SE approach have reported improvements in work outcomes for patients with severe TBI in the US (122-124) and individuals with mental health issues in Norway (125,126), while the CCT program has been found to reduce subjective complaints and improve neurocognitive function in veterans with mild to moderate TBI (140,141,169). As such, the present study indicates that improving early RTW rates for patients who experience persisting symptoms after mild and moderate TBI is possible by implementing early and coordinated efforts. However, as the CCT-SE intervention is complex, it is difficult to determine the specific contribution of each component to the observed higher RTW rate at 3 months.

There was, however, no difference between the CCT-SE and TAU groups regarding RTW proportion at 6 months. These findings are in line with a study by Cicerone et al. (145), which reported that a significantly larger proportion of patients with mild to severe TBI who received comprehensive holistic neuropsychological rehabilitation were engaged in community-based employment 4 months after study inclusion compared to standard care, but found no difference at 6 months. While the CCT-SE intervention may have sped RTW in the early phase, the TAU group also continued to improve and eventually reached the same level. This may indicate that the multidisciplinary follow-up also had a positive impact on RTW. However, a previous publication that compared the effectiveness of the multidisciplinary follow-up received by the TAU group in this study to follow-up by GPs reported that it may have reduced the number of post-concussive complaints but did not improve RTW (142). RTW may also have been influenced by the natural course of recovery. Teasing apart the specific effects of the interventions or natural recovery was unfortunately not possible, as we did not include a no-treatment control group.

Both CCT-SE and TAU had significant within-group improvement in RTW proportion, work percentage and hours worked during the 6-month follow-up. These findings are comparable to intervention studies that have included patients with similar characteristics. Scheenen et al. (147) compared the effectiveness of a cognitive behavioural intervention to telephonic counselling in patients with mTBI who were recruited 4–6 weeks after injury. The study revealed no between-group differences with regard to full RTW at 6 or 12 months after study inclusion but showed that both groups improved in RTW proportion during the study period. Vikane et al. (142) compared the effectiveness of multidisciplinary follow-up to follow-up by GPs in 151 individuals who had sustained an mTBI 2 months previously. Although no differences were found between the groups regarding days to sustainable employment, both groups improved regarding work participation. The improved rates of employment may have been due to the natural course of recovery but also to the effects of the interventions, because all patients received some form of treatment.

Improving early RTW rates following TBI is important to avoid the personal and socioeconomic consequences of unemployment. However, the literature indicates that

individuals who RTW too early may experience unfavourable outcomes (96). Results from this study showed that the majority of participants in both CCT-SE and TAU were stably employed between baseline and 3 and 6 months. This finding is in contrast to a study that reported relatively high rates of employment instability after mild to severe TBI (75). Moreover, a significant increase in hours worked was found from baseline to 6 months. Thus, the findings did not suggest that either CCT-SE or TAU contributed to premature RTW with a negative impact on measures of work stability or productivity. Future publications including the 12-month follow-up will yield important information regarding longer-term stability levels regarding RTW.

Contrary to our hypothesis, we found no significant differences in measures of work productivity between participants who received CCT-SE or TAU at 3 or 6 months. Although the mean work percentage from baseline to 6 months was not significantly different between the two groups, a higher proportion of participants in the CCT-SE group had returned to part-time employment 3 months post injury. Moreover, a non-significant higher proportion of participants in the CCT-SE group reported workplace accommodations at 3 and 6 months. SE aims to provide individually adapted work support to increase the chance of successful RTW, including advice regarding adapting work tasks and other work accommodations, while the CCT intervention provides psychoeducation, stress reduction techniques and compensatory strategies for cognitive complaints. Moreover, the therapists providing CCT and SE worked in close collaboration, increasing the chance of identifying specific issues and implementing individualised strategies in the workplace. These components may have positively influenced the participants' RTW process at an early stage.

In general, the proportion of participants who returned to work at 6 months was high in both groups. Still, 16% of the participants in the intervention group and 26% in the TAU group had not returned to work at 6 months. The standard work week in Norway is 37.5 hours. On average, the participants in the CCT-SE and TAU groups were working 19 and 17 hours per week, respectively, at 6 months. Moreover, only 35% of the participants on average were working between 80 and 100% of their pre injury work level, indicating that many were still working at a reduced level compared to before their injury. The proportion of participants who did not RTW is comparable to the study by de Koning et

al. (97). Norway is characterised by high job security, low unemployment, and a comprehensive welfare system where patients receive a full salary in the first year of sick leave. Possibly as a result of the economic security this provides, the rate of sickness absence is among the highest in Europe, and these sickness benefits may reduce the impact of interventions aimed to improve RTW (180).

### **5.3 Employment probability up to 10 years after moderate and severe TBI**

In contrast to our expectations, the overall employment rate for the full sample in paper IV remained relatively stable at approximately 50% between 1 and 10 years post injury (181). The rate is comparable to but slightly lower than the 58% employment rate reported in an Australian study 10 years after mild to severe TBI (182). Another Australian study (183) reported that 40% of those who were employed pre injury returned to open employment in some capacity and that this percentage remained stable over the first 10 years after mild to severe TBI. A study from the Netherlands (184) found that 43% were employed 10 years after moderate to severe TBI. The somewhat varying findings may be a result of the characteristics of the studied samples. For instance, the study by Dahm and Ponsford (182) included patients with less severe injury as measured by ISS, while Ponsford et al. and Grauwmeijer et al. (184) included patients with more severe TBI, measured by hospital LOS, GCS score, and duration of PTA, compared to our study sample. Differences may also be attributable to pre-injury employment rates or varying definitions of RTW: our study included students in the employed category, while Dahm and Ponsford (182) and Grauwmeijer et al. (184) grouped students with the unemployed. Reporting employment status for both students and those previously employed, Ponsford et al. (183) found almost comparable rates to our study, at 53.2% at 2 years, 50.1% at 5 years, and 49.9% at 10 years post injury.

The stable employment rate across the 10-year follow-up period is probably an expression of ‘plateauing’ recovery after the first year following the injury (184,185), but it may also indicate a lack of effective individually customised VR programs aiming to improve workability and return to employment (115), such as VR with SE (9). In support of this, a previous publication using data from the same sample (186) found that 31% of the patients reported unmet healthcare needs 5 years post injury. Of these, 62% reported

unmet vocational support needs. However, a recently published systematic review and meta-analysis that included 38 studies with moderate to severe TBI found that employment prevalence appeared to increase over time, from 34.9% at 1 year to 42.1% up to 5 years and 49.9% beyond 5 years (72). The overall post-injury employment prevalence reported in the meta-analysis was 42.2%.

The employment rates found in our study may be influenced by the significant long-term disability benefits offered by the Norwegian welfare security system following injury. A previous study from Denmark found that the proportion of individuals with severe TBI receiving welfare system support was considerably higher compared to population-matched controls (187). In contrast, patients with TBI living in countries with less comprehensive welfare systems may be compelled to RTW out of financial necessity (9). Still, comparable RTW rates have been reported across countries with different welfare systems, including the US (188), where limited access exists to disability benefits and employees must to a greater degree personally finance healthcare, medical insurance and education.

#### **5.4 Predictors of employment status 10 years after moderate and severe TBI**

The study results demonstrated that participants with less severe injury and those in white-collar occupations had a significantly higher probability of being employed at all time points. TBI severity, as measured by duration of PTA and GCS score, has consistently been linked to long-term employment outcomes (79,181,189,190). The association between having a blue-collar occupation (i.e. manual labour) at the time of injury and post-injury unemployment is consistent with a review by Ownsworth and McKenna (29) and large-scale studies from the US (74,88) and Australia (85), supporting the association between pre-injury occupation type and vocational outcomes including early RTW and employment probability up to 10 years post injury. This finding is somewhat contradictory because non-manual occupations may be related to higher cognitive demands, and cognitive impairment is frequently reported after moderate and severe TBI and shown to be negatively associated with employment outcomes (11,92,191). Conversely, manual labour is generally more physically demanding and presumably more difficult to resume when experiencing physical limitations. However,

previous publications have reported that cognitive impairments are more closely related to disability than physical limitations in the long term after TBI (11,192). An explanation for this finding may be that white-collar occupations are associated with greater autonomy and flexibility compared to blue-collar occupations, factors that have been suggested to be important when returning to work after TBI (193). In general, financial aspects could also account for different RTW rates between blue- and white-collar occupations, with white-collar occupations often providing higher income and thus a greater incentive to RTW. However, this is likely too simplistic an explanation, and studies have suggested that work status, personality traits, cognitive reserve and motivational factors may also be involved (88).

Being in a partner relationship at the time of injury was found in the present study to significantly improve employment probability trajectories (although the effect was driven by the first time points). Although a systematic review found inconclusive evidence for the association between marital status and employment (90), several studies have supported this finding and suggested that marital status is a significant predictor of employment post TBI (79,81,83,88). However, this finding is not TBI-specific, as studies have also found that being married or in a partner relationship is also associated with an increased chance of employment after a stroke or spinal cord injury (194). Family and social support have been identified as important for employment post TBI (7,96). Being married or in a partner relationship may provide emotional support and stability and help with performing daily tasks, which, in turn, may have a positive impact on work capacity.

The finding that participants who were unemployed at the time of injury were significantly less likely to be employed at each of the four time points is consistent with previous studies from several countries, including Norway (6,181), the US (79,81-84) and Australia (87). A possible explanation for this finding is that previous work experience, as well as familiarity with the workplace and specific tasks, may make the transition back to work more easily achievable for those who are employed at the time of injury.

Interestingly, the time\*employment at injury interaction term was significant, suggesting that those who had been unemployed at the time of injury had an increased likelihood of being employed at the 10-year follow-up. One reason may be that the majority of patients

who were unemployed at the time of injury were job seekers or receiving work assessment allowance, thus having improved prospects of attaining jobs over time.

Regarding gender differences in employment probability over time, a downward trend in employment for women was observed, while men's probabilities remained stable. The existing literature on this topic has shown mixed results. Corrigan et al. (80) investigated changes in employment 1 year after TBI and found that women were more likely to decrease working hours or be unemployed compared to men. This is also in line with a study by DiSanto et al. (82) reporting that women were less likely to be stably employed 5 years after moderate to severe TBI. In contrast, Walker et al. (88) found that women were more likely than men to be competitively employed 1 year after moderate to severe TBI, and Fraser et al. (190) found that women were more likely than men to maintain complex work post injury in a sample with mild complicated to severe TBI. A recent study by Hart et al. (92) reported that women had faster and higher RTW rates compared to men 1 year after moderate to severe TBI, while a study from Denmark found no association between gender and RTW after severe TBI (86). In line with our findings, Cuthbert et al. (74) demonstrated a significant relationship between being female and decreased probability of employment 10 years after moderate and severe TBI. Possible explanations for gender differences in employment outcome following TBI include societal influences related to gender roles, differences in job demands and biological differences (195). Women are more likely than men to report mental health problems and pain, which may interfere with their ability to cope with work demands, after major trauma (196). However, trends also exist in the general population of women reporting more symptoms than men, a higher percentage of women on sick leave, and women more often having part-time jobs (197).

In this study, age, education, cause of injury, CT severity score, and ISS did not significantly predict employment status 10 years post injury. Previous studies have indicated that age above 40 years at the time of injury predicts a lower probability of RTW after TBI (98,198). The lack of predictive value of age in this study may be explained by the limited age range of the included patients (16–55 years). Only 24% of the study sample was between 40 and 55 years of age. While Cuthbert et al. (74) identified lower educational level as a predictor for decreased employment probability 10

years after moderate and severe TBI, Grauwmeijer et al. (184) did not. Possible explanations for this finding are the similar frequencies of patients in the high- and low-education groups.

## **5.5 Methodological aspects**

### **5.5.1 External validity**

External validity refers to the extent to which the results can be generalised or applied to subjects outside the study sample, or whether the observations hold true in other settings and under other circumstances (199).

All patients who participated in the studies were recruited from OUH (a trauma hospital), either hospital-admitted acute TBI or referred from GPs to a specialised outpatient clinic at PM&R. The participants were a mixed population with regard to type and extent of received health services, and should therefore represent a broader range of patients than, for example, studies that recruit participants from rehabilitation facilities (which may lead to overestimation of the severity of TBI-related disability, and lower employment rates).

#### **Paper I**

The main reasons for publishing the study protocol were to enhance transparency, allow for replication and prevent publication bias. This increases the external validity of the study. Subsequent publications from the project will present results from other outcome measures described in the study protocol and all assessment time points (i.e. up to 12 months).

#### **Paper II**

The feasibility study was performed in preparation for the larger-scale RCT, and the same inclusion and exclusion criteria as for the RCT were applied. The feasibility study included patients with mTBI only, thus limiting generalisability to patients with more severe TBI and confirmed intracranial injuries. However, the studies performed in the US included patients with mild and moderate injury, indicating that delivery of the CCT intervention was feasible in groups of patients with both mild and moderate TBI. The



participants in the feasibility study represented a narrow age range (25–51 years). However, all participants were employed in full-time jobs at the time of injury, and were in the middle of their working careers, thus representative of patients who would be included in the larger-scale RCT.

### Paper III

RCTs are considered the gold standard for assessing treatment efficacy but may be limited by poor external validity (199). The present RCT was designed as a pragmatic study with an emphasis on treatment effectiveness. In healthcare interventions, efficacy refers to whether an intervention works under ideal or strictly controlled conditions, while effectiveness refers to whether an intervention works under real-life conditions (199). Most trials lie on a continuum between the two rather than in a dichotomy (200). The present study was pragmatic in that it was performed at, and representative of patients who receive follow-up at, the specialised outpatient clinic at PM&R (i.e. regular clinical practice), but still controlled with regard to the applied inclusion and exclusion criteria and randomisation of participants to the two treatment groups.

Of the 592 patients who were assessed for eligibility, 432 (73%) did not meet the inclusion criteria (see Figure 1). Individuals who were unemployed, receiving a disability pension or work assessment allowance, or students at the time of injury represented 17% of those not eligible for study participation. The main reasons for not meeting the inclusion criteria were time since injury and age, representing 51%. This may have limited the generalisability of the results to older patients and those who had sustained their injury more than 12 weeks previously. However, the inclusion criteria were chosen because we wanted to target patients who experienced continued difficulties affecting work participation before reaching an advanced stage of the chronification processes.

Of the 155 patients who were asked to participate, 39 (25%) declined, mainly due to time and capacity restrictions. No significant difference existed in injury severity (GCS score) between participants and those who declined, but those who declined to participate included a higher proportion of men and younger patients. Almost 60% of the study participants were female, thus differing from the gender distribution reported in epidemiological studies of TBI (51). This could have led to selection bias and should be

considered a limitation of the study. However, it is worth mentioning that the gender distribution reflects patients receiving follow-up at the specialised outpatient clinic at PM&R, thus being representative for the context the study was conducted in. Data from the Quality Registry of the outpatient clinic show that 10% more women than men are referred to multidisciplinary follow-ups (reference: personal communication with Quality Registry staff).

The mean years of education among the study participants was 16. This is higher than the education level among participants in the study by Twamley et al. (140), who reported on average 14 years of education. In 2018, Statistics Norway reported that 51.6% of inhabitants in Oslo and 38.7% of inhabitants in Akershus county (i.e. the counties participants were recruited from) above 16 years of age had a college or university degree. In comparison, the proportion of the general Norwegian population with a college or university degree was 34.1%. As such, the study participants may not be representative of individuals with a lower education level and those living in more rural areas.

The exclusion criteria may have limited the generalisability of the study results to patients with a history of severe psychiatric or neurological illness, active substance use or insufficient command of Norwegian.

#### Paper IV

The study population was unselected and representative of working-age patients with moderate to severe TBI from the south-eastern region of Norway admitted to OUH. OUH covers more than half of the Norwegian population. However, the mainly urban geographic study setting may limit the generalisability of the findings to broader patient populations who inhabit more rural areas. Additionally, because Norway is a welfare state that provides healthcare and social security benefits for all of its citizens, accompanied by better economic security for individuals with TBI compared with many other countries, the study may have limited generalisability to other global regions. Additionally, the age range at study admission (16–55 years) may limit the generalisability of the findings to those outside of this range.

The limited incidence of moderate to severe TBI in Norway (51,201) resulted in the relatively small overall sample size in the study (n = 133). Initially, 160 individuals met the study inclusion criteria. However, 27 individuals declined study participation, and we were unable to collect any data on these individuals due to directives from the Norwegian Data Inspectorate. Thus, a comparison of participants and those who declined to participate was not possible, and selection bias cannot be ruled out.

Four participants withdrew, and 32 died during the first 10 years after TBI, leaving 97 survivors in the study. The total attrition rate from the 1-year to 10-year follow-ups was 21%, which is lower than in other studies, where rates ranging from 56–62% have been reported (182,184).

The definition of employment used in this study may be a source of bias, thus limiting generalisability. Employment was categorised into unemployed (jobseekers, on sick leave or work assessment allowance, or receiving disability pension), and employed (working full- or part-time or studying). The definition of both employees and students as employed has also been applied in previous publications (202,203). Nevertheless, this dichotomous definition may not have been able to capture information on whether participants were able to work at the same workplace or meet the same work demands as compared to pre injury.

### **5.5.2 Internal validity**

Internal validity refers to the extent to which the results of the study are true for the sample of patients being studied – in other words, to what extent biases and confounding factors are kept to a minimum (199).

#### **Paper II**

The study was designed to test whether the CCT intervention was applicable in a convenience sample of Norwegian patients. We used the Therapist Checklist to assess ability to engage with the CCT intervention and the CCT Feedback Form to measure subjective satisfaction with the intervention. Both measures provide a more nuanced picture of treatment satisfaction and engagement by containing several response

categories as opposed to simple yes vs no categories. A limitation of the feasibility study was that we did not include a formal fidelity rating for delivery of the CCT intervention. However, senior researchers in the project attended several of the sessions and provided close supervision throughout the study period. Moreover, the therapists received training by the intervention developer, EW Twamley, before administering the intervention.

### Paper III

The study was conducted as an RCT. To avoid bias, randomisation was performed by an independent researcher not involved in other aspects of study implementation. The baseline assessment was performed before randomisation, leaving assessors unaware of group allocation. Although patients were instructed to not reveal their group assignment to outcome assessors at the 3- and 6-month follow-ups, it is difficult to guarantee that this was fully complied with, and we did not document the proportion of participants who may have revealed group allocation. Due to the nature of the interventions, it was not possible to blind the therapists who delivered the CCT-SE intervention or TAU to group allocation. In general, blinding is considered to be more difficult to achieve in nonpharmacologic than pharmacologic trials (204), but could be a source of bias as the therapists delivering CCT-SE and TAU may have been prompted to be more enthusiastic and attentive towards the participants. The participants were also aware of group allocation, which may have influenced the results in several ways. While knowing that they received a new treatment may have led to more favourable outcomes among the CCT-SE participants, receiving a well-established treatment may also have positively influenced outcomes in the TAU group. Moreover, compared to the follow-up that patients with mTBI receive in general, TAU in this context was rather comprehensive, which may have limited the possibility of capturing the effect of the CCT-SE intervention.

Considering all randomly allocated patients, 3% were lost to follow-up (i.e. dropped out or were unable to reach) in the CCT-SE group and 2% in the TAU group at 3 months, and 5% were lost to follow-up in both groups at 6 months. A loss to follow-up of <5% has been suggested to pose a small risk of bias in clinical trials (205).

Attendance in the cognitive part of the intervention was high, with only three participants missing a total of six sessions, which should be considered a strength of the study.

Regarding the SE part of the intervention, participants received on average three face-to-face meetings and 10 telephone contacts. Of the three face-to-face meetings, approximately one meeting per participant was at the workplace.

Approximately 90% of the participants in the RCT had sustained an mTBI as assessed by GCS score. We used the criteria developed by the ACRM to assess the presence of mTBI, and all patients had a confirmed diagnosis of TBI by a physician. Eleven participants in the CCT-SE group and 16 in the TAU group had confirmed traumatic intracranial injury documented by CT or MRI. Including patients with mild and moderate TBI in a group-based intervention could be considered counterintuitive given clinical characteristics and recovery trajectories may differ between these groups (27,55,206). However, because this was a pragmatic trial, we wanted to include patients reflecting clinical practice and characteristics of the patients referred to our outpatient clinic. Further, we modelled our study on the pilot study by Twamley et al. (140,141), which included individuals with a history of mild and moderate TBI, suggesting that a group-based intervention including both was feasible. However, we chose to exclude patients with a GCS score of 9 to avoid the most severe of the moderate injuries as these patients have clinical outcomes similar to those characterising severe TBI (206). Additional analyses were performed to assess whether the outcomes differed within and between the CCT-SE and TAU groups for participants with and without intracranial injuries, revealing no such differences.

We did not prevent participants from seeking other treatment during the study period. Thus, additional treatment may have confounded study results. The extent of additional treatment use will be assessed in the subsequent papers focusing on the costs and cost-effectiveness of the intervention.

To ensure that the CCT intervention was delivered according to the protocol, a fidelity assessment was performed by senior researchers in the project. Three of six items on the fidelity checklist were rated as excellent, while the remaining items were rated as good. The CCT groups varied in size and group dynamics, and thereby also in terms of time to complete each session. While the content of some CCT sessions was easy to get through in some groups, it took longer in others. As such, some deviation from the manual was

necessary. However, the overall fidelity rating indicated satisfactory adherence to the intervention manual.

#### Paper IV

The sample size in the present study was smaller than the recommendation by Mushkudiani et al. (78), and this is related to the study context as described above. Over time, one fifth of the participants were lost to follow-up. However, the attrition rate from 1-year to 10-year follow-up was low compared to other studies.

The majority of participants were assessed at the outpatient department at PM&R, where they completed the follow-up questionnaires. We could thereby to some degree limit the potential environmental differences in follow-ups and monitor the interpretation of questionnaires. This contributed to the internal validity of the study.

Due to the attrition rate and risk of selection bias, interpretation of the employment rates should be made with caution. Nevertheless, the longitudinal design with four follow-up time points (i.e. 388 observations) makes the probability analysis strong.

#### **5.5.3 Design**

#### Paper III

When planning the RCT, the number of treatment arms was discussed. Applying four treatment arms – one receiving CCT only, one SE only, one a combination of both CCT and SE, and one receiving TAU – would have increased the chance of teasing apart the contribution of specific study elements. However, due to time and funding restraints, and lack of a sufficient number of patients, this was not possible. Thus, it is difficult to determine the specific effects of the different elements of the interventions, which should be considered a study limitation. However, the fact that that the intervention was cross-sectoral and involved a complex intervention should also be considered one of the primary strengths of the project.

## Paper IV

The study was designed as a long-term longitudinal observational study, i.e. an extension of an existing longitudinal TBI research project (68,91,181). This implies that the study protocol, procedures and criteria for data collection were established at the beginning of the project (2005), which secured the relevance and completeness of the data. These policies dictated the direction of the study. Because the data collection at each follow-up followed the established protocol, the study has a high level of validity. The quality of the study data relied on the expertise of the main researcher (i.e., physiatrist), who collected the data across the follow-ups. The main researcher, Nada Andelic, was the principal investigator in the longitudinal observational study and has many years of experience as a researcher and clinician.

