

Symptoms and Disability after Mild Traumatic Brain Injury: A Five-Year Follow-up

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Academic Editor: Gernot Riedel

Submitted: 20 October 2023 Revised: 29 November 2023 Accepted: 12 December 2023 Published: 22 February 2024

Abstract

Background: Every year, many people suffer from traumatic brain injuries (TBI) with dramatic consequences for both the victim and their close relatives in the form of remaining lifelong symptoms and functional disabilities as a result. **Methods:** This study evaluates the outcomes of 49 patients after mild TBI (mTBI) at follow-up after 5 years by using the Rivermead Post-Concussion Symptoms Questionnaire (RPQ) to assess post-TBI symptoms and the Glasgow Outcome Scale Extended (GOSE) to assess disability. The specific aim was to evaluate post-TBI characteristics concerning age, gender, pre-injury systemic disease, computed tomography (CT) result and additional TBIs. **Results:** Almost eighty percent reported RPQ symptoms, the most common for both genders being fatigue (51%) and poor concentration (51%). Seventy-six percent had a good recovery, 18% moderate disability, while 6% reported severe disability. The number of symptoms was significantly correlated to the level of disability. All participants with severe disability had repeated mTBI. Only twenty-one percent reported that they received some form of rehabilitation intervention after their mTBI. **Conclusions:** Five years after suffering mTBI, patients reported high rates of symptoms and disabilities. Our findings suggest that tailored rehabilitation interventions should be designed to identify mTBI patients in need of early rehabilitation. This would result in minimized suffering for the individual and improved cost-effectiveness for society.

Keywords: traumatic brain injury; RPQ; GOSE; post-concussion symptoms; disability; rehabilitation

1. Introduction

Traumatic brain injury (TBI) is a global health problem and one of the most common causes of loss of function and disability. Approximately 69 million individuals are estimated to suffer TBI each year [1]. The incidence of TBI in northern Sweden has been reported as 354 per 100,000 inhabitants and the incidence of hospitalization because of TBI in the whole country is 190 per 100,000 inhabitants [2]. The most common injury events that cause TBI in Sweden are vehicle-related events and falls, as is the case in the rest of the Western world [3].

TBI is defined as a head trauma that leads to a disruption in the brain's normal function. The head trauma can be due to a penetrating injury, a blow or jolt to the head [4]. In the acute setting, the severity of the TBI is usually classified with the Glasgow Coma Scale (GCS) score based on eye opening, verbal and motor response. The injury is defined as mild (GCS 13–15), moderate (GCS 9–12) or severe (GCS 3–8), depending on the patient responses during the acute physical examination [5]. In Sweden, a computed tomography (CT) is typically performed after a head trauma with a GCS score of less than 15 points and/or anamnestic or clinical risk factors, such as focal neurological deficits and anticoagulation therapy [6]. More than 90% of TBI patients treated in the emergency room (ER) have mild TBI (mTBI) where the majority recover within a few months

but identifying the minority at risk of persistent symptoms is of utmost importance.

The ER at the Umeå University Hospital in Northern Sweden was a recruiting institute of data from TBI patients for the Collaborative European Neurotrauma Effectiveness Research in Traumatic Brain Injury study (CENTER-TBI). The aim of the CENTER-TBI project was to better characterize TBI as a disease and improve the care of the patients [7,8]. In the same manner, the goal of physical and rehabilitation medicine is to assess functioning in relation to disorder or disease, personal and environmental factors, such as evaluation of disability after brain injury [9]. The Glasgow Outcome Scale Extended (GOSE) is widely used to measure disability after TBI, assess independence and return of lifestyle [10]. The Rivermead Post-Concussion Symptoms Questionnaire (RPQ) is likewise a well-established way of measuring common symptoms after TBI [11]. Although TBI often causes disability, the outcome and the need for rehabilitation varies. Previous studies have shown that many TBI patients, especially those with mild TBI, have long-term residual symptoms and are not offered rehabilitation despite their need [12,13]. The overall aim of this study was to evaluate symptoms and disability five years after mild TBI in a defined population in the Umeå area. The specific aim was to investigate how characteristics such as age, gender, pre-injury systemic disease, CT-result and additional TBI affect the outcome.