### **5.5.4 Statistics and sample size**

The sample size in the feasibility study, representing 10% of the total sample randomised to the CCT-SE intervention, was limited. A study by Stallard (207) recommended that the sample size in pilot studies should be approximately 0.03 times the intended sample size for a definitive clinical trial. The sample size in the feasibility study was within this recommendation.

The sample size calculation for the RCT was based on the primary outcome measure (i.e. RTW proportion) at 12 months. The required sample size was estimated at 55 participants in each group. We included 60 patients in the CCT-SE group and 55 in the TAU group. From baseline to 6 months, only three participants dropped out.

The data from the RCT were analysed according to the intention-to-treat principle as recommended by the CONSORT guidelines, meaning that all randomised participants were analysed according to the group they were assigned to regardless of study completion. Applying the intention-to-treat method ensured that the original randomisation was retained, increased the chance of drawing conclusions about the effectiveness of the intervention and reduced the risk of bias.

In paper IV, we did not perform a sample size calculation of the required subjects, because this was part of a longitudinal population-based study with relatively low loss to

follow-up compared to other similar studies. The statistical method of HLM was chosen for several advantages when analysing longitudinal data: it handles follow-up time points of unequal spacing and is flexible in handling missing data, substantially reducing the loss of statistical power and precision due to its robustness when handling missing data (208).



## **6 Conclusions and implications**

### **6.1 Conclusions**

- A Norwegian version of the CCT intervention demonstrated satisfactory acceptability and was feasible in a civilian sample with TBI.
- The close trans-sectoral collaboration between health and vocational service providers in the combined cognitive and vocational intervention increased the chance of identifying specific issues and implementing individualised strategies in the workplace.
- The combined CCT and SE intervention may have accelerated early RTW in patients with mild to moderate TBI, compared to TAU.
- Neither TAU nor CCT-SE appeared to contribute to premature RTW with negative impacts on employment outcomes.
- Employment probability remained stable up to a decade after moderate to severe TBI and could be predicted by gender, relationship status, pre-injury employment, occupational status at the time of injury, and severity of injury.

### **6.2 Implications for practice and future research**

The studies included in this thesis aimed to provide new knowledge regarding long-term employment outcomes and the effectiveness of a novel approach to improve employment participation after TBI. The results have several implications and are important to clinicians, as well as health and employment authorities who are concerned with rehabilitation both after TBI and in other patient populations with corresponding conditions. However, the conclusions must be interpreted in light of the strengths and limitations of each paper.

The CCT intervention was feasible and well received by individuals with mild and moderate TBI in the Norwegian context. The combined CCT and SE intervention provided both psychoeducation and strategies targeting cognitive and other common complaints after TBI, in addition to individually adapted work support. The trans-sectoral collaboration between healthcare (the therapists providing CCT) and employment services (employment specialists from the labour and welfare system) increased the

chance of identifying specific issues and implementing individualised strategies in the workplace. These components may have positively influenced the participants' RTW process at an early stage. However, the CCT-SE intervention was time-consuming, and cost-effectiveness needs to be assessed before providing recommendations regarding whether it should be offered as standard treatment.

Future publications from the project will assess the effectiveness of the CCT-SE intervention in reducing somatic, emotional and cognitive symptoms, in addition to its effectiveness in improving health-related quality of life. Moreover, future publications will provide qualitative information on the RTW process focusing on the employer and workplace to identify specific workplace issues that may encourage or hamper RTW after TBI.

Future studies that aim to improve vocational outcomes after TBI may build on experience from this research. To provide more individualised treatment, the CCT intervention may be customised to patients' problems and preferences, and provided together with individualised work support.

Results from the longitudinal observational study provided important insight into employment probability and associated predictors in the long-term perspective following moderate and severe TBI. The findings underline the need for regular follow-up in the short and long term, and provide information on characteristics of individuals who may be at heightened risk of unemployment in the long term. Individualised work-related interventions may be needed to improve employment outcomes after moderate and severe TBI, and could be based on cross-sectoral collaboration and knowledge gained from the RCT.

Comparing outcomes across clinical trials aimed at improving vocational outcomes after TBI is difficult due to large methodological variations, particularly varying definitions of vocational outcomes. Future studies should aim to adopt common definitions of employment outcomes, including RTW and work stability.

Studies aimed at predicting employment outcomes rely largely on individually available sociodemographic and clinical information. Future studies should also assess the potential

impact of rehabilitation services, including VR. Moreover, modifiable workplace-specific factors that could influence RTW, including workplace accommodations and environmental, management and organisational factors, should be investigated.

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## **8 Appendix: Paper I-IV**









STUDY PROTOCOL

Open Access



# Combined cognitive and vocational interventions after mild to moderate traumatic brain injury: study protocol for a randomized controlled trial

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## Abstract

**Background:** A considerable proportion of patients with mild to moderate traumatic brain injury (TBI) experience long-lasting somatic, cognitive, and emotional symptoms that may hamper their capacity to return to work (RTW). Although several studies have described medical, psychological, and work-related factors that predict RTW after TBI, well-controlled intervention studies regarding RTW are scarce. Furthermore, there has traditionally been weak collaboration among health-related rehabilitation services, the labor and welfare sector, and workplaces.

**Methods/design:** This study protocol describes an innovative randomized controlled trial in which we will explore the effect of combining manualized cognitive rehabilitation (Compensatory Cognitive Training [CCT]) and supported employment (SE) on RTW and related outcomes for patients with mild to moderate TBI in real-life competitive work settings. The study will be carried out in the southeastern region of Norway and thereby be performed within the Norwegian welfare system. Patients aged 18–60 years with mild to moderate TBI who are employed in a minimum 50% position at the time of injury and sick-listed 50% or more for postconcussive symptoms 2 months postinjury will be included in the study. A comprehensive assessment of neurocognitive function, self-reported symptoms, emotional distress, coping style, and quality of life will be performed at baseline, immediately after CCT (3 months after inclusion), following the end of SE (6 months after inclusion), and 12 months following study inclusion. The primary outcome measures are the proportion of participants who have returned to work at 12-month follow-up and length of time until RTW, in addition to work stability as well as work productivity over the first year following the intervention. Secondary outcomes include changes in self-reported symptoms, emotional and cognitive function, and quality of life. Additionally, a qualitative RTW process evaluation focused on organizational challenges at the workplace will be performed.

(Continued on next page)

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**Discussion:** The proposed study will combine cognitive and vocational rehabilitation and explore the efficacy of increased cross-sectoral collaboration between specialized health care services and the labor and welfare system. If the intervention proves effective, the project will describe the cost-effectiveness and utility of the program and thereby provide important information for policy makers. In addition, knowledge about the RTW process for persons with TBI and their workplaces will be provided.

**Trial registration:** ClinicalTrials.gov, NCT03092713. Registered on 10 March 2017.

**Keywords:** Mild traumatic brain injury, Cognitive remediation, Supported employment, Individual Placement and Support (IPS), Five-Step Process, Return to work, Work inclusion, Disability management

## Background

Successful return to work (RTW) is a major challenge after traumatic brain injury (TBI) [1–6]. Personal factors such as educational level and occupational status, as well as injury-related characteristics, may predict vocational outcome [7–9]. The person's own perceptions and motivations regarding RTW, as well as aspects of the workplace environment, also have been associated with RTW and work participation after sickness-related absence [10, 11]. Existing literature suggests that the proportion of individuals with TBI who return to work varies from 13 to 85% [7, 8, 12]. Many TBI survivors return to work prematurely and fail to cope with work demands over time once the full impact of the injury is realized. This is probably due to insufficiently coordinated and managed RTW processes and results in low work stability [13].

For many individuals with mild to moderate TBI, it is a major challenge to maintain employment over time while experiencing somatic, cognitive, and emotional symptoms [12, 14]. Impaired executive functioning, learning, memory, and attention are strongly associated with RTW across a variety of disorders affecting brain function and can result in slowness in work performance; difficulties with learning work tasks; distractibility; and problems with planning, organization, and goal-directed behavior. All of these factors may lead to work failure [13, 14]. However, large-scale literature reviews have documented that rehabilitation programs aimed at teaching patients with mild to moderate cognitive problems strategies to manage and compensate for their problems should be a practice standard [15, 16]. Positive work outcomes following cognitive rehabilitation interventions have been reported in studies on moderate to severe TBI [17], but the evidence is insufficient to draw strong conclusions. Compensatory cognitive interventions typically teach clients strategies to compensate for their cognitive deficits in daily living activities, but vocational rehabilitation is rarely addressed specifically in these TBI programs. Authors of a review published in 2009 found that supported employment (SE), based on long-term support and job skills reinforcement through on-the-job coaching, could overcome the limitations of

program-based vocational rehabilitation [18]. Furthermore, authors of a systematic review assessing effective RTW interventions found that involvement of patient and employer and work or workplace accommodations were among the components incorporated in the most effective interventions [19].

To date, only a couple of randomized controlled trials (RCTs) have combined cognitive and vocational rehabilitation/SE for patients with mild to moderate TBI [20, 21]. The only study resembling our present protocol was performed by Twamley et al. [21, 22]. Their 12-week compensatory cognitive rehabilitation intervention (Cognitive Symptom Management and Rehabilitation Therapy [CogSMART]) was offered in addition to SE for U.S. veterans with mild to moderate TBI. All participants were unemployed but wished to return to work. This group was compared with a control group (CG) that received enhanced SE only. Participants assigned to both SE and CogSMART demonstrated significant reductions in postconcussive symptoms and improvements in prospective memory, but there were no effects on RTW. The authors noted that their study was a pilot in need of replication. Moreover, a process evaluation was not performed in their study, and there are significant differences between the United States and Norway regarding the labor market as well as the welfare system. There is a need to explore different stakeholders' experiences and processes at the workplace in the RTW process. Finally, there are no RCTs in which researchers have examined the cost-effectiveness of vocational rehabilitation following TBI.

## Approaches, hypotheses, and choice of methods

The present study was based on Twamley et al.'s 2014 pilot study that targeted individuals with mild and moderate TBI with persistent cognitive and postconcussive symptoms. The aim of their study was to assess the effect of the CogSMART intervention in combination with SE on improving postconcussive symptoms, neuropsychological performance, quality of life, functional capacity, emotional symptoms, and work participation [21]. Compensatory Cognitive Training (CCT) is a further development of CogSMART [23]. It is a group-based, manualized intervention that includes ten weekly

sessions, and it is theoretically based on elements derived from prior cognitive training programs for people with TBI and severe mental illness [21, 23, 24]. The intervention is focused on psychoeducation and compensatory strategy training, and it targets postconcussive symptom management and cognitive symptoms. It is focused on the effect that postconcussive symptoms (such as sleep disturbance, pain, fatigue, headache, tension, and emotional distress) can have on cognitive symptoms and functional recovery. The CCT intervention stresses a biopsychosocial understanding, and it is aimed at educating participants about this complex interrelationship and teaching them stress reduction techniques and strategies to compensate for the functional consequences of the symptoms they are experiencing. The compensatory cognitive strategies target prospective memory, attention and concentration, learning and memory, and executive function [21, 25]. Pilot studies of patients with mild to moderate TBI have demonstrated the efficacy of CogSMART and CCT in improving emotional problems, functional capacity, quality of life, and performance on neurocognitive measures [21–23].

A novel approach to vocational rehabilitation based on the “place-then-train principles” in SE involves support in real-life competitive work settings and is aimed at providing professional services to people with disabilities to help them participate in the competitive labor market [26]. The Five-Step Process describes support activities in the inclusion process: engagement, vocational profiling, job finding, employer engagement, and on-/off-job support. The Individual Placement and Support (IPS) Fidelity Scale is based on eight principles: competitive employment, eligibility based on client choice, integration of rehabilitation and health care services, attention to client preferences, personalized benefits counseling, rapid job search, systematic job development, and time-unlimited and individualized support. SE has not been evaluated in RTW for individuals with TBI in the Norwegian context, but IPS has gained empirical support with positive results in terms of both work inclusion and non-work-related outcomes for people with mental illness [27–29]. SE will be implemented in this RCT in combination with CCT. To determine the feasibility of the proposed interventions and the implementation of procedures in a Norwegian context, a feasibility study will be conducted. In the RCT, the effectiveness of a combined cognitive and vocational rehabilitation intervention compared with treatment as usual (TAU; a nonstandardized rehabilitation provided by a multidisciplinary rehabilitation team) will be evaluated.

The following are the main study hypotheses:

- Combined CCT and SE will result in a faster RTW and better work stability, as well as reduced postconcussive symptoms and improved cognition, than TAU.

- Combined CCT and SE will result in reduced emotional distress and improved quality of life compared with TAU.
- Combined CCT and SE will be a cost-effective alternative compared with the TAU condition.
- Factors related both to the workplace and to the patient’s motivation for RTW will affect the RTW process.

## Methods/design

### Study design

The proposed study will be a parallel-group RCT with a mixed method in design. Based on the Standard Protocol Items: Recommendations for Interventional Trials (SPIRIT), the study flowchart, standard protocol items, and SPIRIT checklist are provided in Figs. 1 and 2, and Additional file 1, respectively. Once included, participants will undergo a baseline assessment of cognitive and emotional status (T1), with further assessments immediately following the CCT intervention (3 months after study inclusion [T2]), following the end of SE (maximum 6 months after inclusion [T3]), and 12 months after study inclusion (T4). All study assessments will be conducted at Oslo University Hospital (OUH). A process evaluation will be performed to explore participants’ experiences with the intervention, as well as individual and workplace-related mechanisms of importance in the RTW process. A qualitative evaluation study regarding patient experiences with CCT is also being planned.

### Study setting

Participants will be recruited from OUH and from general practitioners’ practices. OUH is the trauma referral center for the southeastern region of Norway and has a population base of more than half of the Norwegian population (i.e., 2.9 million). A feasibility study was conducted in the spring of 2017; recruitment for the RCT began in July 2017; and recruitment will continue until the required sample size has been achieved.

### Eligibility criteria

The study population will consist of patients with mild to moderate TBI as assessed by a Glasgow Coma Scale (GCS) score of 10–15, loss of consciousness (LOC) for < 24 h, and posttraumatic amnesia (PTA) for < 7 days [25]. Confirmation of the diagnosis of mild TBI will be done by documenting that acute symptoms adhere to the American Congress of Rehabilitation Medicine’s definition of mild TBI [30]. This will be either extracted from preexisting medical records or established at the time of screening for study eligibility. Patients will be considered eligible for study inclusion if they are employed in a minimum 50% position at the time of injury and are sick-listed at the 50% or higher level because of postconcussive symptoms 2 months postinjury as assessed by

	STUDY PERIOD						
	Enrollment	Baseline assessment	Allocation	Intervention	Outcome assessment		
TIMEPOINT		t <sub>1</sub>			t <sub>2</sub> following CCT (3 months post inclusion)	t <sub>3</sub> following SE (6 months post inclusion)	t <sub>4</sub> 12 months following inclusion
		8 (+/- 2) weeks post-Injury					
<b>ENROLLMENT:</b>							
Eligibility screening	X						
Informed consent	X						
Allocation			X				
<b>INTERVENTIONS:</b>							
Compensatory Cognitive Training + Supported Employment				X			
Treatment as usual				X			
<b>ASSESSMENTS:</b>							
Primary outcome measures (return to work, work stability, work-related changes)		X			X	X	X
Secondary outcome measures (HRQoL, post-concussive symptoms)		X			X	X	X
Other outcome measures (fatigue, sleep, emotional distress, self-efficacy, cognition)		X			X (self-report only)	X	X
Determination of costs					x	X	X

**Fig. 1** Standard Protocol Items: Recommendations for Interventional Trials (SPIRIT) figure. CCT Compensatory Cognitive Training, HRQoL health-related quality of life, SE Supported employment

the Rivermead Post-Concussion Symptoms Questionnaire [31]. Participants will be aged 18–60 years and reside in Oslo or Akershus County. Patients with a history of severe psychiatric or neurological illness, active substance abuse, or inability to speak and read Norwegian will be excluded.

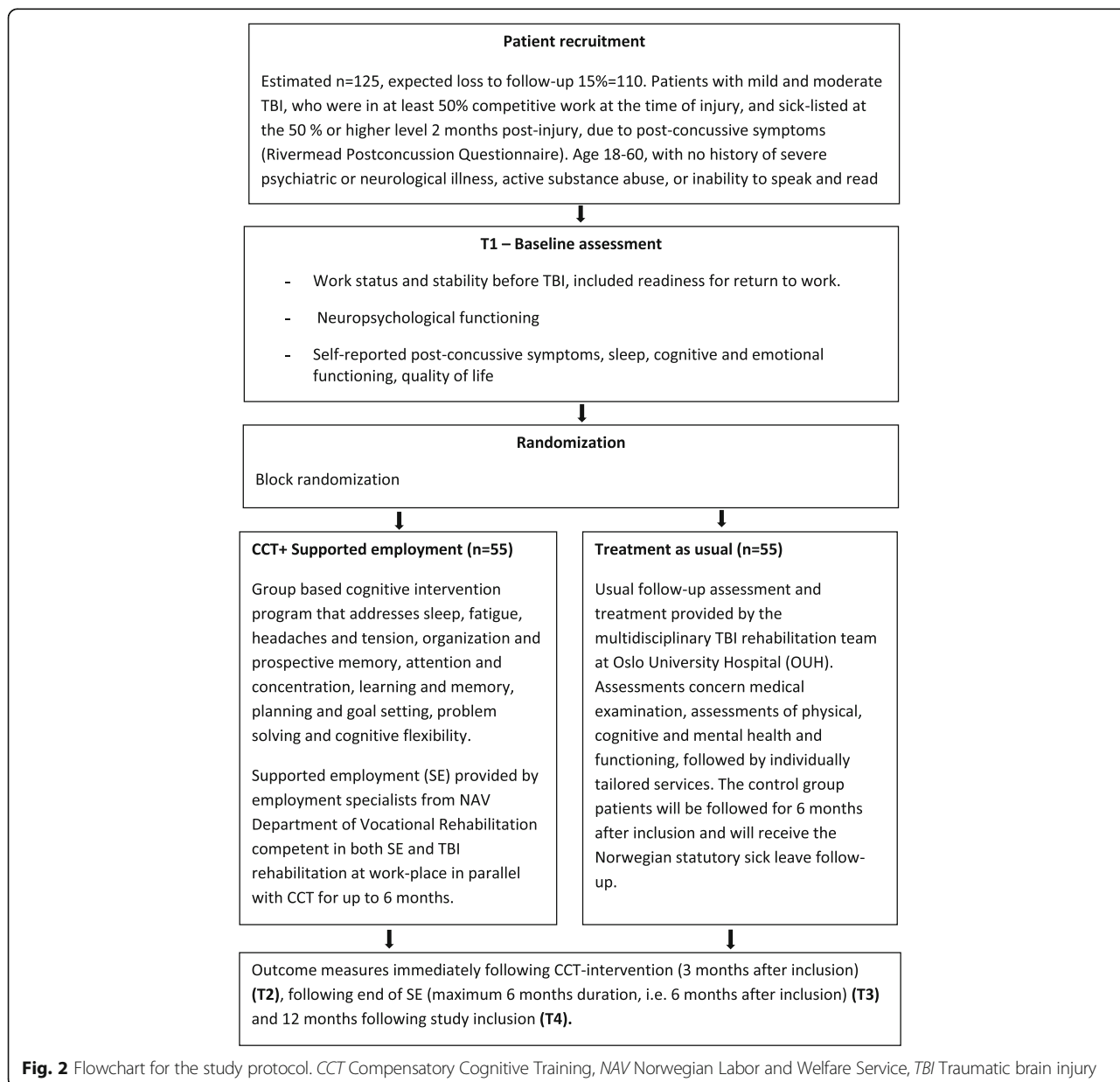
**Patient characteristics**

The following sociodemographic variables will be recorded: age, sex, marital status, living conditions, educational level, description of preinjury employment, workplace, and work stability (days on sickness benefits 1 year prior to the injury). The Readiness for Return to Work scale [32] will be applied at baseline to assess the participants’ perceptions regarding RTW. To measure the impact of the work environment on the RTW process, the Copenhagen Psychosocial Questionnaire (COPSOQ) short version [33] will be applied at baseline. Medical variables include injury characteristics and

clinical severity (GCS, LOC, PTA), neuroimaging results, length of hospitalization, medical treatment modalities, post-concussion symptoms, fatigue, and insomnia.

**Outcomes**

The primary outcome measures are work participation as measured by the proportion of participants who have returned to work at 12-month follow-up and length of time before return to work (in days), work productivity (hours worked, work-related changes [i.e., reduced productivity, increased supervision, work content changes], and work stability [i.e., sickness absence after initial RTW and throughout the study period]). To provide descriptive information and group comparisons, an IQ estimate (Vocabulary, Similarities, Block Design, and Matrix Reasoning subscales of the Wechsler Adult Intelligence Scale–Fourth Edition) will be included at baseline (T1) only [34].



Postconcussive symptoms and quality of life will be used as secondary outcome measures at all time points (T1–T4), whereas outcome will also be measured in the domains of fatigue, sleep, emotional distress, self-efficacy, and cognition. The instruments that will be applied are listed in Table 1. Neuropsychological evaluation will not be conducted at T2.

**Process evaluation: qualitative perspective on RTW process**

The aim of the qualitative process evaluation is to explore features of the “train and maintain” elements that take place at the workplace during the RTW process (i.e. types of support, as well as if and how the employment specialists manage to generate partnerships

with employers for job adjustments and adapt work, job development, and job carving to fit the needs of employees with TBI). Additionally, we will assess how risks, challenging behavior, and conflicts are dealt with, as well as how natural internal company support and increased inclusion competencies within the workplaces may be developed. In line with theory [35], we assume that increased practical knowledge of opportunities and obstacles for work inclusion at the workplace generates increased commitment among the relevant stakeholders. This knowledge and learning process in the work organization may increase the possibility for successful RTW and job tenure. Furthermore, via the qualitative evaluation process, we will seek to identify which

**Table 1** Secondary and other outcome measures

Outcome measure	Measures
Secondary outcomes	
Postconcussive symptoms	Rivermead Post-Concussion Symptoms Questionnaire (RPQ) [31]
Quality of life	EuroQol five dimensions (EQ-5D) [48] Quality of Life After Brain Injury instrument (Qolibri) [49]
Other outcome measures	
Fatigue	Fatigue Severity Scale (FSS) [50]
Sleep	Insomnia Severity Index (ISI) [51]
Self-reported cognitive functioning	Cognitive Failures Questionnaire (CFQ) [52]
Emotional functioning (anxiety and depressive symptoms, posttraumatic stress symptoms, and self-efficacy)	The Patient Health Questionnaire (PHQ-9) [53] Generalized Anxiety Disorder seven-item (GAD-7) scale [54] Posttraumatic Symptom Scale (PTSS-10) [55] General Self-Efficacy Scale (GSS) [56]
Neuropsychological test measures	
Learning and memory	California Verbal Learning Test–Second Edition (CVLT-II) [57]
Prospective memory	Memory for Intentions Screening Test (MIST) [58]
Processing speed/executive function	Color Word Interference Test from the Delis-Kaplan Executive Function System (D-KEFS) [59] Trail Making Test (TMT) from the Delis-Kaplan Executive Function System (D-KEFS) [59] Coding from the Wechsler Adult Intelligence Scale–Fourth Edition (WAIS-IV) [34] Ruff 2 and 7 Selective Attention Test [60] Modified Six Elements Test from the Behavioral Assessment of the Dysexecutive Syndrome (BADS) (to be applied at T4 only) [61]
Validity	Forced Choice Recognition index from the CVLT-II [57]

managerial styles are most effective in creating secure work environments and promoting successful RTW processes for the targeted population.

The process evaluation will be based on semistructured interviews in individual RTW case processes. Each case process will include three informant groups: participant, workplace employer, and employment specialist (intervention group only) or supervisor at the local office of the public Norwegian Labor and Welfare Service (NAV) (CG only). Interviews will be conducted at two different time points in each case process: 1 month and 12 months following RTW. The interviews will provide an empirical base for additional knowledge on job

content and skill requirements (i.e., possibilities for adapted/alternative work tasks); work environment quality (i.e., demands, control, support); the role of management as well as types and features of work organization (i.e., division of tasks, specialization, interdependencies), and what kind of external support is needed (i.e., the employment specialists’ contributions that influence job match achievement and the sustainability of the work relationship).

The contents of the interview questionnaires are developed on the basis of selected elements from the COPSOQ [33], the Multifactor Leadership Questionnaire [36], and the SE Five-Step Process and IPS Fidelity Scale [37, 38]. In the interviews in both the intervention and control groups, we will seek to achieve the following:

- Identify the employment specialist’s methods as well as cooperation between the employment specialist and the CCT team, the employment specialist and the employer, and the employment specialist and the person with TBI
- Identify attributes and workplace conditions (e.g., work tasks/production, internal company training systems, work environment, and management factors) that may influence the RTW process
- Identify work organizational indicators for successful RTW and job stability
- Identify significant changes in individual inclusion and exclusion processes at the work organization level
- Identify effective managerial styles that promote RTW

**Sample size**

Regarding RTW, an OR of 2.0 between the Compensatory Cognitive Training–Supported Employment (CCT-SE) and CG is regarded as the smallest relevant clinical and societal OR. Thus, the required total sample size calculated using G\*Power is 110 (i.e., 55 persons in each group;  $\alpha = 0.05$ , power level of 0.80) [39]. With an estimated loss to follow-up of 15% [40], 125 participants will be required. On the basis of an ongoing TBI study [41], we assume that this will be achievable within 12–18 months. An OR of 2.0 is equivalent to a 33% absolute difference in employment status between the two groups. According to Twamley et al. [21], 50% of patients attained competitive work at 12-month follow-up. If the proportion of employed patients in the CG is 50% at 12-month follow-up, the proportion for the intervention group in this study will be expected to be 83% or above on the basis of the given estimation.

Two strategic samples will be drawn for the process evaluation, comprising 40 cases from the intervention group and 20 from the CG. It is a goal to achieve a heterogeneous sample with variation in severity of TBI,

sex, age, type of job and workplace, company size, industry, and sector.

### Randomization

A permuted block randomization sequence will be generated by an independent statistician prior to the start of the trial. Eligible patients who consent to study participation will be randomly allocated in a 1:1 ratio in each block to receive either the study intervention or TAU (CG). An investigator who is independent of the patient screening process will be responsible for allocating the patients to the study conditions. Blinding of the patients and rehabilitation professionals is not possible, but the outcome assessors will be blinded to study allocation.

### Study interventions

#### *CCT-SE intervention*

The CCT-SE intervention will comprise a 10-week manualized group intervention that includes weekly CCT group sessions with three to seven participants, which will be provided by a psychologist at OUH. CCT includes psychoeducation, strategy training, and establishment of new habits in several domains. Patients learn about the natural course of postconcussive symptoms and are introduced to sleep hygiene and stress reduction techniques. Compensatory cognitive strategies are taught regarding organization and prospective memory (task management), attention and concentration (during tasks and social interaction), planning and goal setting, learning and memory (internal and external strategies), and executive function (problem solving and self-monitoring). The CCT manual has been translated into Norwegian and adapted to Norwegian conditions in collaboration with the original author of the manual (Twamley [21, 42]). The Norwegian user organization (Personskadeforbundet LTN) has participated in the translation process [43].

The vocational part of the intervention is based on SE principles and will be provided by three trained employment specialists from the NAV Department of Vocational Rehabilitation. For the purpose of this study, the participants will receive vocational intervention for a maximum of 6 months. A main emphasis will be on stages 1 (client engagement), 4 (employer engagement), and 5 (on- and off-the-job support) of the SE Five-Stage Process [38], because all participants will be in regular employment at the time of injury. The initial contact with the participant will be focused on establishing a trustful relationship between the employment specialist and the participant. The employment specialists will use the approach of “discovery,” a process for involving the participant in his/her own RTW process. The next step is mapping the patient’s resources, limitations, and work tasks, as well as establishing common goals between the employment specialist and the participant. The following sessions will be customized to the employee’s needs and

may include consultations, guidance and advice, learning/training, work task adaptations, and assistive technology. The sessions may also include the employer and the supervisor at the local NAV office if considered beneficial. The vocational intervention will be integrated with standard Norwegian statutory sick leave follow-up. The International Classification of Health Interventions (ICHI) will be applied for the standardization and documentation of the individualized interventions [44]. ICHI is a tool developed by the World Health Organization for reporting and analyzing health interventions and covers interventions carried out by a broad range of health care providers, including acute care, postacute care, and rehabilitation, as well as assistance with functioning, health prevention, and public health matters. ICHI is still under development, and the last published version is denoted as alpha version 2. The classification will be ready for operational use during the study period.

For the CCT-SE, three NAV employment specialists in the project will follow one group program each to become well acquainted with CCT content and ensure implementation of strategies and compensatory techniques at the workplace. Continuous cooperation between the CCT team, employee, and SE personnel will be emphasized. Employment specialists have participated in formalized postgraduate SE education at Oslo and Akershus University College of Applied Sciences (HiOA). The content of the education is based on the SE Five-Stage Process and the SE Fidelity Scale [37, 38]. Supervision of the employment specialists will be provided by HiOA, with special attention given to discovery, working with employers, on- and off-the-job training, and ongoing support.

The two doctoral candidates in the project will be responsible for provision of the CCT intervention. They are both experienced psychologists and will work in close collaboration with their doctoral program supervisors and the intervention developer (E. W. Twamley). The feasibility study will ensure adequate training and provide an opportunity to make necessary adjustments to the Norwegian version before inclusion in the RCT.

#### *TAU*

The CG will receive TAU, which includes follow-up assessment and treatment provided by the multidisciplinary TBI rehabilitation team at OUH. The team consists of six rehabilitation professionals, thus fulfilling requirements for complex rehabilitation [45]. Patients will undergo a medical examination and assessment of physical, cognitive, and mental health and functioning, followed by individually tailored services. The CG will be followed for 6 months after inclusion. These patients will also receive the Norwegian statutory sick leave follow-up, and the treatment received will be registered and mapped according to the ICHI.

### Statistical analysis

Descriptive statistics will be used to describe the baseline and injury characteristics of the variables related to participants and services. The *t* test will be used to analyze between-group mean comparisons for normally distributed continuous data, and the Mann-Whitney *U* tests will be used to analyze skewed data. For the primary outcome measures, a logistic regression model will be used to compare the proportions of participants returning to work at T4 in the CCT-SE and TAU groups, adjusting for other potential confounders. In addition, linear regression analysis will be applied to compare the difference in the mean length to RTW between the intervention groups at T4, adjusting for other potential confounders. For the secondary outcome measures, repeated measures analysis of variance will be used with time (T1–T4) as the repeated-measures factor and group (CCT-SE and TAU) being a between-group factor to test whether the CCT-SE intervention has a beneficial effect compared with TAU on RTW, symptoms, and functioning. The intention-to-treat principle will be applied for all proposed analyses.

### Process evaluation analysis

Each semistructured interview will be audio-recorded and last approximately 60 minutes. After the interview, the researchers will complete a table describing the main topics that emerged. Each interview will be summarized into keywords and coded into the table. Each case process will be coded into one overarching table, including different informant groups' perspectives within the same case over time. Finally, all cases will be analyzed thematically.

### Health economic analysis

Information concerning costs will be gathered at follow-up (T2–T4) using a cost registration form. For the calculation of the total costs, direct health care costs (i.e., health care provider costs), direct nonhealth costs (i.e., costs of informal health care), and indirect costs (i.e., loss of paid and unpaid work productivity) will be determined. Costs of interventions and patient income will be calculated in Norwegian kroner.

Cost-effectiveness and cost-utility analyses will be performed to determine the cost-effectiveness of the intervention. The analysis will be based on the effect of the intervention on RTW/work participation and effect on functioning, including health-related quality of life (HRQoL). First, we will calculate the economic benefit as a result of the employment effect of the intervention (income and cost of intervention) as compared with the CG. Second, the cost of the intervention will be seen in terms of health benefits (improved HRQoL). Using standardized conversion tools, it is possible to convert

health benefits into an index of HRQoL as measured by the EuroQol five dimensions questionnaire (EQ-5D). With this analysis, we can compare quality of life in the intervention group and the CG. Standard discounting will be performed for both costs and outcomes together with sensitivity and uncertainty analysis. Full- or part-time work will be accounted for.

### Ethics and dissemination

The study has been presented to and approved by the Norwegian Regional Committee for Medical and Health Research Ethics (REK) (REK number 2016/2038). The project will be conducted according to the ethical guidelines of the Helsinki declaration [46]. Information about the study will be presented to the patients in written and oral form. Written informed consent will be obtained, and the right to withdraw from the project at any time without any explanation necessary will be emphasized. We consider the randomization procedure to be ethically acceptable. All data will be unidentifiable when sharing between partners, and personal data will not be identifiable in the analysis or presentations.

The study will be conducted in close collaboration with the user organization [43]. The user organization is represented in the management committee and has had an active role in the translation and adaptation of the cognitive intervention manual to the Norwegian setting.

The anonymized quantitative data will be stored in the database on the research server at OUH. In the qualitative part of the study, additional informed consent will be obtained from workplace managers, employment specialists, and supervisors at the local NAV office who will be interviewed. The qualitative data (the audio recordings of the interviews) will be properly stored in controlled access folders on an HiOA research server. Both tapes and transcripts will be kept locked at the Work Research Institute/HiOA. All data will be securely contained for 5 years after the end of the project.

The trial report and other dissemination documents will be written according to the Consolidated Standards of Reporting Trials (CONSORT) statement to facilitate complete and transparent reporting and aid in critical appraisal and interpretation [47]. The dissemination plan reflects the research communities involved in this multidisciplinary project. We aim to publish reports of the project in journals of neurology, neuropsychology, brain injury rehabilitation, occupational research, and social sciences. Experiences with and results of the project will also be disseminated in relevant expert forums, national and international meetings, conferences, popular scientific journals, and reports. The results will also be shared with the user organization and its members through their communication channels in print and on the Internet.



## Discussion

This project is highly innovative by involving cross-sectoral partnerships (between specialized health care and research services, the labor and welfare system, and work and social scientist milieus) in a well-controlled RCT on cognitive and vocational rehabilitation after TBI. The project results can inform decisions and ultimately labor and welfare system practice. Because cognitive difficulties and challenges in RTW are not limited to TBI, this study has potential relevance to other patient groups whose cognitive symptoms complicate work participation. The RCT will provide knowledge about the cost-effectiveness of the treatment program. The project will have an impact on knowledge of the “train and maintain” aspects of support systems and businesses dealing with sick leave and RTW, as well as on the further development of the SE approach, especially concerning the role of the employment specialist at the workplace. Because TBI tends to affect young people, there is considerable potential societal monetary gain, given that the intervention results in faster and more stable long-term RTW. Thus, the project can serve as a benchmark study regarding the efficacy of combined cognitive rehabilitation and SE efforts.

## Limitations

The present protocol has limitations that should be addressed. First, this is a pragmatic clinical trial in which the nature of the interventions prevents blinding of participants and therapists. Furthermore, outcome assessment will be performed by personnel unaware of group assignment. Second, the participants will be allocated to one of two groups, TAU or CCT combined with SE, potentially making it difficult to tease apart the active ingredients of the CCT-SE intervention. However, as mentioned previously, what makes this study innovative is the combination of rehabilitation and vocational science perspectives, in addition to strong cross-sectoral collaboration between specialized health care services and the welfare system. If we had decided to include a CG with traumatic injury but without head trauma, it would have been possible to identify nonspecific effects of traumatic injury that may contribute to symptoms and lasting functional impairment. The grant provided to us unfortunately prevents us from implementing this. Furthermore, the main aim of this study is to affect work participation through a combination of cognitive remediation and SE. For this purpose, a TAU CG seems appropriate because etiology and causation will be comparable across groups.

A third possible limitation is the risk of nonadherence to the interventions and losing patients to follow-up (i.e., risk of dropout). To facilitate study adherence and keep the dropout rates as low as possible, the research team will be well-trained, perform outreach, and be

flexible with respect to timing of the intervention. Last, this trial is taking place in the southeastern region of Norway, and participants might not be representative of the whole population of Norway. It should also be mentioned that this is a single-center trial, which could potentially limit external validity. However, we are confident that the results could be generalizable, because more than half of the Norwegian population resides in this region.

## Trial status

This is protocol version 1.0. A feasibility study including six patients has been performed and concluded in July 2017. The results of the feasibility study are being prepared for publication. No major changes to the protocol were made as a result of the feasibility study. Recruitment and randomization of participants for the main study commenced in July 2017 and will end when we have enrolled the estimated sample size (approximately in November/December 2018).

## Additional file

**Additional file 1:** SPIRIT checklist. (PDF 128 kb)

## Abbreviations

CCT: Compensatory Cognitive Training; CCT-SE: Compensatory Cognitive Training–Supported Employment; CG: Control group; CogSMART: Cognitive Symptom Management and Rehabilitation Therapy; CONSORT: Consolidated Standards of Reporting Trials; COPSOQ: Copenhagen Psychosocial Questionnaire short version; CVLT-II: California Verbal Learning Test–Second Edition; EQ-5D: EuroQol five dimensions questionnaire; GCS: Glasgow Coma Scale; HiOA: Oslo and Akershus University College of Applied Sciences; HRQoL: Health-related quality of life; ICHI: International Classification of Health Interventions; IPS: Individual Placement and Support; LOC: Loss of consciousness; NAV: Norwegian Labor and Welfare Service; OUH: Oslo University Hospital; PTA: Posttraumatic amnesia; RCT: Randomized controlled trial; REK: Norwegian Regional Committee for Medical and Health Research Ethics; RTW: Return to work; SE: Supported employment; SPIRIT: Standard Protocol Items: Recommendations for Interventional Trials; TAU: Treatment as usual; TBI: Traumatic brain injury; WAIS-IV: Wechsler Adult Intelligence Scale–Fourth Edition

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## Availability of data and materials

Not applicable.

## Authors' contributions

EH, KPSL, and HCAT are doctoral fellows in the project; they contributed to the study design and will also carry out recruitment and screening of participants, set up the intervention and collect baseline data, and perform statistical analysis and interpretation of results. CR, AKS, HLS, and US are senior researchers; they have participated in developing the study protocol and will help interpret the results. EA is responsible for the design of the health economic part of the study and will contribute to analyzing the cost data. HE, DEA, and PK are senior researchers, have designed the process evaluation, and will collect and interpret qualitative data. KS, CMM, and KT are employment specialists and will carry out the vocational part of the intervention. AML will perform a qualitative evaluation of the cognitive

intervention. THN is a senior researcher who helped design the study and will interpret results. BSR is a representative from the user organization who has contributed to the adaptation of the cognitive intervention to the Norwegian context and also has contributed to the study design. GW has contributed to the design of the study and is the supervisor of the employment specialists. JL, JP, and EWT have contributed to the design of the study, choice of outcome measures, and adaptation of the interventions. HU, ØS, ML, and NA are chief investigators and members of the steering committee; they have designed the study and will partake in analyzing and interpreting the results. ØS, ML, and NA are the main supervisors of the doctoral fellows and are responsible for the main statistical outcome analysis. All authors helped draft the manuscript and consent to publication. All authors read and approved the final manuscript.

#### Ethical approval and consent to participate

The study has been presented to and approved by the Norwegian Regional Committee for Medical and Health Research Ethics (REK) (REK number 2016/2038). The project will be conducted according to the ethical guidelines of the Helsinki declaration. Information about the study will be presented to the patients in written and oral form. Written informed consent will be obtained, and the right to withdraw from the project at any time without any explanation necessary will be emphasized. All participants will be assigned an identification number, and all the questionnaires and datasets will be anonymized. Only the project team will have access to the document that links study identifiers with participant names.

#### Consent for publication

Not applicable.

#### Competing interests

The authors declare that they have no competing interests.

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## PHYSIOLOGY & REHABILITATION | RESEARCH ARTICLE

# Feasibility of a cognitive rehabilitation program for individuals with mild-to-moderate traumatic brain injury: Participants' engagement and satisfaction

Emilie Isager Howe<sup>1,2\*</sup>, Marianne Løvstad<sup>3,4</sup>, Knut-Petter S. Langlo<sup>1</sup>, Torgeir Hellstrøm<sup>1</sup>, Øystein Spjelkavik<sup>5</sup>, Helene Ugelstad<sup>6</sup>, Elizabeth W. Twamley<sup>7,8</sup> and Nada Andelic<sup>1,9</sup>

**Abstract: Purpose:** To assess the feasibility of recruitment procedures and delivery of a Norwegian adaptation of a manualized cognitive intervention to a civilian sample with traumatic brain injury (TBI).

**Materials and methods:** Six individuals received a 10-week group-based intervention (Compensatory Cognitive Training, CCT) targeting post-concussive symptom management and cognitive symptoms. Participant engagement (i.e. attendance, level of participation, ability to learn and apply strategies, and homework completion) and satisfaction were assessed by the Therapist Checklist and CCT Feedback Form.

**Results:** All participants had a diagnosis of concussion, were enrolled on average 4 months post-injury, and were sick-listed at a range of 70–100% at the time of inclusion. Attendance across CCT sessions was 97%. Eight out of nine topics in the CCT-intervention received a rating above 3.5 on a 5-point scale (i.e. towards very helpful). The items that received the highest mean ratings were information about TBI and post-concussive symptoms, and strategies targeting fatigue, prospective

### ABOUT THE AUTHOR

This article was written by a multinational, multidisciplinary group of researchers with wide-ranging research interests and expertise in quantitative and qualitative research methodology. The main research interest of the group is to contribute to development of knowledge in the trauma population across recovery phases and sectors involved in patient care and social support. All authors are associated with a larger scale project aiming to evaluate the efficacy of a combined cognitive and vocational intervention on vocational and functional outcomes following traumatic brain injury.

### PUBLIC INTEREST STATEMENT

Traumatic brain injury (TBI) may lead to functional impairments and difficulties with performing daily activities, including return to work and maintaining stable employment. This study aimed to assess the feasibility of a group-based cognitive intervention, Compensatory Cognitive Training (CCT), covering psychoeducation and compensatory cognitive strategies, previously administered to veterans with TBI in the US. We delivered a Norwegian adaptation of the intervention to a civilian sample with mild and moderate TBI and assessed the participants' satisfaction with the intervention and ability to engage with it. The participants found most of the information and strategies provided in the intervention helpful, and were able to apply the skills to a satisfactory degree. The study gave insight into practical aspect that will be important to consider when initiating a larger scale trial evaluating the effect of combining CCT and supported employment on vocational outcome in individuals with traumatic brain injury.

memory, and memory and learning. All participants were rated as participating fully (3/6) or moderately (3/6), and most participants (5/6) attempted to apply the trained skills to real-life situations.

**Conclusions:** The results support the feasibility of a Norwegian adaptation of the intervention for a civilian sample with TBI.

**Subjects:** Neuropsychological Rehabilitation; Rehabilitation Medicine; Trauma

**Keywords:** cognitive remediation; feasibility studies; post-concussive symptoms; traumatic brain injury; vocational rehabilitation

## 1. Introduction

Traumatic brain injury (TBI), defined as “an alteration in brain function, or other evidence of brain pathology, caused by an external force” (Menon, Schwab, & Wright et al., 2010), is a public health concern and may result in long-term disability, decreased quality of life, and significant personal and socio-economic costs (Corrigan, Selassie, & Orman, 2010; Roozenbeek, Maas, & Menon, 2013). It is estimated that 50–60 million new cases of TBI occur worldwide each year, of which 2.5 million new cases occur in the European Union, and 3.5 million cases in the US (Maas et al., 2017).

Among reported TBIs, approximately 70–90% are classified as mild or moderate (Maas et al., 2017). For most individuals in the mild end of the TBI spectrum, symptoms resolve within weeks following the injury (Sigurdardottir, Andelic, Roe, Jerstad, & Schanke, 2009). For others, physical, emotional, and cognitive complaints, referred to as post-concussive symptoms, persist beyond this point, which may lead to functional limitations and difficulties coping with the demands of everyday life, such as returning to work, or social activities (Levin & Diaz-Arrastia, 2015). A substantial number of TBIs are sustained by adults who are in working age (Roozenbeek et al., 2013). The literature suggests that approximately 5–20% of workers who sustain a mild TBI experience persisting problems in the longer term (Cancelliere et al., 2014). TBI may also affect vocational outcomes besides return to work (RTW), including employment stability and productivity (Chu, Tsai, Xiao, Huang, & Yang, 2017; Ponsford & Spitz, 2015; Silverberg, Panenka, & Iverson, 2018; Theadom et al., 2017).

Although several studies have identified demographic, functional, pre-injury and injury-related factors that may predict RTW after TBI (Saltychev, Eskola, Tenovuo, & Laimi, 2013; Shames, Treger, Ring, & Giaquinto, 2007; Yasuda, Wehman, Targett, Cifu, & West, 2001), systematic reviews assessing vocational rehabilitation following TBI have not shown strong evidence for effectiveness (Fadyl & McPherson, 2009). A Campbell review (Graham, West, & Bourdon et al., 2016) assessed the effectiveness of vocational interventions aimed at helping individuals with TBI to attain competitive employment. Although finding positive gains, the three randomized controlled trials (RCTs) included in the review showed no greater effect on vocational outcomes than the treatment received by the control groups (Man, Poon, & Lam, 2013; Salazar et al., 2000; Twamley, Jak, Delis, Bondi, & Lohr, 2014; Twamley et al., 2015). The study sample in two of the three RCTs were veterans (Salazar et al., 2000; Twamley et al., 2014, 2015). The review concludes that there is a need for more RCTs that assess a broader range of employment outcomes (such as hours worked and wages earned), including studies of adult civilian populations with TBI outside the US. Other reviews have assessed the efficacy of specific approaches, such as cognitive rehabilitation. A recently published Cochrane review evaluated the effects of cognitive rehabilitation on return to work (Kumar, Samuelkamaleshkumar, & Viswanathan et al., 2017). The authors identified four randomized controlled trials (Cicerone et al., 2008; Salazar et al., 2000; Twamley et al., 2014; Vanderploeg et al., 2008) specifically aiming to improve RTW but did not find sufficient evidence that cognitive rehabilitation improved RTW-rates and noted that the quality of evidence was too low to allow firm conclusions.