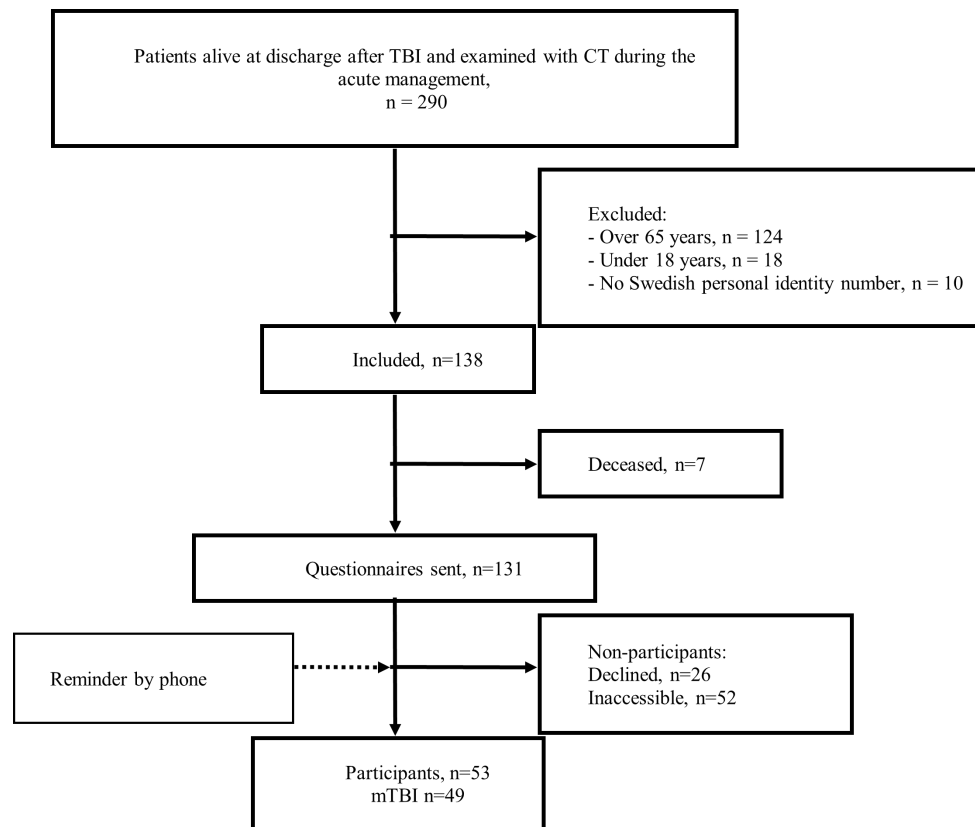


Fig. 1. Flow chart of the recruitment process. TBI, traumatic brain injury; mTBI, mild TBI; CT, computed tomography.

2. Materials and Methods

2.1 Study Design

This study was a single-centre prospective observational cohort study that enrolled patients aged between 18–65 years suffering from mild to severe TBI. Between 1 January 2015 and 31 December 2016, data were sourced on patients who came to ER at Umeå University Hospital, Sweden. The catchment area was the city of Umeå, with a few exceptions. All patients with suspected TBI had suffered an event of clear external mechanical force to the head within at most 24 hours before arrival. The CT examination had to be performed latest 24 hours after arrival. The study was approved by the Swedish Ethical Review Authority (Dnr 2019-05337). All participants gave informed consent prior to their enrolment. The study was performed in accordance with the principles of the Declaration of Helsinki.

2.2 Setting and Study Size

Follow-up questionnaires were collected during 2020, about five years after TBI. In total, 138 patients met the criteria above. As seen in Fig. 1, 131 patients were included since seven patients had since died. Those who did not return questionnaires were later contacted by phone to be reminded. Afterwards, those who had still not returned questionnaires were contacted and asked to provide answers over the phone. Written answers were received from 26 patients and oral answers from 27 patients.