There are several factors which underline the importance of studies on vocational rehabilitation in civilian populations outside the US. An obvious reason is that PTSD-related symptomatology likely will be less prevalent when injuries sustained in combat settings are excluded. Socio-economic status may also be expected to vary between military populations in the US, and a civilian population in a high-income country like Norway. Additionally, universal access to healthcare may have an impact on what is considered as “treatment as usual,” and studies comparing interventions to treatment as usual may yield different results depending on where they are performed. Lastly, work-related welfare systems may affect motivation and willingness to return to work.

In sum, few studies have explored the effect of combined cognitive and vocational rehabilitation efforts on vocational outcomes following TBI (Man et al., 2013; Twamley et al., 2014). In preparation for a larger scale RCT evaluating the effect of combining a cognitive intervention (Compensatory Cognitive Training, CCT) and supported employment (SE) on vocational outcome in individuals with mild-to-moderate TBI, a feasibility study was performed at Oslo University Hospital (OUH), Norway, in the Spring of 2017. The full protocol for the trial has been described in a previous paper (Howe et al., 2017). The aim of the feasibility study was to assess the feasibility of recruitment procedures and delivery of a Norwegian adaptation of a manualized cognitive intervention to a civilian sample with mild-to-moderate TBI in the South-Eastern region of Norway. Specifically, the feasibility of recruitment procedures and delivery of the cognitive part of the intervention (i.e. a Norwegian translation and adaptation of the CCT manual) was assessed by exploring whether the procedures were satisfactory in terms of: 1) recruitment and retention (i.e. drop-out), 2) acceptability (i.e. satisfaction with the intervention, load of follow-up), and 3) treatment engagement (i.e. attendance, level of participation, ability to learn and apply strategies). The feasibility of delivering the vocational part of the intervention (supported employment) is not addressed in this paper but will be evaluated in subsequent publications.

The Medical Research Council (MRC) (Craig et al., 2008) underlines the importance of feasibility or pilot testing when developing, implementing and evaluating complex interventions. The MRC further points to the impact of the local context in which the intervention is carried out and urges researchers to pay greater attention to feasibility or pilot testing to tailor the intervention to the specific context. This advice might be particularly relevant regarding vocational rehabilitation, as national welfare systems, protection of the workforce, and job markets vary substantially between countries.

## 2. Materials and methods

### 2.1. Participants

Individuals with TBI who were referred to the Department of Physical Medicine and Rehabilitation at OUH from the neurosurgical department at OUH, and from general practitioners, were identified as potential participants. Once identified, they were screened according to the following inclusion criteria: residents of Oslo or Akershus county, aged 18–60 years, with mild-to-moderate TBI as measured by a Glasgow Coma Scale (GCS) score of 10–15, loss of consciousness (LOC) for <24 hours and posttraumatic amnesia <7 days (Management of Concussion/mTBI Working Group, 2009). The criteria for diagnosing mild TBI developed by the American Congress of Rehabilitation Medicine (ACRM), (1993) were used to establish the presence of mild TBI, either according to patient records or while screening for eligibility. Participants were included if they were employed in a minimum 50% position at the time of injury, and sick-listed 50% or more due to post-concussive symptoms, as assessed by the Rivermead Post Concussion Symptoms Questionnaire (RPQ). Exclusion criteria included inability to speak or read Norwegian, severe pre-existing neurological or psychiatric disorders, and active substance abuse. The study was approved by the Norwegian Regional Committee for Medical and Health Research Ethics (REK nr. 2016/2038) and performed in accordance with the principles of the Declaration of Helsinki. Information about

the study was presented to participants in written and oral form, and written informed consent was obtained upon agreement to participate.

## 2.2. The intervention

Compensatory Cognitive Training, CCT (Storzbach et al., 2017), is a further development of Cognitive Symptom Management and Rehabilitation Therapy (CogSMART), developed by Professor Elizabeth W. Twamley and colleagues (Twamley et al., 2014, 2015). CCT and CogSMART has previously been administered to individuals with severe mental illness (Twamley, Vella, Burton, Heaton, & Jeste, 2012) and veterans with a history of mild-to-moderate TBI (Storzbach et al., 2017; Twamley et al., 2014, 2015). When administered to veterans with TBI, CogSMART and CCT has shown to reduce post-concussive symptoms, improve subjective and objective measures of cognitive function, and quality of life (Storzbach et al., 2017; Twamley et al., 2014, 2015).

CCT is a manualized intervention targeting post-concussive symptom management and cognitive symptoms (Storzbach et al., 2017). It is a group-based treatment program delivered in 10 two-hour sessions in which the participants receive psychoeducation and learn compensatory cognitive training strategies. The CCT intervention is based on theoretical literature on compensatory strategy training for populations who suffer from cognitive symptoms, such as TBI, severe mental illness, and mild cognitive impairment (MCI) (Storzbach et al., 2017). It emphasizes a biopsychosocial understanding of causative and maintaining factors that contribute to a person's symptoms and level of functioning. CCT aims at providing psychoeducation and teaching strategies to compensate for the functional consequences of post-concussive symptoms. The compensatory cognitive strategies target prospective memory, attention and concentration, learning and memory, problem-solving and cognitive flexibility, while the psychoeducation is focused on the natural course of mild and moderate TBI and post-concussive symptoms. Stress reduction techniques are also an integral part of the intervention, acknowledging that stress may enhance symptom levels. Additionally, the participants receive information about additional services they may find helpful, such as individual/group/family therapy, pain clinics, physiotherapy, and other vocational services. The participants are assigned home exercises after each session for them to practice the strategies and increase the chance of automating and generalizing the skills. Table 1 provides an overview of the content in each of the 10 sessions.

The CCT intervention manual was translated and adapted to the Norwegian setting by researchers at the Department of Physical Medicine and Rehabilitation, OUH, and Sunnaas Rehabilitation Hospital, in collaboration with the author of the original manual (Professor Twamley) and

**Table 1. Overview of the topics provided the CCT intervention**

Session	Topic	Examples of strategies
1	Course introduction and information about TBI	Finding a "home" for important personal items
2	Managing fatigue, sleep problems, headaches, and tension	Sleep hygiene and relaxation techniques
3	Organization and prospective memory	Time management and establishing routines
4	Organization and prospective memory (continued)	Calendar use and to-do lists
5	Attention and concentration	Paying attention during conversations
6	Learning and memory	Internal and external memory strategies
7	Learning and memory (continued)	Overlearning and name learning strategies
8	Planning and goal setting	Plan to meet goals and deadlines
9	Problem solving and cognitive flexibility	6-step problem solving method and self-monitoring
10	Skills integration, review, and next steps	Application of strategies to everyday life and progress toward goals

a representative from the Norwegian user organization, Personskadeforbundet LTN. The main translator (author EIH) is bilingual (Norwegian/English). Supplementary material, including an information leaflet containing information about TBI and post-concussive symptoms, and audio files containing stress-reduction and relaxation techniques, were also translated to Norwegian. When adapting the manual and information leaflet to the Norwegian setting, extensive information about post-traumatic stress disorder (PTSD) and injury mechanisms specifically relating to combat settings, was removed, as the target population in the current study was civilian. Furthermore, some minor changes, including language adjustments, were made in agreement with Professor Twamley. The CCT intervention was delivered at an outpatient clinic at OUH by two clinical psychologists (authors EIH & KPSL), who were responsible for one group each. Prior to starting the intervention, the psychologists received training from experienced senior researchers and discussed practical aspects of delivering the intervention with Professor Twamley.

### 2.3. Assessment methods

#### 2.3.1. Primary outcome—work participation

Work-related outcome was documented. Questions regarding work participation (percentage sick leave, time until return to part-time or full-time work), work productivity (hours worked, reduced work productivity compared to before the injury, need for increased supervision, alterations in work tasks) and work stability (changes in sick leave percentage) were administered to the participants in an interview format. Sick leave percentage and hours worked at baseline and post-treatment follow-up are reported.

#### 2.3.2. Cognitive function

An IQ estimate was made at baseline based on four subtests (Vocabulary, Similarities, Block Design, and Matrix Reasoning) of the Wechsler Adult Intelligence Scale-Fourth Edition (WAIS-IV) (Wechsler, 2008). Additionally, cognitive function in the domains of learning and memory (California Verbal Learning Test-Second Edition, CVLT-II) (Delis, Kramer, & Kaplan et al., 2000), prospective memory (Memory for Intentions Screening Test, MIST) (Raskin, 2004), and processing speed and executive function (Color Word Interference Test (CWIT) and Trail Making Test (TMT) from the Delis-Kaplan Executive Function System (D-KEFS) (Delis, Kaplan, & Kramer, 2001); Coding from WAIS-IV (Wechsler, 2008); Ruff 2 and 7 Selective Attention Test (Ruff, Niemann, Allen, Farrow, & Wylie, 1992) was assessed.

#### 2.3.3. Emotional symptoms and fatigue

Presence of depressive symptoms was assessed with the Patient Health Questionnaire-9 items (PHQ-9) (Kroenke, Spitzer, & Williams, 2001). The PHQ-9 has a score range from 0 to 27, with scores of 5, 10, 15, and 20 representing cut-off values for mild, moderate, moderately severe and severe symptoms of depression, respectively. Symptoms of anxiety were assessed with the Generalized Anxiety Disorder-7 items (GAD-7) (Spitzer, Kroenke, Williams, & Löwe, 2006). The GAD-7 has a score range from 0 to 21, with scores of 5, 10, and 15 representing cut-off values for mild, moderate, and severe symptoms. Fatigue was assessed with the Fatigue Severity Scale (FSS) (Krupp, LaRocca, Muir-Nash, & Steinberg, 1989). The FSS consists of nine items with a mean score ranging from 0 to 7 (0–3.9 = no fatigue, 4–4.9 = moderate fatigue, 5–7 = severe fatigue) (Lerdal et al., 2011).

#### 2.3.4. Post-concussive symptoms

The Rivermead Post Concussion Symptoms Questionnaire (RPQ) (King, Crawford, Wenden, Moss, & Wade, 1995) is a self-report checklist consisting of 16 items to evaluate the presence and severity of PCS symptoms. The 16 items are divided into three symptom categories: somatic (headache, dizziness, nausea, noise sensitivity, sleep disturbance, fatigue, blurred vision, light sensitivity), emotional (irritability, depression, frustration, restlessness), and cognitive (poor memory, poor concentration, taking longer to think). Individuals are asked to rate to what degree they have experienced the 16 symptoms over the past 7 days on a 5-point Likert scale ranging from 0 to 4 (0 = not experienced at all, 4 = a severe problem). As advised by King et al. (1995), all scores of 1 (indicating that the problem was the same as before the injury) were

removed. The RPQ has been validated in a Norwegian context (Ingebrigtsen, Waterloo, Marup-Jensen, Attner, & Romner, 1998).

#### **2.3.5. CCT feedback form**

The CCT feedback form was specifically designed to assess participants' satisfaction with the CCT intervention. Participants were asked to rate the usefulness of the information provided about TBI and post-concussive symptoms, specific strategies for dealing with headaches, fatigue, and sleep problems, and strategies to compensate for cognitive symptoms relating to prospective memory, attention and concentration, learning and memory, problem-solving and cognitive flexibility. The feedback form also included questions about what topic or strategy was most useful, what strategies the participants were using regularly now that they were not using before, if the strategies had helped them in their daily life, and what topic or strategy was least helpful. Questions about additional topics that should be included in the intervention or suggestions to improve the program were also welcomed. Finally, the participants were asked if they would recommend the CCT-intervention to others with similar problems.

#### **2.3.6. The Therapist Checklist**

The Therapist Checklist was used to assess participants' engagement in the intervention. It was originally developed to track participants' attendance and session-by-session progress in a day treatment program described by Cantor et al. (2014). It is a modified five-item scale where participants are rated according to the level of participation (active/passive), homework completion, interaction with therapist and other participants, and ability to learn and apply skills and strategies. Additionally, the therapists who provided the CCT-intervention kept a log where impressions from each session were documented along with the participants' attendance levels.

### **2.4. Assessment timeline**

After consenting to participate, socio-demographic, injury- and work-related information was collected. Additionally, the participants underwent a baseline assessment of neurocognitive function and self-reported symptoms. The baseline assessment took approximately 3.5 h to complete and was done on the same day for all participants. Following completion of the CCT intervention (approximately 3 months following inclusion), the participants underwent a post-treatment assessment of self-reported symptoms and vocational outcome. Additionally, the participants rated their satisfaction with the intervention on the CCT feedback form and the therapists who delivered the intervention rated the participants on the Therapist Checklist.

### **2.5. Statistical methods**

Data analyses were completed with IBM SPSS, version 22. Descriptive statistics were used to characterize the sample at baseline. Due to the very small sample size, non-parametric statistical methods with median (interquartile range, IQR) is reported for socio-demographic variables and self-reported symptoms. A Wilcoxon Signed Rank Test was applied to assess changes in post-concussive symptoms from baseline to post-treatment follow-up. For neuropsychological test results at baseline, the participants' performance are characterized as deviance from the normative mean (in SD).

### **2.6. Success criteria**

To assess whether the proposed procedures were satisfactory, we pre-defined success criteria based on a previous pilot study by Twamley et al. (2014) and studies that have been performed at the Department of Physical Medicine and Rehabilitation at OUH (Hellstrom et al., 2016): three quarters of the patients who were asked to participate would agree, less than 30% dropout, the participants would tolerate the burden of the follow-up procedures, 90% attendance at CCT sessions, and subjective satisfaction with the CCT-intervention would be comparable to that reported in the pilot study by Twamley et al. (2014).

### 3. Results

#### 3.1. Recruitment

The feasibility study was carried out in the spring of 2017. During March and April, a total of 14 individuals were screened according to the eligibility criteria. Five individuals did not meet the criteria due to place of residence, receiving work assessment allowance, or having recovered. The remaining nine patients were asked to participate, whereof eight agreed (89%), and one declined. One patient (12%) dropped out prior to starting the intervention preferring another treatment option, and one (12%) dropped out after two sessions due to having a low symptom burden. This left a total of six participants (75%) being enrolled in the feasibility study. Figure 1 shows a flow chart of the inclusion procedure.

#### 3.2. Baseline socio-demographic and injury characteristics

The participants were enrolled on average 4 months (range 3–5 months) after the injury. Baseline socio-demographic and injury characteristics are presented in Table 2.

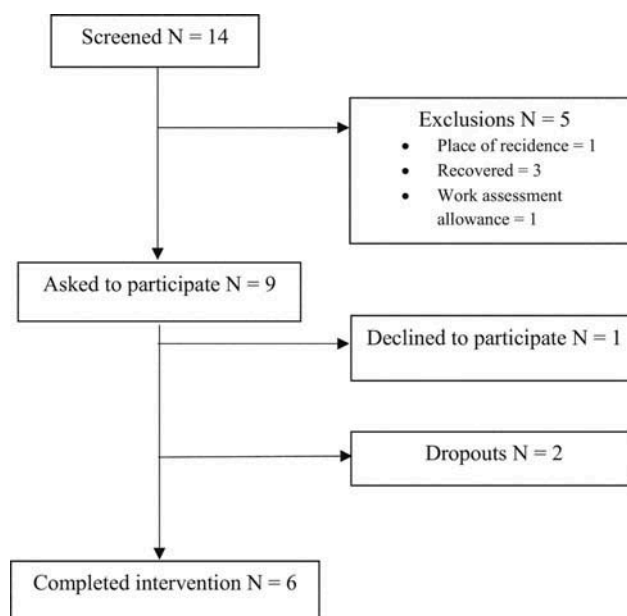
#### 3.3. Work participation

All participants were employed in full-time positions at the time of injury, with a number of years in the current job ranging from 0 to 16 years, with a median (IQR) of 2 (7). At the time of inclusion, they were all sick-listed above 50% (range 70–100%). Immediately following the CCT intervention, three participants had decreased their percentage of sick leave, while one participant had increased their level. Table 3 shows the percentage of sick leave and hours worked for each of the participants at baseline and at the post-treatment follow-up.

#### 3.4. Cognitive function

A baseline estimation of premorbid cognitive function (four subscales from the General Ability Index, WAIS-IV) revealed that all patients were within normal range (IQ estimates range 96–129). With very few exceptions, measures of neurocognitive functioning (CVLT-II, Coding, Ruff 2 and 7, CWIT, TMT, MIST) were within normal range ( $\pm 1$  SD from the mean).

Figure 1. Flow chart of the inclusion.



**Table 2. Baseline socio-demographic and injury characteristics**

Variable	n (%)	Median (IQR)
Age		40 (15)
Gender		
Female	3 (50)	
Education (years)		16 (3)
Relationship status		
Single	2 (33)	
Married	4 (67)	
Glasgow Coma Scale (GCS)		
15	6 (100)	
Injury mechanism		
Fall	2 (33)	
Blow to head	4 (67)	
CT/MRI findings		
No	6 (100)	
Work-related injury		
Yes	2 (33)	
No	4 (67)	

**Table 3. Sick leave percentage and hours worked at baseline and post CCT-treatment follow-up**

Participant	Sick leave (%)		Hours worked	
	Baseline	Post-treatment	Baseline	Post-treatment
1	100	85	0	6
2	100	70	0	11,25
3	100	100	0	0
4	70	100	12	0
5	80	50	8	18,75
6	100	100	0	0

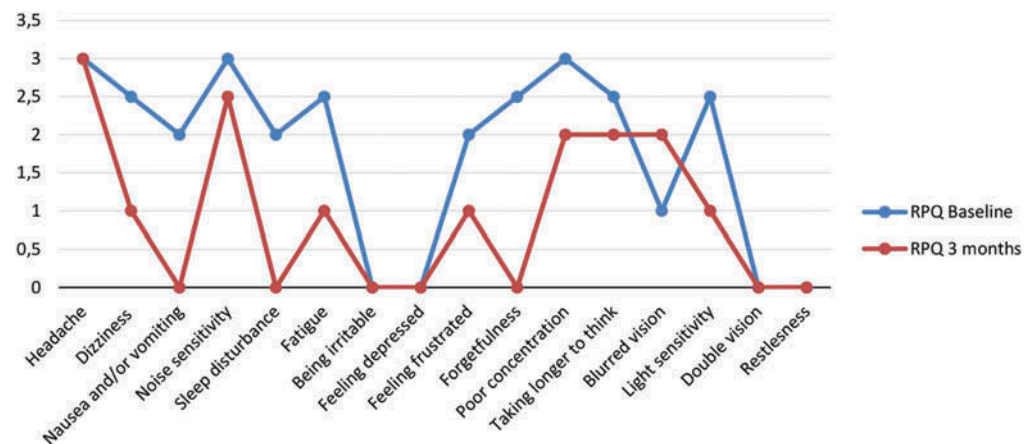
### 3.5. Emotional symptoms and fatigue

Baseline assessment of self-reported depressive symptoms (PHQ-9) revealed a median (IQR) score of 11.5 (6). Two participants reported no significant or minimal symptoms, two reported mild symptoms, while one reported moderate symptoms. A measure of self-reported symptoms of anxiety (GAD-7) showed a median (IQR) score of 7 (7). Two participants reported no or minimal symptoms, two reported mild symptoms, while one reported moderate symptoms. Moreover, the patients reported moderate to severe levels of fatigue (FSS) with a median (IQR) score of 5 (2). Three participants reported moderate symptoms and three reported severe fatigue.

### 3.6. Post-concussive symptoms

All participants reported post-concussive symptoms that represented more of a problem than before the injury at baseline. The symptoms that were most frequently reported as a moderate or severe problem (reported by three or more participants) were headache, dizziness, noise sensitivity, fatigue, forgetfulness, poor concentration, taking longer to think, and light sensitivity.

**Figure 2. Median RPQ symptom score at baseline and post-treatment follow-up.**



A Wilcoxon Signed Rank Test revealed a statistically significant decline in RPQ-scores from baseline to the post-treatment control,  $z = -2.201$ ,  $p < 0.05$ , with a large effect size ( $r = 0.63$ ). The median score on the RPQ decreased from baseline ( $Md = 31$ ) to the follow-up after completing the CCT-intervention ( $Md = 17$ ). Comparing the total RPQ scores for each of the individual participants revealed that all had a reduction of symptoms from baseline to the post-treatment follow-up. Figure 2 shows the median scores for each of the 16 symptoms at baseline and at the post-treatment follow-up.

### 3.7. Treatment satisfaction

Table 4 shows the number of participants who rated each of the items on the CCT feedback form on a scale ranging from 1 to 5 (not helpful to extremely helpful), while the column to the right indicates the overall score. The items that received the highest mean ratings were information about TBI and post-concussive symptoms, information about fatigue, prospective memory, and memory and learning. Information about additional services received the lowest mean rating. With exception of information about additional services, all items received a rating above 3.5 (i.e. towards very helpful). Five participants indicated that they would recommend the intervention to others with similar problems. Some of the qualitative comments to the question “what strategies are you using regularly now that you weren’t using before” included:

- “Breaks, relaxation, breathing exercises.”
- “Mindfulness, breaks, eliminating distractions, new ways of learning.”
- “Has made me think about my life and take the breaks that I need.”
- “Categorizing tasks and prioritizing. Acronyms.”

The participants were also asked what topic or strategy they found least helpful, and some of their comments included:

- “Calendar use. I already knew this.”
- “Relaxation, done a lot of this before, well known to me.”
- “Problem solving and cognitive flexibility plus a bit too much focus on calendar use and organization. I do a lot of this already.”
- “Planning, organization, life style strategies are very relevant, I already do this, but very relevant for those who do not!”

### 3.8. Treatment engagement

Overall attendance across the 10 sessions of the CCT-intervention was 97%. With exception of one participant who missed two sessions due to personal reasons, all participants attended all 10

**Table 4. Participants rating of satisfaction with the intervention (CCT feedback form)**

Topic	Not helpful	Mildly helpful	Moderately helpful	Very helpful	Extremely helpful	Overall rating
Information about TBI and post-concussive symptoms			1	4	1	4/5
Headache		1		5		3,7/5
Fatigue				6		4/5
Sleep problems			3	3		3,5/5
Prospective memory			1	4	1	4/5
Attention and concentration		1		4	1	3,8/5
Memory and learning				6		4/5
Problem solving and cognitive flexibility		1	1	4		3,5/5
Additional services	1	1	2	1		2,2/5

sessions. The therapists' rating of the participants on the Therapist Checklist showed that all the participants participated fully or moderately. Four participants completed the homework to a satisfactory degree, while two did not. Five participants interacted well with the other participants and the therapists, while one participant was rated to interact negatively. Four participants acquired the strategies and skills that were taught to a good degree, while two participants were rated as modest and minimally competent. Five participants attempted to apply the skills and strategies to real-life situations, and one participant made minimal or no use of the strategies. Table 5 shows the number of participants who were rated on the five items of the Therapist Checklist.

#### 4. Discussion

The purpose of this study was to assess the feasibility of recruitment procedures and delivery of an adaptation of a cognitive intervention to the Norwegian context and to a civilian sample. The cognitive intervention comprises psychoeducation and compensatory cognitive strategies, in addition to stress reduction techniques. The feasibility study was performed in preparation for a full-scale RCT that will assess the efficacy of a combined cognitive and vocational intervention on vocational and other outcomes in individuals with mild-to-moderate TBI. The study allowed us to gain information about potential issues that will need to be addressed when performing the clinical trial.

##### 4.1. Feasibility of recruitment procedures

Eighty-nine per cent of the individuals who were asked to participate in the study consented, which is well above the pre-defined success criterion of 75%. Two (25%) of the eight patients who initially consented dropped out. This is also below the success criterion of 30%, and below the number of drop-outs reported in Twamley's pilot study, where nine (36%) of the 25 individuals who initially consented and were randomized to receive CogSMART, dropped out (Twamley et al., 2014). Even though the baseline assessment was time consuming, and it was necessary to incorporate several breaks due to fatigue and other symptoms, all participants completed the assessment in one session. The load of follow-up assessments was therefore deemed acceptable.

##### 4.2. Feasibility of the CCT intervention

When adapting the CCT manual to the Norwegian setting, a representative from the collaborating user organization (Personskadeforbundet LTN) forwarded the manual and additional material to additional members of the organization. The feedback from the user organization was overwhelmingly positive and gave important insights on the appropriateness of the translation and content. While the overall content of the CCT manual remained the same, important changes were made to increase the cultural relevance of the treatment to the Norwegian civilian population. For example,



**Table 5. Number of participants rated on each item of the Therapist Checklist**

Participation	Participated fully	3
	Participated moderately	3
	Participated minimally	0
Homework	Inattentive and nonresponsive	0
	Completed homework	4
	Did not complete homework for legitimate reason	1
	Did not complete no legitimate reason	1
Interpersonal	Was not aware that homework was assigned	0
	Interacts well with others and therapist	5
	Interacts with therapist only	0
	Interacts minimally with therapist and others	0
	Interacts negatively	1
Skills acquisition	Exceptional	0
	Good	4
	Modest	1
	Minimally competent	1
Generalization of skills	Applies skills exceptionally well to real-life situations	0
	Attempts to apply skills to real-life situations	5
	Attempts to apply skills to hypothetical real-life situations	0
	Minimal or no use of skills	1

as the original manual contained information on injury mechanisms relating to combat settings and extensive information about post-traumatic stress disorder, adjustments to the content was made with contextual differences in mind. Tailoring interventions to fit the target population is important to increase treatment engagement and effectiveness (Ramos & Alegria, 2014).

The findings of the study demonstrated the feasibility of the CCT intervention. Moreover, the results indicate that the adaptations of the manual were appropriate for a civilian sample in the Norwegian context. All six participants completed the intervention, and the percentage of CCT sessions attended was above 97%. This is comparable to Twamley et al. (2014) pilot study where approximately 94% of the participants receiving both CogSMART and SE attended all sessions. With the exception of information about additional services, all items on the CCT feedback form received a mean rating of 3.5 or more, indicating that the participants found the information and strategies useful. In Twamley's pilot, all items received a mean score of 3.5 or more, and the item receiving the highest rating was memory strategies with a mean score of 4 (i.e. very useful). In this feasibility study, information about post-concussive symptoms and TBI, strategies to deal with fatigue, prospective memory, and memory and learning were all rated as very useful. The qualitative feedback further indicated that the participants found the psychoeducation and relaxation techniques helpful. However, the feedback also indicated that they did not find the strategies relating to organization and calendar use as helpful. This may reflect methodological differences in that our participants, in contrast to those in Twamley and colleagues' study, were employed at the time of injury, and already had a system for organizing their daily routines.

Most participants interacted well with the therapists and the other group members and participated in group discussions and assignments to a satisfactory degree. Moreover, five of the six participants tried to apply the skills they had learned to real-life situations. However, two participants did not complete the assigned homework. Reported rates of compliance with homework assignments in clinical trials range from 49% to 94% (Kazantzis, Deane, & Ronan, 2004), and the 67% homework completion rate in this study is in accordance with this. Even though one participant had a legitimate reason, failing to complete homework may limit the ability to generalize from the intervention. Thus, motivating the participants to complete home assignments and underlining the importance of practice to automate skills should be addressed to a greater degree in the further RCT.

At the end of the 10 CCT sessions, there were positive reductions of self-reported post-concussive symptoms in the following areas: dizziness, nausea and/or vomiting, noise sensitivity, sleep disturbance, fatigue, feeling frustrated, forgetfulness, concentration, taking longer to think, and light sensitivity. The only symptoms showing no decrease were headache and blurred vision. This is in line with previous studies that have reported positive effects of cognitive interventions on self-reported symptoms (Storzbach et al., 2017; Twamley et al., 2014, 2015; Vikane et al., 2017). Moreover, the observed changes corresponded with the strategies and information that received the highest mean ratings on the CCT Feedback Form. Regarding symptoms of irritability and depression, double vision and restlessness, the participants had a median score of 0 at both baseline and post-treatment follow-up. Severity of symptoms of headache remained unchanged between the two time points, with a median score of 3. The only symptom which increased in severity, was blurred vision, with a median severity score of 1 at baseline and 2 at the post-treatment control. These symptoms were probably not in focus at baseline as they were subtle and may have been masked by the other post-concussion symptoms. Thus, as the other symptoms decrease in severity, the participants may become more aware of blurred vision. Furthermore, the CCT intervention does not provide vision therapy, and there is not free access to an optometrist for visual evaluations.

There were trends towards reductions of sick leave percentage and increased hours worked for half of the participants. Two participants demonstrated the same level of sick leave and hours worked at baseline and post-intervention follow-up, while one participant had increased their sick leave percentage. The participant who showed a worsening resigned from their job during the study period and would therefore not be expected to show improvement on these measures. The participants received the intervention shortly after their injury (3–5 months). No previous studies have assessed the effect of cognitive interventions on vocational outcome this shortly after TBI, and the results are therefore difficult to compare to the existing literature.

#### **4.3. Limitations**

It is important to note that the findings should be interpreted with caution due to the lack of a control group and the relatively small sample size. However, the purpose of this study was not first and foremost to determine the effect of the intervention, but to assess the feasibility of it. Stallard (2012) has recommended that the sample size in pilot studies should be approximately 0.03 times the intended sample size for the definitive clinical trial. The calculated sample size for this RCT is 120 participants, with 60 in each group (Howe et al., 2017). Thus, six participants constitute 10% of the total number of participants that will receive the intervention and is well above the recommended sample size.

All the participants that were included had sustained mild TBIs. The RCT will include participants with both mild and moderate TBI histories, and more severe injury could potentially bring about issues that have not been addressed in this feasibility study. It may be necessary to increase the assessment time at baseline in the RCT, or even to perform the assessment over two days due to reduced capacity and fatigue. During the recruitment period for the feasibility study, no patients with moderate TBI were eligible for inclusion, and we chose to move forward due to time

constraints. However, the CogSMART intervention has previously been administered to participants with moderate TBI in the US and found to be feasible (Twamley et al., 2014).

#### 4.4. Conclusion

The findings from this study indicate that the participants found most of the information and strategies provided in the CCT intervention helpful. The attendance rate was high, and the participants were able to interact well with the therapists and other group members, and participate in group discussions, acquire skills and apply the skills to a satisfactory degree. Most of the individuals who were asked to participate agreed, and the participants tolerated the follow-up procedures. In sum, the results demonstrate that the delivery of a Norwegian adaptation of the CCT intervention to a civilian sample with TBI is feasible. We also found that the recruitment and follow-up procedures were feasible. As a result, no major protocol adjustments were made. However, the knowledge gained provided important information on acceptability and treatment engagement. It also gave insight into relevant practical aspects that will be taken into consideration before initiating the RCT.

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#### Disclosure statement

The authors report no conflicts of interest.

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#### Competing interests

The authors declare no competing interests.

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# Effectiveness of a combined compensatory cognitive training and vocational intervention on return to work following mild-to-moderate traumatic brain injury: a randomized controlled trial

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### Abstract

**Aims:** Employment participation is a key rehabilitation goal after traumatic brain injury (TBI). The objective of this randomized controlled trial was to compare the effectiveness of a combined cognitive and vocational intervention to treatment as usual (TAU) on return to work and work stability after TBI.

**Methods:** Patients with a history of mild-to-moderate TBI ( $n=116$ ) who were referred to a specialized outpatient clinic at Oslo University Hospital, Norway, were randomized to receive both group-based compensatory cognitive training (CCT) and supported employment (SE) ( $n=60$ ) or TAU consisting of individualized multidisciplinary treatment ( $n=56$ ). Participants were enrolled 2-3 months post-injury, and work participation, stability and productivity was assessed at baseline, 3, and 6 months following inclusion.

**Results:** Mixed effects models showed a statistically significant within-group increase in the proportion of participants who had returned to work, work percentage, and hours worked in both CCT-SE and TAU groups from baseline to 6 months, but no between-group differences. Adjusting for baseline difference, results showed that a higher proportion of participants in the CCT-SE group had returned to work at 3 months. The majority of participants who were employed at 3 and 6 months were stably employed.

**Conclusion:** The findings suggest that CCT-SE can accelerate RTW for individuals following mild-to-moderate TBI.

The trial was registered at the US National Institutes of Health (ClinicalTrials.gov) #NCT03092713.

### 1 Introduction

Failure to return to work (RTW) and decreased work stability following traumatic brain injury (TBI) constitutes a major personal and societal burden (1). A substantial proportion of those who sustain a TBI are of working age (2), and the lifetime work loss costs of TBI in the US have been estimated to almost \$70 billion (3), while costs due to productivity loss and early retirement have been estimated to approximately €19 billion annually in Europe (4). Work participation is not only important financially, but is also related to quality of life, self-esteem, and social interaction (5). Thus, improving employment participation post-TBI is a critical goal in rehabilitation programs for patients with a history of TBI.

To resume and maintain employment while experiencing post-injury difficulties is challenging for many individuals with TBI (6). Overall, it is estimated that approximately 40% are able to RTW one year after injury (7). Most patients with mild TBI (mTBI) resume work within weeks to months after their injury (8). Still, between 5 and 30% of individuals who sustain a mild or moderate TBI are unable to RTW within 6-12 months (8, 9). Considering that approximately 70-90% of all TBIs are classified as mild (1), this represents a substantial number of people. Studies have also shown that individuals who resume employment may continue to experience symptoms affecting work stability and productivity (10-13).

In an effort to identify individuals at risk of adverse vocational outcome after TBI, several studies have assessed individual characteristics associated with reduced likelihood of resuming employment. Among the most consistently linked factors are age, education, pre-injury employment status, duration of post-traumatic amnesia (PTA) and hospital admission, extracranial injuries, functional level, emotional and cognitive status, and access to social support (14-17). Although injury-related factors seem to be influential early on, psychological distress, maladaptive coping style and lack of social support may be of greater importance in the longer term (18-21).

Cognitive deficits are common after TBI and have consistently been linked to negative employment outcome (15, 22, 23). Cognitive skills such as learning new tasks, and social interaction at the workplace are crucial for job performance. A literature review by Mani and colleagues (22) found that executive functioning, attention, memory, and verbal skills were predictive of RTW post-TBI. The review also found evidence for the efficacy of cognitive rehabilitation in facilitating RTW. In later years, researchers have urged increased attention to modifiable factors such as cognitive and psychosocial sequelae to tailor vocational rehabilitation programs and maximize outcome (11).

Although individual and injury related characteristics associated with RTW have been extensively studied, the impact of work-place factors has not attracted comparable attention (21). One study found greater independence and decision-making latitude at work to be predictive of higher RTW rates for patients with mTBI (24). A qualitative study involving twelve individuals with mTBI reported more positive experiences with RTW in workplaces with a supportive work culture (25). Cancelliere and colleagues (8) performed a synthesis of systematic reviews on factors affecting RTW after injury and illness. They found support for involving multiple stakeholders (i.e., employee, employer, health care providers, and employment service providers), work accommodation, multidisciplinary interventions, and return-to-work coordination. These stated factors are in line with recommendations by Wehman and colleagues (26) stating that communication and collaboration between stakeholders, in addition to workplace support, is essential in promoting successful RTW.

## Cognitive and vocational intervention

Previous interventions aimed at returning individuals to competitive employment after mild or moderate TBI have focused mainly on providing information and advice (27) or trying to increase work participation through alleviation of post-concussive symptoms (28-30). For example, Man et al. (30) assessed the efficacy of virtual reality-based training vs. a psycho-educational program in a civilian sample with mild-to-moderate TBI, and found no significant differences in vocational outcome between the two groups. Vikane and colleagues (29) evaluated the effect of multidisciplinary follow-up program vs. follow-up by general practitioners (GPs) for patients with persistent symptoms 2 months after mTBI. The multidisciplinary program reduced the number of symptoms, but there was no difference between the groups regarding RTW. Scheenen et al. (28) compared cognitive behavioral therapy to telephonic counseling in a civilian sample 4-6 weeks post mTBI. Results showed no significant difference regarding RTW, but surprisingly indicated that the patients receiving telephone counseling had more favorable outcome as measured by Glasgow Outcome Scale-Extended and fewer post-traumatic complaints. In summary, the existing literature is equivocal and does not provide strong clinical recommendations regarding vocational rehabilitation for people with longstanding post-concussive symptoms.

A few clinical trials exploring the effect of combining cognitive rehabilitation efforts with vocational support have been developed over the past few years. Twamley et al. (31, 32) performed a randomized controlled trial (RCT) comparing a 12-week compensatory cognitive training (CogSMART) and supported employment (SE) intervention to enhanced SE for unemployed veterans with mild-to-moderate TBI. CogSMART included strategies to improve sleep, fatigue, headaches and tension, and compensatory cognitive strategies for prospective memory, attention, learning and memory, and executive functioning. The duration of SE, which was delivered according to the principles of Individual Placement and Support (33) was 12 months. The findings suggested that the intervention improved quality of life, symptom levels and prospective memory, and speeded RTW, but there were no differences regarding RTW over the long term.

A Campbell review (34) evaluated the effectiveness of vocational interventions in individuals with TBI and concluded that there is a need for more RCTs that assess a broader range of employment outcomes, including studies of adult civilian populations outside the US. Hence, well-designed clinical studies that combine early interventions (i.e., cognitive rehabilitation and supported employment in real-life competitive work settings) and long-term follow-up in civilian TBI-samples are warranted. As previous cognitive interventions have proven effective in reducing post-concussive complaints in the TBI population (31, 32, 35) and SE has been successfully applied in the Norwegian context to participants with mental illness (36), we developed a combined cognitive and vocational intervention to be tested in people with mild-to-moderate TBI who were still on sick leave 2 months post-injury due to persisting symptoms (37).

The aim of this study was thus to explore the effectiveness of a rehabilitation intervention with combined manualized cognitive rehabilitation efforts and SE in real-life competitive work-settings on employment participation following mild-to-moderate TBI. The main hypothesis was that those who received the study intervention would return to work sooner than patients receiving treatment as usual (TAU). Furthermore, it was expected that the intervention would result in increased work stability and productivity compared to TAU.

## 2. Materials and methods

### 2.1 Study design

We performed a single center pragmatic RCT comparing the effectiveness of a combined cognitive and vocational intervention program to treatment as usual (TAU) on work participation in a civilian sample with mild-to-moderate TBI.

### 2.2 Study population

Potentially eligible patients were referred from the Emergency department (ER), Neurosurgical department and GPs to an outpatient clinic at the Dept. of Physical Medicine and Rehabilitation (PM&R), Oslo University Hospital (OUH), Norway. The clinic provides specialized rehabilitation and follow-up services to patients with TBI. All patients referred to the clinic between July 2017 and April 2019 were eligible according to the following criteria: (1) diagnosed with mild-to-moderate TBI as assessed by a Glasgow Coma Scale (38) (GCS) score of 10-15, loss of consciousness (LOC) <24 hours and posttraumatic amnesia (PTA) <7 days, (2) aged 18-60 years, (3) employed in a minimum 50% position at time of injury and (4) sick listed 50% or more 8-12 weeks post-injury due to post-concussive symptoms as assessed with Rivermead Post Concussion Questionnaire (RPQ) (39). The criteria for diagnosing mild TBI developed by the American Congress of Rehabilitation Medicine (40) were used to establish mild TBI, either according to patient records or while screening for eligibility. Individuals were excluded if they were active substance abusers, had severe pre-existing neurological or psychiatric conditions, and/or were unable to speak or read Norwegian.

### 2.3 Procedures

Eligible patients who received oral and written information about the study were invited to participate by a medical doctor (MD) at the outpatient clinic, either during an initial consultation or later by phone. All patients who provided consent were contacted by phone to make an appointment for the baseline assessment where participants completed an assessment of self-reported symptoms and neurocognitive function. The following demographic characteristics were recorded: age, gender, education and marital status. Work-related information included occupation type (blue vs. white collar), occupation category, and percentage of sick listing at baseline. Clinical characteristics were also recorded and included time since injury (days), cause of injury, GCS score at time of injury or admission to hospital, duration of LOC and PTA, neuroimaging results, Abbreviated Injury Scale (AIS) head score, extracranial injuries (yes vs. no), admitted to hospital (yes vs. no), intoxication at time of injury (yes vs. no), and injured at the workplace (yes vs. no). The information was collected from medical records and self-report. Trained study personnel (clinical psychologist or MD) performed the baseline assessment at the outpatient clinic at PM&R.

### 2.4 Randomization

A computer-generated permuted block randomization sequence was created by an independent statistician using randomized block sizes of 2, 4, 6, or 8 before initiating the study. Following baseline assessment, the participants were randomly allocated to the study intervention or TAU in a 1:1 ratio by an independent investigator who was not involved in the initial patient assessment. The nature of the intervention prevented blinding of participants or therapists providing the treatment. As randomization was performed after the baseline assessment, the study personnel performing these assessments were unaware of group allocation. Furthermore, outcome assessors performing the follow-up assessments were blinded. To prevent the participants from revealing group allocation, the assessors were instructed to inform the participants to not reveal the type of treatment they had received.

### 2.5 Study interventions

#### 2.5.1 Treatment as usual

TAU consisted of individual contacts and an educational group provided by a multidisciplinary team at PM&R, OUH. The specific treatment each participant received varied according to individual needs. An MD addressed physical problems related to the injury, while a neuropsychologist addressed psychological or cognitive complaints. An occupational therapist helped the patients structure their day and a social worker advised patients on issues relating to work, legal rights, and benefits. A physical therapist addressed vestibular symptoms and physical activity. In addition, the educational group entailed meeting 2 hours once a week over a period of 4 weeks and addressed general information about mild-to-moderate TBI, common symptoms and problems in daily life, and advice regarding how to manage these.

#### 2.5.2 Cognitive and vocational intervention

The combined cognitive and vocational intervention (CCT-SE) consisted of Compensatory Cognitive Training (CCT) and supported employment (SE). CCT is a manualized, group-based program to improve cognition and functioning in individuals who have sustained mild-to-moderate TBI (35). The intervention targets post-concussive and cognitive symptoms through psychoeducation and the implementation of compensatory strategies. CCT was provided in groups of 2-5 participants over a period of 10 weeks with one 2-hour session each week. The intervention provides information about common symptoms that may occur after a TBI and strategies for dealing with fatigue, headache, sleep problems, and tension, in addition to specific strategies for cognitive problems. All participants were given a copy of the treatment manual and were assigned homework to increase generalizability of the learned strategies. Table 1 provides an overview of the cognitive domains targeted in the intervention and examples of strategies. The intervention manual was translated to Norwegian by researchers at PM&R, OUH and Sunnaas Rehabilitation Hospital. To adapt the manual to a Norwegian civilian setting, we adjusted and down-scaled information about post-traumatic stress and injuries sustained in war settings. Before the intervention, the translated manual and an accompanying information leaflet was sent to The National Association for the Traumatically Injured (Personskadeforbundet LTN) who suggested minor changes. We performed a feasibility study prior to the RCT and found that the CCT program was acceptable within the Norwegian context (41).

The vocational part of the intervention is based on supported employment (SE) principles (33). SE originates from research demonstrating that people with neuropsychiatric disabilities can perform complex work tasks and participate in paid work in the open labor market when appropriate level of support is provided (5, 33). The SE model consists of five stages: 1) Client engagement, 2) Vocational profiling, 3) Job finding, 4) Employer engagement, and 5) On and off the job support. Because all participants were employed at the time of injury, the main efforts in this study were on stages 1, 4, and 5. The first session focused on establishing a good working alliance, mapping the patient's resources, limitations and work tasks, and establishing common goals. Further follow-ups were tailored to the participants' needs and included work task adaptations, advice regarding assistive technology, learning new approaches, and training. The sessions included employers and other collaborators where appropriate. Participants received SE for a maximum of 6 months and the number of contacts between the participants and employment specialists and their content was recorded.

Both groups received standard Norwegian statutory sick leave follow-up in addition to the CCT-SE intervention or TAU.

### *2.6 Treatment fidelity and adherence*

Three employment specialists employed by the Norwegian Labor and Welfare Administration (NAV) delivered SE. They completed training in SE prior to the trial and received ongoing supervision during the trial. All sessions of the CCT intervention were provided by a clinical psychologist or MD who received training by EWT prior to administering the program. A fidelity check list used to evaluate the therapist's adherence and competency in administering the CCT intervention was completed by senior researchers (ML & NA). The six checklist items which were chosen from a previous publication by Winter et al. (42) and a consensus in the project group were: 1- Explained content of each CCT session clearly; 2- Used appropriate pace and language; 3- Showed sensitivity to participants responses; 4- Responded clearly to participants questions; 5- Demonstrated overall fidelity to the CCT manual; 6- Explained next step of the CCT intervention. The rating levels were poor, good and excellent. Treatment fidelity was assessed for 30 (5%) CCT-sessions. The following items were on average rated as excellent: 2- appropriate pace and language; 3- sensitivity to participant's responses and 6- explained next steps of intervention. The remaining items were rated as good.

Attendance across the 10 sessions of the CCT-intervention was 99%, with only three participants missing a total of 6 sessions. Participants who were unable to attend sessions at the scheduled time (e.g. due to illness or other reasons) were rescheduled and given the opportunity to attend the session at a later time. When asked if they would recommend the CCT intervention to others with similar problems, 93% replied yes, 3.5% replied I don't know, and 3.5% replied no.

### *2.7 Outcome measures*

The primary outcome was the proportion of participants who had returned to work (at any level) 3 and 6 months after study inclusion. In addition, we assessed work percentage, stability, and productivity at 3- and 6-months follow-up. The percentage of work participation was further divided into four categories relative to pre-injury employment grade (0 = not working at all; 1 = working <50%, 2 = working 50-79%, 3 = working 80-100%, i.e. full-time), describing the quantity of the work resumed at 3 and 6 months follow-up. Stable employment was defined as working at the same or increased level (%) as the previous follow-up time point (i.e., baseline to 3-months or 3 months to 6 months follow-up), while unstable employment was defined as working at a decreased level (%) compared to the previous follow-up. Work productivity was operationalized by hours worked per week and whether there were accommodations at the workplace (yes/no). Participants were asked to describe the type of accommodations that were made. Number of hours worked per week was calculated by dividing 37.5 (i.e. standard time norm for full time work in Norway) by 100 and multiplying with work percentage relative to pre-injury work level at 3 and 6 months. All outcomes were collected by structured interviews.

The outcomes were collected at 3, 6, and 12 months following inclusion. As the 12 months follow-up is ongoing, this study reports the work-related outcomes from the first two follow-ups.

### *2.8 Statistical methods*

Data were analyzed with IBM SPSS Statistics for Windows v. 25 and Stata v. 16. Descriptive statistics are presented with mean and standard deviation (SD) or median and inter-quartile range (IQR) for continuous variables, and proportions and percentages or range for categorical variables. Between-group differences at each follow-up (3 and 6 months) were analyzed using independent samples *t* tests for continuous and chi-square tests for categorical variables. Mixed effect models were fitted to all outcome variables to account for the repeated measures by patient. Continuous

endpoints were analyzed using linear mixed models with random intercept and slope. Time and time-by-treatment interaction were fixed effects in all models. Based on the linear mixed model, we estimated mean values with 95% confidence intervals (CI) for the three time points (baseline, 3 months, and 6 months) for each treatment group. We also estimated the mean between group changes from baseline to 6 months. Dichotomous endpoints were analyzed using mixed effects logistic regression with treatment and time-by-treatment as fixed effects. Based on the mixed effects logistic regression we estimated risk differences with 95% CI from baseline to 3 and 6 months using the delta method. All analyses were done by intention to treat.

The sample size calculation is based on primary study outcome at 12 months, and is described elsewhere (37). The required sample size was estimated to 110 (i.e. 55 in each group). Based on a previous study (14), we estimated a loss to follow-up of 15%, requiring a total of 125 participants. However, loss to follow up was lower than expected and we concluded enrollment at 116 participants.

### *2.9 Ethics*

All subjects gave their informed consent for inclusion before they participated in the study. The study was conducted in accordance with the Declaration of Helsinki, and the protocol was approved by the Regional Committee for Medical Ethics in South-Eastern Norway.

## **3. Results**

A total of 116 patients were enrolled from July 2017 to April 2019 (see figure 1). Three participants dropped out after randomization, two before receiving any treatment, and one after completing one CCT session. Participants received the CCT-SE intervention or TAU from August 2017 until November 2019. There were no statistically significant differences between CCT-SE and TAU on baseline characteristics, with the exception of previous TBI and intoxication at the time of injury (see table 2). Further analysis revealed that these variables were not associated with any of the outcomes, thus were not controlled for in the main analyses.

The median duration of follow up in the TAU group was 155 days, and the median number of individual contacts per participant was 9. Of the 55 participants who received TAU, 100% were consulted by a MD, 50 (91%) received occupational therapy, 39 (71%) participated in the educational groups, 31 (56%) received physical therapy, 21 (38%) were referred to a neuropsychologist, and 20 (36%) received advice from a social worker.

The duration of the CCT-SE intervention is described in the methods section. Regarding SE, the total number of face-to-face meetings between the employment specialists and participants was 178 (on average three meetings per participant of which approximately one was at the work-place). The mean number of contacts per e-mail or telephone was 10 per participant.

### *3.1 Proportion of participants returned to work at 3 and 6 months*

At baseline, 40% in CCT-SE and 30% in TAU were working (at any level). At the 3 month follow-up, 81% in CCT-SE and 60% in TAU were working. At the 6 month follow-up, 84% in CCT-SE and 74% in TAU were working. There was a statistically significant higher proportion of participants working in the CCT-SE group compared to TAU at 3 months, but there was no difference between the groups at 6 months (see figure 2). Mixed effects logistic regression analysis showed a statistically



significant within group increase in both groups from baseline to 3 and 6 months regarding number of participants working. However, the between group difference did not reach statistical significance (table 3).

### *3.2 Work percentage*

Work percentage in CCT-SE and TAU from baseline to 3- and 6-month follow-up is shown in figure 3. At baseline, 33% in CCT-SE and 21% in TAU were working below 50%, while 7% in CCT-SE and 9% in TAU were working 50% or more. At 3 months, 53% in CCT-SE and 29% in TAU were working below 50%, whereas 28 % in CCT-SE and 31% in TAU were working 50% or more. At 6 months, 33% in CCT-SE and 24% in TAU worked below 50%; 51% in CCT-SE and 49% in TAU worked 50% or more. There was a statistically significant difference between the groups across the categories of work participation at 3 months, showing that for CCT-SE the highest proportion of work participation was in the category working <50% while for TAU the highest proportion was found in the not working at all category. The groups did not differ at 6 months. Using work percentage as continuous variable, linear mixed model analyses showed a statistically significant within group increase in work percentage from baseline to 3 and 6 months, but no significant between group difference (table 3).

### *3.4 Hours worked per week*

At baseline, the mean (SD) number of work hours per week in CCT-SE and TAU were 4.5 (6) and 4 (6), respectively. At 3 months, the CCT-SE group worked 13 (10) hours and TAU worked 11 (12) hours weekly. At 6 months, CCT-SE and TAU worked 19 (13) and 17 (15) hours per week, respectively. Mixed model analyses showed a statistically significant within group increase in hours worked, but no between group differences (table 3).

### *3.3 Work stability*

The majority of participants who were employed at 3- and 6-months were stably employed. In the CCT-SE group, three participants (2%) decreased their work percentage between baseline and 3 months, and three participants (2%) decreased their work percentage between 3 and 6 months. In the TAU group, two participants (1%) decreased their work percentage between baseline and 3 months, and four participants (2%) decreased their work percentage between 3 and 6 months. There were no statistically significant differences between the two groups regarding the proportion of unstably employed participants at 3- or 6 months. The number of unstably employed participants was too low to perform additional analyses.

### *3.5 Work place accommodations*

Among the 47 participants in the CCT-SE group who were working at 3 months, a total of 34 (72%) had accommodations made at the workplace, compared to 21 (64%) among the 33 who were working in the TAU group. At 6 months, 46 in CCT-SE were working with 25 (54%) having accommodations at the workplace compared to 19 (49%) of the 39 participants who were working in TAU. Accommodations included modified equipment (i.e. adjusted lighting, adapted computer screens, noise cancelling head phones), flexibility with regard to working hours and location (i.e. opportunity to work from home, separate office, more breaks, limited travelling, exempt from night shifts), receiving help or allocating work tasks to someone else (i.e. hiring substitutes) and adjustment of work tasks (i.e. fewer tasks, exemption from stressful tasks and short deadlines). There were no statistically significant differences between the two groups regarding the proportion of participants who had accommodations at the workplace at 3 or 6 months.

### 4. Discussion

The aim of this RCT was to compare the effectiveness of a combined cognitive and vocational intervention to multidisciplinary follow-up on employment participation in a sample of patients with mild-to-moderate TBI. In line with previous studies (28, 29) both groups had significant improvement regarding RTW, in addition to work percentage and hours worked during the 6-month study period. Contrary to our hypotheses, we found no statistically significant differences in the measures of work stability and productivity between the two groups at either follow-ups. However, compared to TAU, a higher proportion of participants in the CCT-SE intervention group had returned to work at 3 months, suggesting that CCT-SE accelerated RTW in our sample.

Previous studies have recommended the use of compensatory cognitive strategies in rehabilitation following TBI (43). When facilitating RTW post-TBI, early supported employment could be applied and achieved when health care professionals, vocational counselors, and job coaches work together (26, 44, 45). We found significantly greater RTW in the CCT-SE group at the first follow-up, and consider the between group difference of 11% (adjusted for group difference at baseline) clinically relevant. This finding is in contrast to the previously mentioned study by Scheenen and colleagues finding no between-group differences regarding RTW at 3 months follow-up (28). However, the results may not be directly comparable as Scheenen et al. provided less complex interventions and assessed full RTW. Our results indicate that the study intervention may have had a positive effect in the early phase by speeding RTW. However, the proportion of participants working doubled in both groups, and the observed difference was no longer present at the 6-month follow-up. This may indicate that the TAU group, although taking longer to RTW, continued to improve over time and eventually reached the same level. Although the TAU group only received statutory sickness absence follow-up, and not SE at the workplaces, the multidisciplinary follow-up may have positively influenced the patients' conditions and frequency of return to work. As we did not include a no-treatment control group, we were not able to establish the influence of the natural course of recovery or the isolated contribution of CCT-SE, as the TAU group also received multidisciplinary treatment, although less specific and not manualized.

The TAU group received individual follow-up by a multidisciplinary team and limited group-based education about common symptoms and problems, while the CCT-SE group received individualized work support and a combination of psychoeducation about TBI, strategies to manage common symptoms and compensatory cognitive strategies. As such, both groups received rather extensive follow-up, although the content of the two treatments differed. The effect of the multidisciplinary follow-up was assessed in a previous publication and found to reduce number of post-concussive symptoms, but did not improve RTW (29). Previous studies have reported that the CCT program can reduce subjective complaints and improve neurocognitive function in veterans with mild-to-moderate TBI (31, 32, 35), while SE has been shown to significantly improve work outcomes in individuals with mental health issues in the Norwegian context (36). The main difference between the two groups regarding RTW proportion was seen during the first three months, i.e. while the participants were receiving both CCT and SE, thus indicating that the combined intervention had a positive impact on RTW.

Improving early RTW rates post-TBI is of personal and socioeconomic importance. However, the literature shows that individuals who return to work may experience continued difficulties affecting work stability and productivity (10, 12). Results from this study showed that the majority of participants in both groups were stably employed between baseline, 3, and 6 months. Furthermore,

there was a significant increase in hours worked from baseline to 6 months. Thus, the findings did not suggest that either CCT-SE or TAU had a negative impact on objective measures of stability and productivity, and that neither treatment group actually contributed to premature RTW with negative effect.

Although we did not find a significant between-group difference regarding work percentage in the overall model, a higher proportion of individuals in the CCT-SE group had returned to part-time work at 3 months. There was also a non-significant higher proportion of individuals with accommodations at the work-place in the CCT-SE group at the 3 month follow-up. SE aims to provide individually adapted work-support, including advice regarding adapting work tasks and assistive technology to increase the chance of successful RTW, while the CCT intervention provides psychoeducation, stress reduction techniques and compensatory strategies for cognitive complaints. Moreover, the therapists providing CCT and SE worked in close collaboration, thereby increasing the chance of identifying specific issues and implementation of individualized strategies at the work place. These components may have positively influenced the participants' RTW process at an early stage. Data from a 12-month follow-up will be published when available, and will provide insight to the long-term RTW parameters in this sample.

In general, the proportion of participants that returned to work at 6 months was high in both groups. Still, 16% of the participants in the intervention group and 26% in the TAU group had not returned to work at 6 months. Furthermore, only 35% of the participants on average were working between 80 and 100%, indicating that many participants were still working at a reduced level compared to before their injury. The proportion of participants who did not RTW is comparable to the study by de Koning and colleagues (19) who included a sample with comparable patient characteristics. Norway is characterized by high job security, low unemployment, and a comprehensive welfare system where patients receive a full salary the first year of sick-leave. However, the rate of sickness absence is among the highest in Europe, and the mentioned sickness benefits may reduce the impact of interventions aimed to improve return to work (46).

The majority of the participants had sustained a mTBI and were recruited based on experiencing persistent complaints 2 months following injury. Furthermore, they were employed in a minimum 50% position at the time of injury. More women than men were recruited to this study, which diverges from epidemiological TBI studies. As such, the results may not be generalizable to all patients with TBI, including individuals who are unemployed at the time of injury. Additionally, the results should be generalized with caution with regard to gender differences. However, the study sample was civilian as opposed to veterans, generalizing the results beyond the military context. The study also extends existing data to a sample derived within a Scandinavian welfare system.

To avoid interference from the researchers or therapists providing the intervention or TAU, the required medical sick-leave certificates were completed by the participants' GPs. Information about sick-listing, percentage of sick leave and number of hours worked per week was self-reported by the participants at each follow-up. Self-reported work status has been found to be reliable in other patient populations (47) and we regard the participants' self-reports as valid as they regularly visited GPs for sick-leave certifications.

The study was performed in Norway, a welfare state with long-term sickness benefits. TAU, in this context, encompassed individualized multidisciplinary follow-up provided by experienced therapists which can be considered a specialized version of usual care. The level of treatment provided in the TAU group represents a University hospital service delivery in the capital of Norway, which might

not be representative for patients treated in other hospitals or geographical regions, or countries with different organization of health care. This may have influenced the results of the study. Additionally, control groups receiving CCT or SE only might have made it possible to tease apart the effect of specific components of the combined intervention. Due to a limited number of TBIs in our region (6), we were unable to design the study with more than one control group.

This is the first study conducted in close collaboration between hospital staff, job coaches from the Norwegian Labor and Welfare organization and the Work Research Institute (i.e., trans-sectorial collaboration). The outcomes were selected based on recommendations from a previous systematic review on vocational interventions after TBI (34) thus describing a broader range of employment outcome. Furthermore, findings from a process evaluation across sectors will be published in a subsequent paper.

### Conflict of Interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

### Author Contributions

All authors have contributed substantially to the work reported. All authors critically revised the paper. All authors read and approved the final manuscript. Conceptualization, E.I.H., S.C.R.F, M.L., H.E. and N.A.; methodology, E.I.H, M.L., H.E., C.R., E.T., J.L. and N.A.; formal analysis, E.I.H, M.L., C.B. and N.A.; investigation, E.I.H, S.C.R.F, M.L., K.S., T.H. and N.A. ; data curation, E.I.H., S.C.R.F., M.L., K.S., T.H., T.H.N. and N.A.; writing—original draft preparation, E.I.H, M.L. and N.A.; writing—review and editing, E.I.H, S.C.R.F, M.L., H.E., K.S., T.H., C.B., C.R., T.H.N., H.L.S., E.T., J.L., and N.A.; Visualization, E.I.H, C.B., N.A., M.L.; Supervision, N.A., M.L., C.R., T.H.N., H.E. and H.L.S.; Project Administration, N.A., M.L., C.R. and H.E.; Funding Acquisition, N.A.

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**Table 1.** Topics covered in the CCT intervention.

<b>Session</b>	<b>Topic</b>	<b>Examples of strategies</b>
1	Course introduction and information about TBI	Finding a “home” for important personal items
2	Managing fatigue, sleep problems, headaches, and tension	Sleep hygiene and relaxation techniques
3	Organization and prospective memory	Time management and establishing routines
4	Organization and prospective memory (continued)	Calendar use and to-do lists
5	Attention and concentration	Paying attention during conversations
6	Learning and memory	Internal and external memory strategies
7	Learning and memory (continued)	Overlearning and name learning strategies
8	Planning and goal setting	Plan to meet goals and deadlines
9	Problem solving and cognitive flexibility	6-step problem solving method and self-monitoring
10	Skills integration, review, and next steps	Application of strategies to everyday life and progress toward goals



**Table 2.** Participant characteristics at baseline.

	<b>CCT-SE</b> (n = 60)	<b>TAU</b> (n = 56)
<b>Demographic information</b>		
Age, mean (SD)	41 (10)	44 (9)
Gender (female), n (%)	33 (55)	36 (64)
Education, mean (SD)	16 (2)	16 (3)
Marital status, n (%)		
Married/co-habitant	43 (72)	34 (61)
Divorced/separated/single	17 (28)	22 (39)
<b>Clinical information</b>		
Time since injury at inclusion (days), mean (SD)	77 (25)	68 (22)
Cause of injury, n (%) (n = 115)		
Fall	19 (32)	30 (54)
Transport	12 (20.5)	11 (20)
Blow to head	15 (25.5)	8 (14)
Sport	10 (17)	4 (7)
Violence	3 (5)	3 (5)
GCS, median (min-max) (n = 114)	15 (10-15)	15 (11-15)
LOC, n (%) (n = 115)		
None	31 (51.5)	30 (54.5)
<30 min	21 (35)	16 (29)
<24 h	1 (2)	2 (4)
Not registered	7 (11.5)	7 (12.5)
PTA, n (%) (n = 115)		
None	25 (42)	26 (47)
<1 h	18 (30)	17 (40)
<24 h	7 (11.5)	9 (16)
<7 days	0 (0)	2 (4)
Not registered	10 (16.5)	1 (2)
Trauma-related CT/MRI findings, n (%)		
Yes	11 (18)	16 (29)
No	45 (75)	35 (62)
No CT/MRI	4 (7)	5 (9)
AIS head score, n (%)		
Minor	34 (57)	25 (44.5)
Moderate	18 (30)	16 (28.5)
Serious	5 (8)	10 (18)
Severe	3 (5)	5 (9)

## Cognitive and vocational intervention

Extracranial injuries (yes), n (%)	28 (47)	25 (45)
Admitted to hospital (yes), n (%)	8 (13)	16 (28)
Intoxicated at time of injury (yes), n (%), (n = 115)	5 (9)	12 (21)
Injured at the workplace (yes), n (%), (n = 114)	9 (15)	7 (13)
<b>Work factors</b>		
Occupation type (white collar), n (%)	53 (88)	50 (89)
Occupation category, n (%)		
Military/Academic professions	30 (50)	28 (50)
Leaders	15 (25)	13 (23)
Office/Sales	10 (17)	9 (16)
Craft/Machine operators/Transportation/Cleaning	5 (8)	6 (11)
Employment duration (months), median (IQR), (n = 114)	54 (114)	42 (108)
Full time position (yes), n (%)	55 (92)	48 (86)
Enterprise size, n (%)		
Micro (1-9 employees)	4 (7)	5 (9)
Small (10-49 employees)	17 (28)	19 (34)
Medium (50-249 employees)	12 (20)	16 (28.5)
Large (>250 employees)	27 (45)	16 (28.5)
Sick listed, n (%)		
80-100%	48 (80)	46 (82)
50-79%	12 (20)	10 (18)

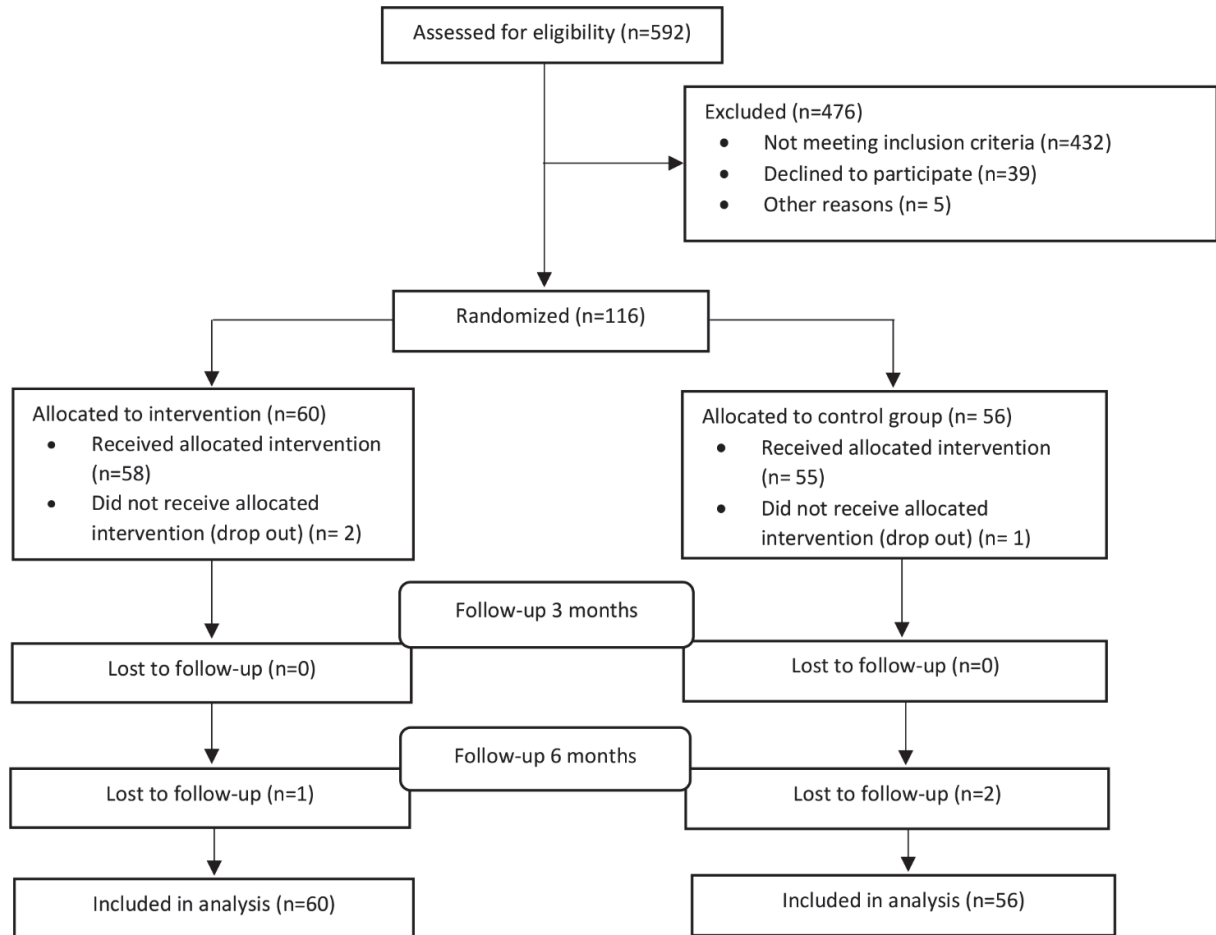
*Notes:* CCT-SE, Compensatory Cognitive Training and Supported Employment; TAU, treatment as usual; GCS, Glasgow Coma Scale; LOC, loss of consciousness; PTA, post-traumatic amnesia; AIS, Abbreviated Injury Scale.

**Table 3.** Results from mixed model analyses.

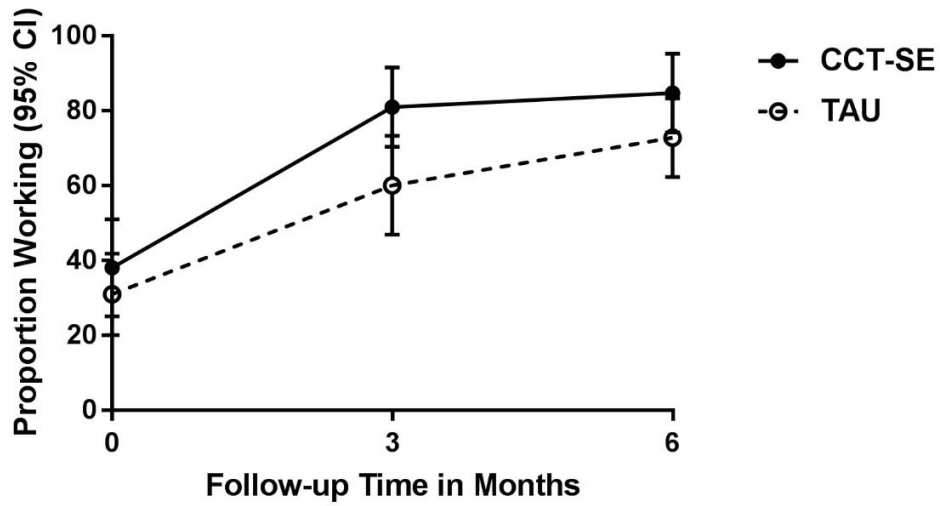
Proportion working	Baseline Proportion (95% CI)	3 months Proportion (95% CI)	6 months Proportion (95% CI)	Within group difference baseline to 6 mo., (95% CI), p-value	Between group difference (95% CI), p-value
CCT-SE	38.0 (25.1 – 51.0)	81.0 (70.4 – 91.5)	84.7 (74.2 – 95.2)	46.7 (32.9 – 60.5), p<0.001	4.8 (-13.3 – 23.0), p=.601
TAU	31.0 (20.1 – 41.8)	60.1 (46.8 – 73.3)	72.8 (62.3 – 83.3)	41.8 (30.0 – 53.6), p<0.001	
	Baseline Mean (95% CI)	3 months Mean (95% CI)	6 months Mean (95% CI)	Mean within group change baseline to 6 mo., (95% CI), p-value	Mean between group change (95% CI), p-value
Work percentage					
CCT-SE	12.8 (8.2 - 17.4)	32.1 (26.2 – 38.0)	51.4 (41.9 – 60.9)	38.6 (29.6 - 47.7), p<0.001	2.0 (-11.0 – 15.1), p=.760
TAU	10.4 (5.6 - 15.2)	28.7 (22.6 - 34.8)	47.0 (37.2 - 56.8)	36.6 (27.2 – 46.0), p<0.001	
Hours worked					
CCT-SE	4.8 (3.1 – 6.5)	12.0 (9.8 – 14.3)	19.3 (15.7 – 22.8)	14.5 (11.1 – 17.9), p<0.001	0.76 (-4.1 – 5.7), p=.760
TAU	3.9 (2.1 – 5.7)	10.8 (8.5 – 13.1)	17.6 (14.0 – 21.3)	13.7 (10.2 – 17.3), p<0.001	

Notes. CCT-SE, Compensatory Cognitive Training and Supported Employment; TAU, treatment as usual.

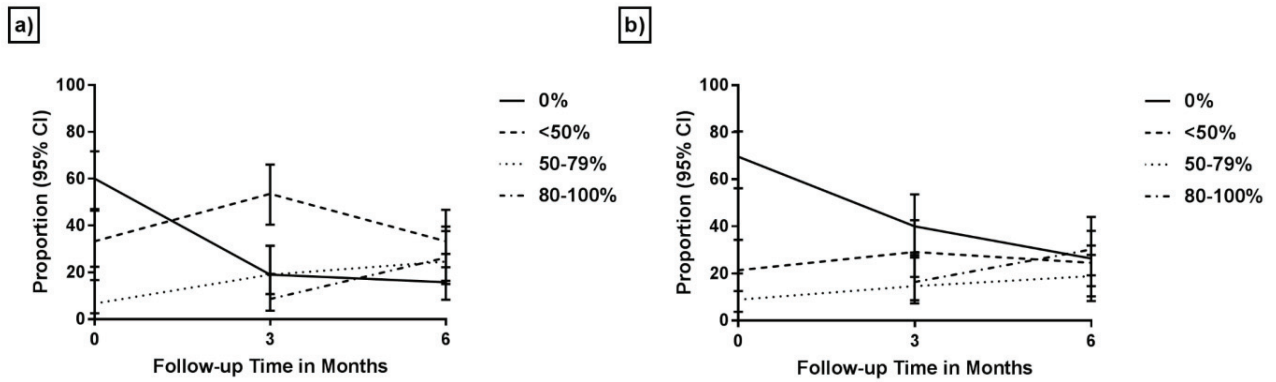
Figure 1. CONSORT flow chart.



**Figure 2.** Estimated proportion of participants working at baseline, 3- and 6 months per treatment group from mixed effects logistic regression analyses. CCT-SE, Compensatory Cognitive Training and Supported Employment; TAU, treatment as usual.



**Figure 3.** (a) Observed proportion of participants working 0%, <50%, 50-79%, and 80-100% at baseline, 3- and 6 months in the CCT-SE group; (b) Observed proportion of participants working 0%, <50%, 50-79%, and 80-100% at baseline, 3- and 6 months in the TAU group. CCT-SE, Compensatory Cognitive Training and Supported Employment; TAU, treatment as usual.











# Employment Probability Trajectories Up To 10 Years After Moderate-To-Severe Traumatic Brain Injury

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**Aims:** To examine trajectories of employment probability up to 10 years following moderate-to-severe traumatic brain injury (TBI) and identify significant predictors from baseline socio-demographic and injury characteristics.

**Methods:** A longitudinal observational study followed 97 individuals with moderate-to-severe TBI for their employment status up to 10 years post injury. Participants were enrolled at the Trauma Referral Center in South-Eastern Norway between 2005 and 2007. Socio-demographic and injury characteristics were recorded at baseline. Employment outcomes were assessed at 1, 2, 5, and 10 years. Hierarchical linear modeling (HLM) was used to examine employment status over time and assess the predictors of time, gender, age, relationship status, education, employment pre-injury, occupation, cause of injury, acute Glasgow Coma Scale (GCS) score, duration of post-traumatic amnesia (PTA), CT findings, and injury severity score, as well as the interaction terms between significant predictors and time.

**Results:** The linear trajectory of employment probabilities for the full sample remained at ~50% across 1, 2, 5, and 10-years post-injury. Gender ( $p = 0.016$ ), relationship status ( $p = 0.002$ ), employment ( $p < 0.001$ ) and occupational status at injury ( $p = 0.005$ ), and GCS ( $p = 0.006$ ) yielded statistically significant effects on employment probability trajectories. Male gender, those in a partnered relationship at the time of injury, individuals who had been employed at the time of injury, those in a white-collar profession, and participants with a higher acute GCS score had significantly higher overall employment probability trajectories across the four time points. The time\*gender interaction term was statistically significant ( $p = 0.002$ ), suggesting that employment probabilities remained fairly stable over time for men, but showed a downward trend for women. The time\*employment at injury interaction term was statistically significant ( $p = 0.003$ ),

suggesting that employment probabilities were fairly level over time for those who were employed at injury, but showed an upward trend over time for those who had been unemployed at injury.

**Conclusion:** Overall employment probability trajectories remained relatively stable between 1 and 10 years. Baseline socio-demographic and injury characteristics were predictive of employment trajectories. Regular follow-up is recommended for patients at risk of long-term unemployment.

**Keywords:** brain injury, outcome assessment, prospective studies, return to work, rehabilitation

## INTRODUCTION

The majority of individuals with traumatic brain injuries (TBIs) in high-income countries survive due to improvements in overall trauma care (1). Most survivors are of working age (2), and one of the challenges for this group is to return to work and maintain employment over time (3–6). The participation in employment represents a key rehabilitation goal after TBI in order to avoid the personal and socio-economic burden of unemployment. Identifying early prognostic factors associated with employment and employment probability trajectories can help identify persons who are at risk of unemployment and to alleviate the burden of TBI through more effective vocational rehabilitation programs.

Despite substantial research regarding employment outcomes and their prognostic factors (7–13), there are few studies looking at employment probability from a long-term perspective after TBI (i.e., 10 years after injury) (14). Ponsford et al. (15) examined aspects of functioning affected by complicated mild to severe TBI over a span of 10 years and found that only half of the sample returned to previous leisure activities and fewer than half were employed at each follow-up post-injury (2, 5, and 10 years). More recently, Cuthbert et al. (16) studied the 10 years patterns of employment in working age persons with moderate-to-severe TBIs who were discharged from a Traumatic Brain Injury Model Systems (TBIMS) center in the United States. They used a generalized linear mixed model, and included 1, 2, 5, and 10 years follow-ups. Results indicated that age, gender, cultural factors, education, duration of post-traumatic amnesia (PTA), and pre-injury substance abuse significantly predicted the trajectory of post-injury employment. The authors concluded that the overall decline in trajectories of employment probability between 5 and 10 years post-injury may suggest the chronic effects of TBI, and the influence of national and labor market forces on employment outcome. Similarly, Grauwmeijer et al. (14) evaluated the predictors and probability of employment over a 10 years period (3, 6, 12, 18, 24, and 36 months and 10 years post-TBI) in a Dutch sample of moderate-to-severe TBIs using generalized estimating equations and a logistic regression analysis. The authors concluded that 10 years employment probability is related to time, severity of injury and pre-injury employment. After an initial increase in the first 2 years post TBI, the employment probability stabilized at 57% after 2 years and decreased to 43% in the long-term (14), in line with the study by Cuthbert et al. (16).

Taken together, in addition to the socio-demographics and injury related characteristics, differences in governmental policies, health care and welfare systems, rehabilitation services, and culture may influence the predictors of employment trajectories (5, 13, 16–19). Thus, studies from different countries are required to provide a better understanding of factors influencing the employment probability and needs of rehabilitation and long-term follow-up programs.

We previously reported the employment probability trajectories up to 5 years post-injury (5) by using multi-level modeling, and found fairly constant employment rates of ~50% across the three follow-up time points at 1, 2, and 5 years post-TBI. Being single, unemployment at the time of injury, blue collar occupation, lower GCS score at hospital admission, and longer duration of PTA were significant predictors of unemployment at 1, 2, and 5 years post-injury.

This study is an extension which aims to examine employment probability trajectories up to 10 years after moderate-to-severe TBI, and to investigate whether those trajectories could be predicted by socio-demographics and injury characteristics. Based on the previously mentioned studies from the US and Netherlands, we hypothesized that the employment probability would decrease from 5 to 10 years post-injury.

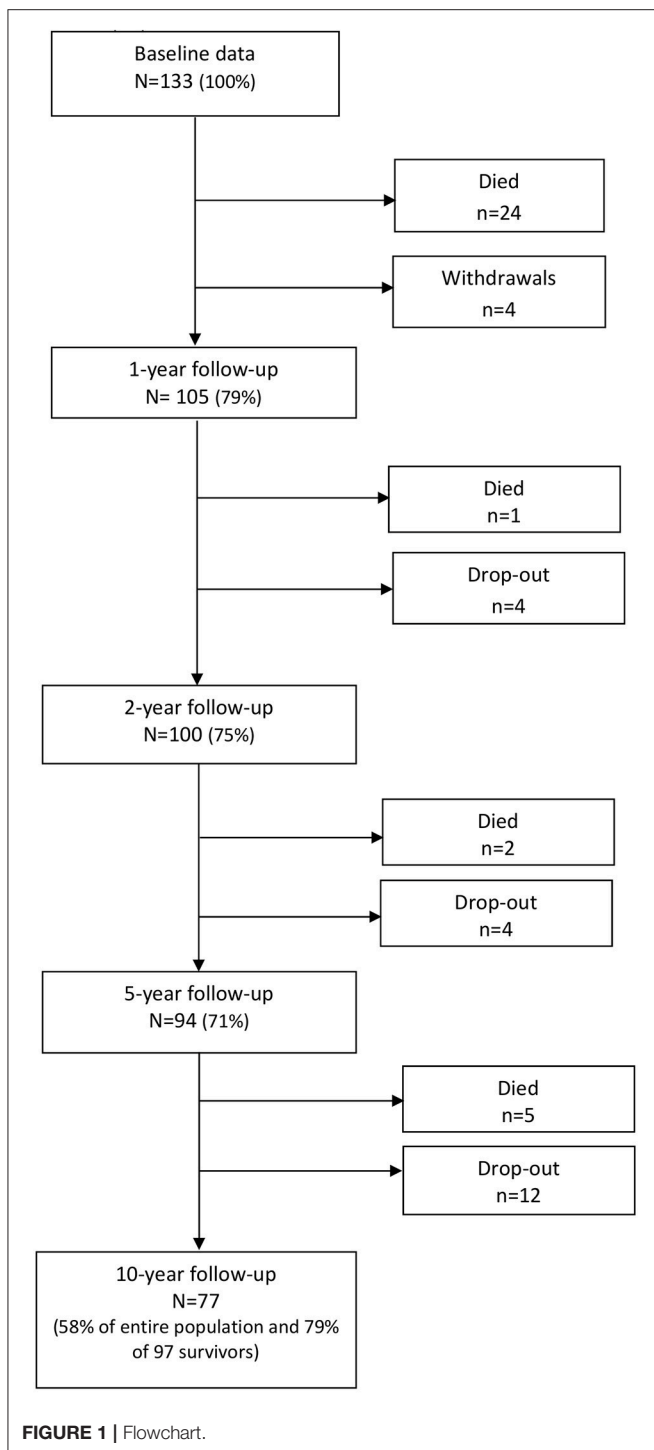
## MATERIALS AND METHODS

### Participants

A longitudinal cohort study was conducted including patients with acute TBI who had been admitted from 2005 to 2007 to the Trauma Referral Centre for the South-Eastern region of Norway, covering a population of nearly 2.6 million people. Patients were assessed in the acute phase (baseline) and followed up at 1, 2, 5, and 10 years after injury. Inclusion criteria were (a) age 16–55 years, (b) residence in eastern Norway, (c) admission with ICD-10 diagnosis S06.0–S06.9 within 24 h of injury, and (d) presence of moderate-to-severe TBI with a Glasgow Coma Scale (GCS) (20) score of 3–12 at admission or before intubation. Exclusion criteria were (a) previous neurological disorders/injuries, (b) associated spinal cord injuries, (c) previously diagnosed severe psychiatric or substance abuse disorders, and (d) unknown address or incarceration. For additional details, see study by Forslund et al. (5).

Overall, 133 individuals met the inclusion criteria. Thirty-two patients died during the acute or post-acute phase and

four withdrew, leaving 97 survivors analyzed in this study (see **Figure 1**). The overall attrition rate in the surviving population was 21%. Because full information maximum likelihood (FIML) estimation was used to account for missing data at the various follow-ups, all participants were able to be retained in the model, generating statistical estimates that were unbiased due to attrition.



## Measures

The outcome variable in this study was employment status at 1, 2, 5, and 10 years after injury. Employment was dichotomized into employed and unemployed, where individuals in the employed group consisted of individuals working full/part time or studying (high school, college, or university), while members of the unemployed group were jobseekers, on sick leave or work assessment allowance, or receiving disability pension. Working or studying full time was equal to 37.5 productive hours per week (i.e., 100% in Norway), while part-time employment was defined as working <37.5 h per week.

The independent variables (predictors) used in this study were: Gender (male vs. female), age at time of injury (in years), relationship status at hospital admission (partnered [married/cohabitant] vs. single), education ( $\leq 12$  years vs.  $> 12$  years), employment status at time of injury (employed vs. unemployed), occupation prior to admission [blue collar (physical work) vs. white collar (non-physical work/being a student)], acute GCS (continuous), cause of injury (traffic accident vs. other), length of PTA (number of days) measured by the Galveston Orientation and Amnesia Test (GOAT) (21), Injury Severity Score [ISS; range from 1 to 75 (best to worst)] (22), and CT severity score. All patients had an acute CT head scan followed by a second control scan between 6 and 12 h after the injury. All CT scans were assessed and categorized by the same neuroradiologist according to the Marshall CT classification (23). The CT scan that showed the most extensive degree of intracranial damage (i.e., the largest hematoma thickness/midline shift and/or with the most extensive degree of parenchymal damage) within the first 24 h was used for classification.

## Procedure

Pre-injury and injury-related characteristics from the acute phase were extracted from medical records. At the 1, 2, 5, and 10 years follow-ups, a physiatrist performed the assessments and interviews of patients at the outpatient department. Several patients made requests that the assessments and interviews should be conducted by telephone, and this was complied with. The study was approved by the Regional Committee for Medical Research Ethics, East Norway, and the Norwegian Data Inspectorate. All participants gave their written informed consent to participate in the study.

## Data Analysis

Descriptive statistics were used to present demographics and injury related variables, and results are presented as percentages and means with standard deviations (SD) as appropriate. Hierarchical linear modeling (HLM) was used to examine trajectories of employment probability across 1, 2, 5, and 10 years after injury and identify baseline predictors. HLM was selected so that a full trajectory across all four time points could be analyzed and predicted, as opposed to separate and limited predictions of employment probability at each independent time point. A conditional (null) model was run first to determine whether there was sufficiently large clustering of employment probability variance within participants to proceed with HLM.

Unconditional growth linear (straight line), quadratic (U-shaped), and cubic models (S-shaped) were then run with no predictors to determine the most accurate model for linear or polynomial (curved) architecture of employment probabilities over time.

Once the most accurate curvature model was identified, predictors were entered simultaneously as fixed effects into an HLM after being centered or given a reference point of 0, along with time (given that linear trajectories of employment probabilities were found, outlined below). The HLM determined whether linear trajectories of employment probabilities across the four time points could be predicted by the demographic and injury characteristics of time [coded as 0 (1 year), 1 (2 years), 4 (5 years), or 9 (10 years) to reflect actual spacing between time points], gender (1 = female, 0 = male), age, relationship status (1 = partnered, 0 = single), education (1 = >12 years, 0 = ≤12 years), employment at admission (1 = employed, 0 = unemployed), occupational status (1 = white collar, 0 = blue collar), continuous GCS score, cause of injury (1 = motor vehicle, 0 = not motor vehicle), length of PTA (days), CT severity score, and ISS. A second HLM included the significant predictors identified from the full HLM, the variable of time, and interaction terms between the variable of time and the significant predictors.

## RESULTS

The mean age of the 97 patients at the time of injury was 30.3 (SD = 10.8) years, 76% were men and 60% were injured in traffic accidents. The mean GCS at hospital admission was 7.2 (SD = 3.2). Of all patients, 73% received inpatient rehabilitation with mean length of stay 59 days (SD = 37 days). Demographics and injury-related characteristics are presented in **Table 1**.

Of all patients, 18% were unemployed at the time of injury (jobseekers 7%; work assessment allowance 5%; sick leave 2%; disability pension 4%). Of these, 80% were men, 60% >30 years, 70% with <12 years of education and 60% living alone.

The employment rate dropped from 82% pre-injury to 53% at 1 year follow-up and thereafter remained fairly stable up to 10 years (48, 55, and 50% at 2, 5, and 10 years follow-ups). At 10 years follow-up, 28% of the patients were in full-time jobs. Among the 22% of patients who were in part-time jobs, the majority (76%) received graded disability pension. Of the unemployed patients, 80% received full disability pension, 13% received work assessment allowance, and the remaining patients were jobseekers. A majority (79%) of the patients who were unemployed at 10 years were in the severe TBI group as measured by the GCS at injury time.

## Unconditional Model and Unconditional Growth Models

The unconditional model yielded a statistically significant estimated participant variance of 0.17 (Wald  $Z = 6.05$ ,  $p < 0.001$ ), as well as a statistically significant estimated residual variance of 0.08 (Wald  $Z = 11.33$ ,  $p < 0.001$ ). The intraclass correlation

**TABLE 1 |** Demographics at time of injury and injury characteristics.

Variable	n (%)	Mean (SD)	Total n
Age at injury in years		30.3 (10.8)	97
Gender			97
Male	76 (78.4)		
Female	21 (21.6)		
Relationship status			97
Partnered	28 (28.9)		
Single	69 (71.1)		
Education level			96*
≤12 years	54 (56.3)		
>12 years	42 (43.7)		
Employment status			97
Yes	80 (82.5)		
No	17 (17.5)		
Occupational status			97
Blue collar	46 (47.4)		
White collar	51 (52.6)		
Disability pension	4 (4.0)		
Injury cause			97
Traffic accident	58 (59.8)		
Other	39 (40.2)		
Glasgow Coma Scale (GCS)		7.2 (3.2)	97
Moderate (9–12)	32 (33.0)		
Severe (3–8)	65 (67.0)		
Post-traumatic amnesia (PTA) in days		26.0 (30.0)	91**
CT Head Marshall Score		2.6 (1.1)	97
Score 1–2	46 (47.4)		
Score 3+	51 (52.6)		
Injury Severity Score		30.0 (13.6)	97
Total acute length of stay in days		29.0 (25.0)	97
In-patient rehabilitation length of stay in days		59.0 (37.0)	71***

\*Missing data on 1 individual.

\*\*Missing data on 6 individuals.

\*\*\*Only 71 individuals received in-patient rehabilitation (length of stay and mean stay is only calculated for those actually receiving it rather than the whole population).

coefficient was calculated to be 0.68, indicating that ~68% of the total variance of employment probabilities was associated with the participant grouping (i.e., based on employment probability being correlated within each participant) and that the assumption of independence was violated. This suggests there was sufficiently large clustering of employment probability variance within participants to proceed with HLM. In other words, an intraclass correlation coefficient this high suggests a fairly high level to which employment probability is consistent across the same individual. The unconditional growth model was then run separately with the successive additions of time (-2LL = 321.50) quadratic time (-2LL = 321.35) and cubic time (-2LL = 315.48) in order to determine the shape of the best fitting architecture of employment probabilities over time, suggesting that a linear (straight line) trajectory best fit employment probability trajectories (The critical  $X^2$  value for significant difference at  $\alpha = 0.05$  is a >3.841 drop from the previous model).

## Full Model

An HLM examined whether employment probability trajectories over time could be predicted by socio-demographic and injury characteristics at the time of injury. All statistically significant and non-significant fixed effects from the full HLM and their b-weights, *p*-values, and 95% confidence intervals appear in **Table 2**. The linear trajectory of employment probabilities remained level over time across the full sample (e.g., no significant increase or decrease). Gender, relationship status at injury, employment at injury, occupational status, and GCS all yielded statistically significant effects on participants' employment probability trajectories.

Men had a higher overall employment probability trajectory across the four time points compared to women (**Figure 2**). Individuals who had been in a partner relationship at the time of injury had a slightly higher probability trajectory of employment than those who had been single, although this effect seemed to be driven by the first three time points (**Figure 3**). Individuals who had been employed at the time of injury had a higher probability trajectory of employment than those who had been unemployed at injury (**Figure 4**). Individuals in a white collar occupation had a higher probability trajectory of employment than those in a blue collar occupation (**Figure 5**). Finally, participants with a lower GCS score had a lower employment probability trajectory than those with a higher score (**Figure 6**).

## Model With Time Interactions

An HLM examined whether employment probability trajectories could be predicted by the previously significant predictors (gender, relationship status at injury, employment at injury, occupational status, and continuous GCS), time, as well as their interactions with time (see **Table 3**). The time\*gender interaction term was statistically significant ( $p = 0.002$ ), suggesting that employment probabilities remained fairly stable over time for men but showed a downward trend over time for women (**Figure 2**). The time\*employment at injury interaction term was statistically significant ( $p = 0.003$ ), suggesting that employment probabilities were fairly level over time for those who had been employed at injury but showed an upward trend over time for those who had been unemployed at injury (**Figure 4**). The time\*occupational status interaction term approached significance ( $p = 0.069$ ) (**Figure 5**).

## DISCUSSION

The present study is an extension of a study performed by Forslund et al. (5) which reported employment probability trajectories up to 5 years post-injury. This paper describes the 10-years trajectories and predictors of employment for 97 individuals with moderate and severe TBI.

Based on previous studies (14, 16), we hypothesized that the employment probability would decrease from 5 to 10 years post injury. Contrary to our hypothesis, the overall employment rates for the full sample remained relatively stable between 1 and 10 years at ~50% (5). The baseline employment rates were comparable to employment rates in the general population aged 25–54 years (Statistics Norway). In the past 8 years, there has

been a slight decline in the employment rates in Norway. It is not possible to deduct whether the return to work process in the study population were affected by the slight general decrease in employment rates. However, even though the number of patients receiving disability pension in our study increased across the follow-ups, the percentage of jobseekers remained unchanged when comparing the baseline assessment and 10 years follow-up data.

Dahm and Ponsford (24) investigated employment trajectories after complicated mild-to-severe TBI and found an employment rate of 58% at the 10 years follow-up. Ponsford et al. (15) reported that 40% returned to open employment in some capacity and that this percentage remained stable over the first 10 years after mild-to-severe TBI in Australia. A stable employment rate across the follow-ups is probably an expression of “plateauing” of recovery after the 1st year following the injury (14, 25), but may also indicate a lack of effective, individually customized vocational rehabilitation programs aiming to improve workability and return to employment (26) such as vocational rehabilitation with supported employment (3).

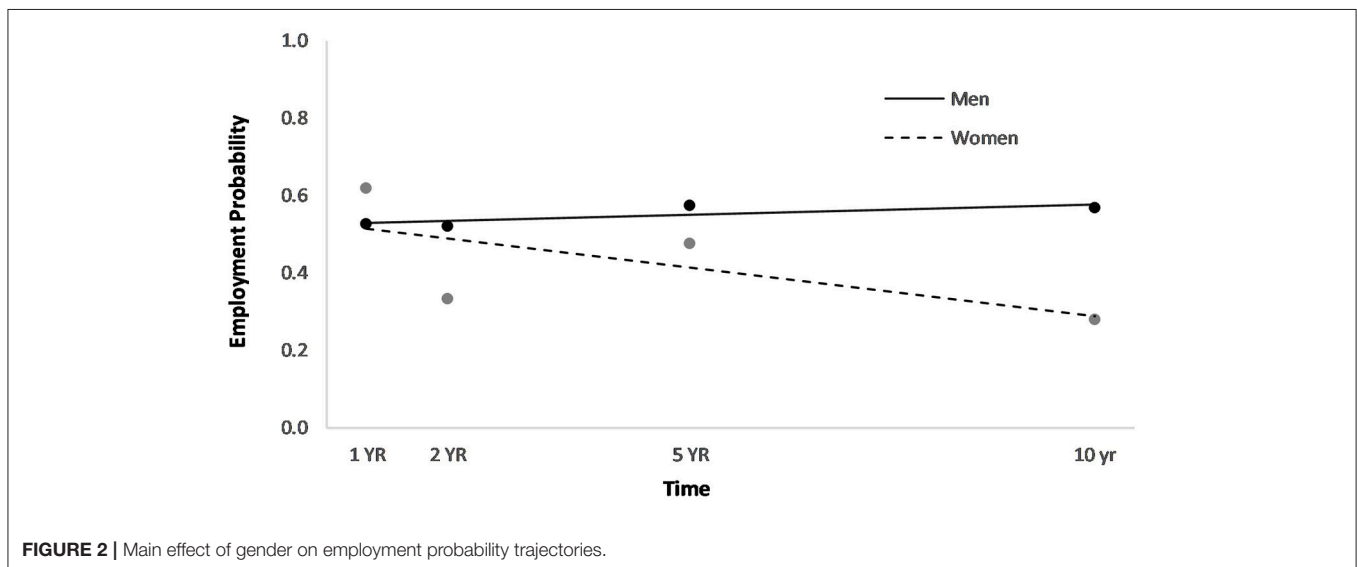
Compared to the study by Grauwmeijer et al. (14), we included younger patients (age at the time of injury 16–55 years vs. 16–67 years), which may positively influence the employment probability results. The study by Cuthbert (16) included patients in the same age range as ours; however, their patients were selected from inpatient rehabilitation centers, thus representing more severe injuries which may lead to persistent, chronic consequences, with late deterioration and more unfavorable long-term outcomes. Nonetheless, methodological differences and the influence of national welfare provisions and labor market forces make it difficult to compare the employment trajectory results across countries. We can only speculate whether the demographic and injury characteristics, changes in the labor market, and welfare system differences contribute to the stable employment rates found in this study.

The following predictors were statistically significant in the models used in this study: employment at injury, relationship status, occupational status, and GCS. This is in line with results from the 5 years follow-up (5) acknowledging the importance of these factors when predicting employment outcomes after TBI. The study results demonstrated that participants who had higher GCS scores at the time of injury, and were in white-collar occupations, had significantly higher probability of being employed at all time-points. Severity of TBI (i.e., GCS score) has consistently been linked to long-term employment outcomes (5, 27, 28). Although non-significant, there was a trend toward an association between duration of PTA and employment status at 10 years. This is in accordance with previous long-term studies (16, 24), and the 1, 2, and 5-year follow-up of the current sample (5). The association between having a blue-collar occupation (i.e., manual labor) at the time of injury and post-injury unemployment is consistent with a review by Ownsworth and McKenna (29) and a study by Walker et al. (30), showing support for the association between pre-injury occupational status and employment outcomes. Being in a partner relationship at time of injury was found to significantly

**TABLE 2 |** Demographic and injury predictors of employment probability trajectories across 1, 2, 5, and 10 years.

Predictor	b-weight	SE	p-value	95% Confidence Interval	
				Lower Bound	Upper Bound
Intercept	0.018	0.109	0.870	-0.198	0.234
Time	-0.002	0.005	0.642	-0.012	0.008
Gender (1 = female, 0 = male)	-0.222*	0.090	0.016	-0.400	-0.043
Age	-0.006	0.004	0.159	-0.015	0.002
Relationship Status (1 = partnered, 0 = single)	0.305**	0.097	0.002	0.112	0.498
Education	-0.045	0.050	0.367	-0.143	0.054
Employment (1 = employed, 0 = unemployed)	0.447***	0.097	<0.001	0.254	0.640
Occupational Status (1 = white collar, 0 = blue collar)	0.243**	0.085	0.005	0.074	0.411
GCS	0.038**	0.014	0.006	0.011	0.065
Cause of Injury (1 = motor vehicle, 0 = not motor vehicle)	0.007	0.085	0.936	-0.161	0.175
PTA	-0.003	0.001	0.068	-0.006	0.000
CT Severity Score	-0.031	0.037	0.404	-0.104	0.042
ISS	-0.003	0.003	0.267	-0.009	0.003

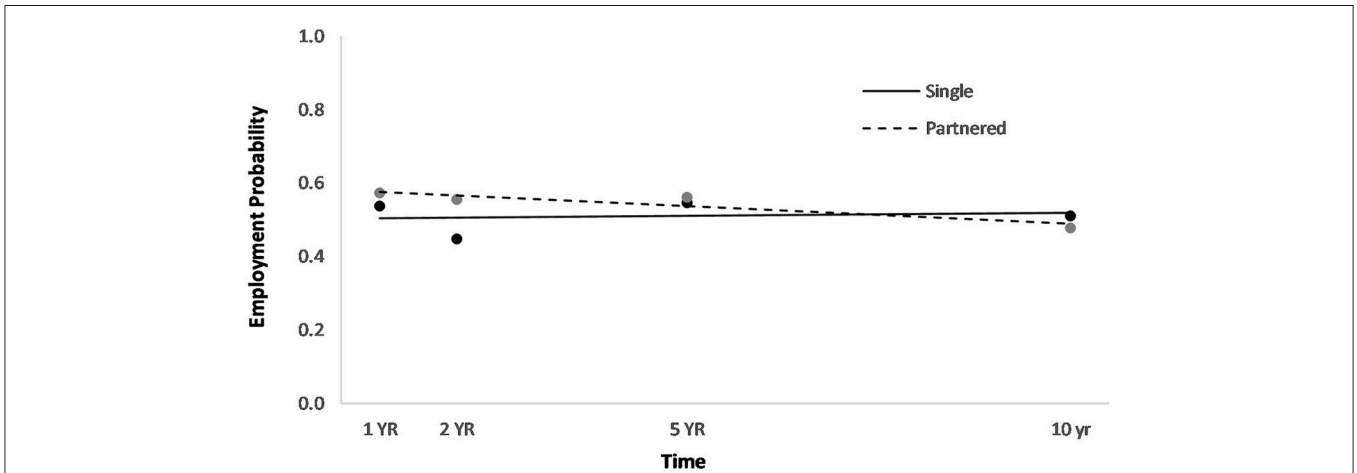
\* =  $p < 0.05$ ; \*\* =  $p < 0.01$ ; \*\*\* =  $p < 0.001$ .



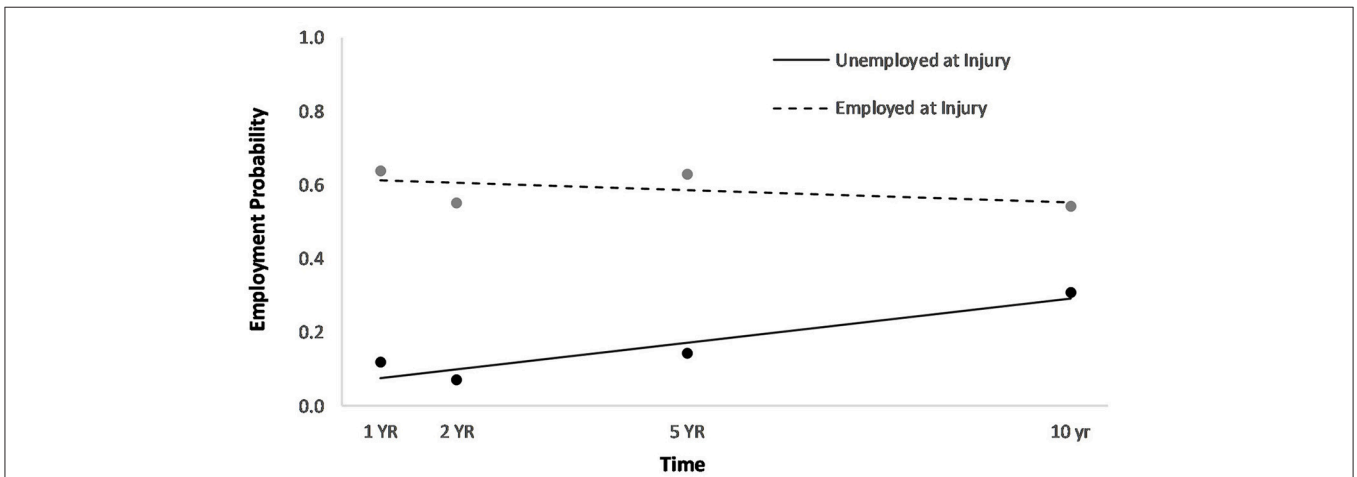
improve employment probability trajectories in the present study (although the effect was driven by the first time points). The results are in line with previous studies (9, 17, 31) suggesting that marital/relationship status is a significant predictor of post-injury employment.

The finding that participants who were unemployed at the time of injury were significantly less likely to be employed at each of the four time points is consistent with previous literature (5, 10, 17). A possible explanation for this finding is that previous work experience, as well as familiarity with the workplace and specific tasks, may make the transition back to work more easily achievable for those who are employed at the time of injury. Interestingly, the time\*employment at injury interaction term was significant, suggesting that those who had been unemployed at the time of injury had an increased likelihood of being employed at the 10 years follow-up. One

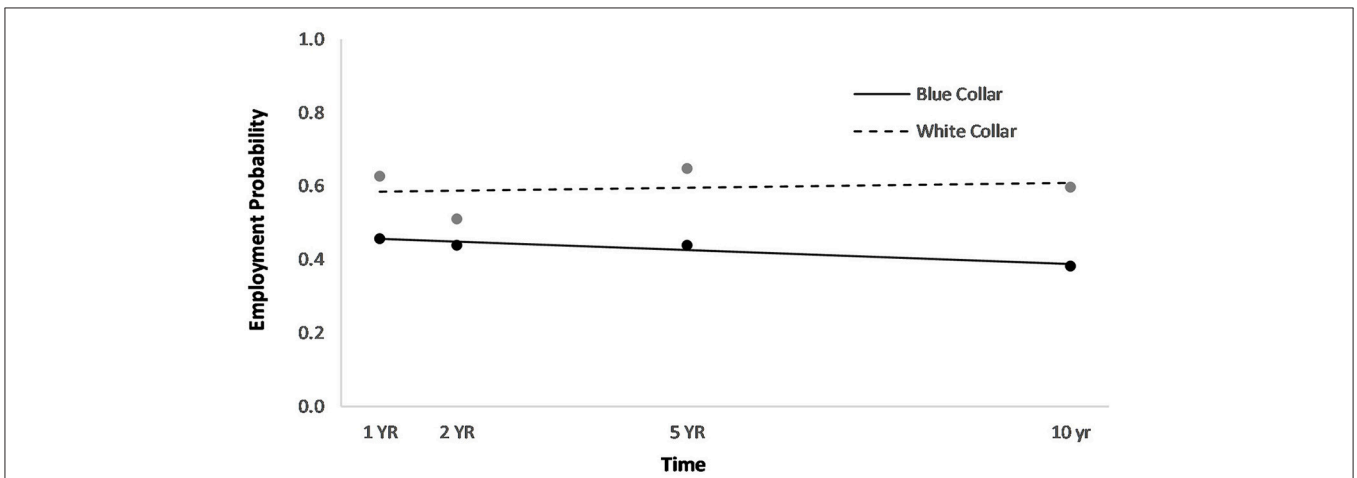
of the reasons may be that the majority of patients in the unemployed group were job seekers or on work assessment allowance at the time of injury, thus having the prospect of attaining jobs over time. Different workfare programs have been introduced in Norway over the last decade to meet problems in the labor market. One of the programs is the Inclusive Working Life (IW) Agreement introduced by the Norwegian Labor and Welfare Service to create a more inclusive workplace through adaptation and improvement of the work environment, reducing the utilization of sick leave and disability benefits, and retaining senior employees longer (32). The IW Agreement covers approximately 60% of the country's employees (33). However, the IW agreement has been questioned due to implementation problems and whether challenges concerning sickness related welfare consumption need to be regarded in a wider context (32).



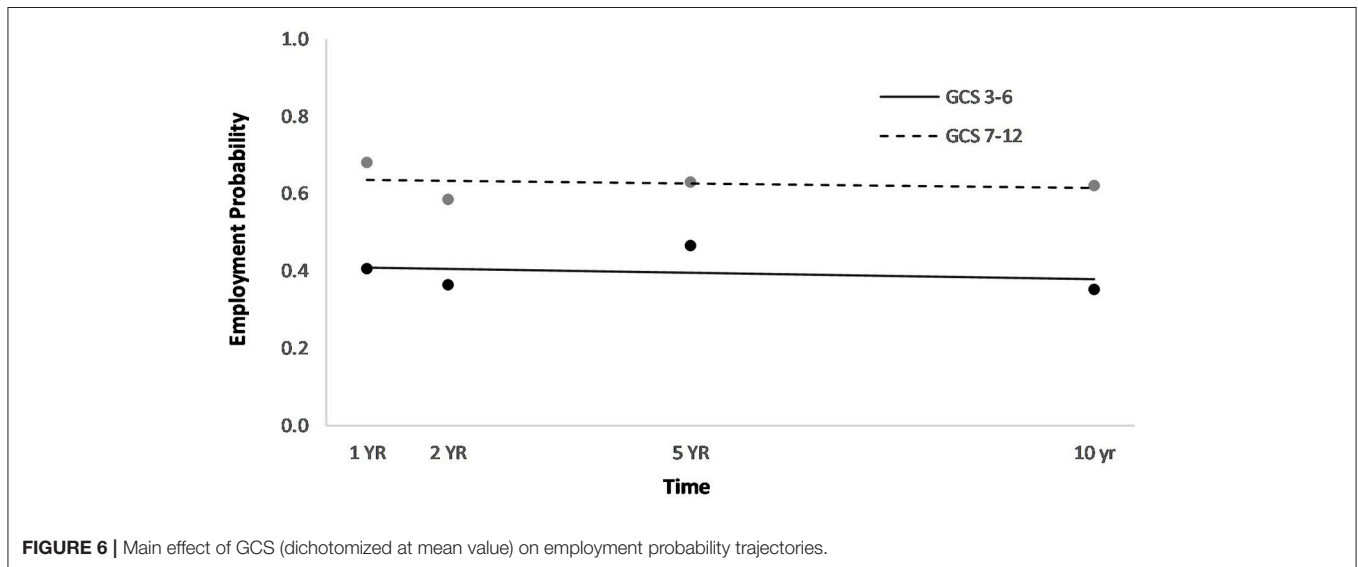
**FIGURE 3** | Main effect of relationship status at injury on employment probability trajectories.



**FIGURE 4** | Main effect of employment at injury on employment probability trajectories.



**FIGURE 5** | Main effect of occupational status on employment probability trajectories.



**FIGURE 6 |** Main effect of GCS (dichotomized at mean value) on employment probability trajectories.

**TABLE 3 |** Previously significant predictors and their time interaction effects on employment probability trajectories across 1, 2, 5, and 10 years.

Predictor	b-weight	SE	p-value	95% Confidence Interval	
				Lower Bound	Upper Bound
Intercept	-0.007	0.102	0.947	-0.210	0.196
Time	0.026*	0.012	0.033	0.002	0.051
Gender (1 = female, 0 = male)	-0.069	0.098	0.478	-0.263	0.124
Relationship Status (1 = partnered, 0 = single)	0.090	0.093	0.334	-0.094	0.274
Employment (1 = employed, 0 = unemployed)	0.532***	0.106	<0.001	0.322	0.742
Occupational Status (1 = white collar, 0 = blue collar)	0.133	0.086	0.124	-0.037	0.304
GCS	0.061***	0.012	<0.001	0.036	0.085
Time*Gender	-0.034**	0.011	0.002	-0.056	-0.013
Time*Relationship Status	-0.003	0.010	0.754	-0.024	0.017
Time *Employment	-0.036**	0.012	0.003	-0.060	-0.012
Time*Occupational Status	0.018	0.010	0.069	-0.001	0.038
Time*GCS	-0.002	0.001	0.120	-0.005	0.001

\* =  $p < 0.05$ ; \*\* =  $p < 0.01$ ; \*\*\* =  $p < 0.001$ .

Regarding gender differences in employment probability over time, a downward trend in employment for women was observed, while men’s probabilities remained constant. The existing literature on this topic has shown mixed results (29). A study by Corrigan et al. (34) investigated changes in employment 1 year after TBI and found that women were more likely to decrease working hours or be unemployed compared to men. Fraser et al. (28) found that women were more likely than men to maintain complex work post-injury. In line with our findings, the more recent study by Cuthbert et al. (16) demonstrated a significant relationship between being female and decreased probability of employment, the same was reported in a systematic review by Willemse-Van Son (8). Possible explanations for gender-differences in employment outcome following TBI have ranged from societal influences related to gender roles, differences in job-demands, to biological differences (35). Nevertheless, there is a trend in the general population that women report more

symptoms as compared to men, that there is higher percentage of women on sick leave, and that women more often have part-time jobs (36).

### Limitations and Future Directions

The current study is an extension of an existing longitudinal TBI research project. Several limitations inherent in the original design need to be acknowledged when interpreting the results. Firstly, although the study population was unselected and representative of working-age patients with moderate-to-severe TBI from the South-Eastern region of Norway, the inclusion and exclusion criteria from the original study, particularly the patients’ age range at the study admission (16–55 years) and geographic setting, may limit the generalizability of the findings to a broader patient population and other healthcare settings. Secondly, the definition of employment used in this study may be a source of bias, thus limiting generalizability. Employment



was categorized into unemployed (jobseekers, on sick leave or work assessment allowance, or receiving disability pension), and employed (working full-time or part-time or studying), which may have been different from other studies. Thirdly, the overall sample size for the current study is relatively small. Future studies with a larger sample size are needed to verify the findings of this study, and to account for factors other than baseline characteristics (such as functional status) which we did not assess in this study. This includes several subjective and environmental factors that may influence the employment probability such as the ability to adapt, resilience, physical, emotional and social supports, as well as access to care and current vocational rehabilitation practice. The role of work-place related factors such as possibilities for adapted work tasks, work environment, features of work organization, and the role of management also needs to be investigated to a larger degree in future research, as most TBI studies rely exclusively of individual patient characteristics. More research is needed to clarify the association between gender and interaction effects between gender and other factors on employment following TBI. Despite these limitations, the results from this study provides important insight into trajectories and predictors of employment in the long-term perspective following TBI. This information may be useful for patients, clinicians, and employment authorities and underlines the need for regular follow-ups both short- and long-term. Given the individual and societal importance of employment and return to work after TBI, future research could examine employment in more granular terms. For instance, it would be interesting to understand how the type of work, adaptations at the work place, hours worked, and/or employment stability changes over time. This would require more frequent follow-up and collecting more detailed information regarding the survivor's job situation. Better knowledge of all these factors may encourage cross-sectoral collaboration between health care

services and the labor and welfare system in order to develop new individualized work-related interventions to improve both short- and long-term employment outcomes.

## ETHICS STATEMENT

This study was carried out in accordance with the recommendations of the Norwegian law on research ethics and medical Research, Regional Committees for Medical and Health Research Ethics of Norway with written informed consent from all subjects. All subjects gave written informed consent in accordance with the Declaration of Helsinki. The protocol was approved by the Regional Committee for Medical Research Ethics, East Norway, and the Norwegian Data Inspectorate.

## AUTHOR CONTRIBUTIONS

EH, NA, CR, SS, and MF contributed to study design, data acquisition, analysis, interpretation, drafting, and finalizing the manuscript. PP contributed to analysis, interpretation, drafting, and finalizing the manuscript. JA-L, JL, and ML contributed to data interpretation, drafting, and finalizing the manuscript.

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**Conflict of Interest Statement:** The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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