2.3 Variables and Data Sources

2.3.1 Rivermead Post-Concussion Symptoms Questionnaire (RPQ)

Sixteen of the most common somatic, cognitive, sensory, and affective symptoms are included in the RPQ questionnaire [11]. Each symptom is rated by the individual, to what degree they experienced it within the last 24 hours compared with before the injury, on an item ordinal scale (0–4): not experienced at all, no longer a problem, mild, moderate, or severe problem, making 64 points the total highest score possible. Each symptom from the RPQ was dichotomized into experiencing or not experiencing the symptom.

2.3.2 Glasgow Outcome Scale Extended

The GOSE was used for scoring based on the lowest level of function indicated on the scale. The scale from 1 to 8 points measures impact on independence and work capacity, restriction on social and leisure activities, and strains on family and friendships [10]. The GOSE includes eight categories which correspond to death, vegetative state, lower or upper severe disability.

2.3.3 Characteristics

Patient data were collected from a database containing TBI patients including age, gender, arrival status (GCS), CT result and pre-injury systemic disease based on ASA-

classification [14]. An American Society of Anesthesiologists (ASA) score of 1 was defined as normal, 2 as mild, 3 as moderate, and ≥ 4 as severe.

The patients were divided into three age groups: young adults (18–35 years), middle-aged adults (36–55 years) and older adults (56–65 years).

CT result was considered pathological if there was any evidence of acute intracranial injury, such as acute subdural hematoma, compressed basal cisterns, contusion, epidural hematoma, midline shift or traumatic subarachnoid haemorrhage.

The participants were asked about perceived rehabilitation after TBI and if they had sustained additional head traumas during the five year follow-up period.

2.4 Statistical Methods

Evaluation of the difference between the participants and non-participants regarding the characteristics (severity of the TBI, CT result, age, gender and ASA-classification) was performed using the Pearson Chi-Square test. Association between RPQ symptoms and gender was analysed using the Pearson Chi-Square test. The relationships between (1) GOSE score and the number of RPQ symptoms and (2) GOSE score and total RPQ score were analysed using the Spearman rank correlation. The participant characteristics such as age, gender, ASA-classification, additional head trauma and CT result were tested using the Spearman rank correlation or Mann-Whitney U-test. All statistical analyses were performed using SPSS version 27 (IBM Corp., Armonk, NY, USA), and values with $p < 0.05$ were considered to be significant.

3. Results

3.1 Descriptive data

In this study, 93% of the participants had an injury defined as mild TBI classified with GCS, and 30% had a pathological CT result in the acute management. The average age was 42 years, with a 72% male preponderance. According to the ASA-classification, the majority of participants (57%) were classified as healthy, with no pre-existing systemic diseases before their injuries.

Regarding these characteristics, the study participants and the non-participants (inaccessible or declined) were comparable with no significant differences ($p > 0.05$) (Table 1).

As noted in Table 1, only four participants had a moderate or severe TBI. Since most (93%) were classified as mild TBI, only this group was studied further.

3.2 RPQ

At follow-up, 76% of the individuals with mild TBI reported that they still suffered from one or more of the symptoms in the RPQ. The mean number of RPQ symptoms was 6.78, standard deviation (SD) 4.92 and the mean RPQ total score was 16.06, SD 14.02. No significant dif-

Table 1. Demographic and injury characteristics for the included patients.

	Participants	Non-Participants
Mild TBI (GCS 13-15), n (%)	49 (93)	64 (87)
Moderate TBI (GCS 9-12), n (%)	1 (2)	6 (8)
Severe TBI (GCS 3-8), n (%)	3 (6)	4 (5)
Pathological CT, n (%)	16 (30)	15 (19)
Age, mean (median)	42 (41)	38 (33)
Gender, male, n (%)	38 (72)	52 (67)
Healthy, n (%)	30 (57)	54 (69)
Mild systemic disease, n (%)	16 (30)	19 (24)
Severe systemic disease, n (%)	7 (13)	5 (6)

Abbreviations: GCS, Glasgow Coma Scale; ASA, American Society of Anesthesiologists. Systemic disease is based on ASA classification, none with ASA 3 (moderate) were included.

ference was found between women and men regarding the number of symptoms (women: mean 8.0, SD 5.54, men: mean 6.24, SD 4.60, $p = 0.240$) and the total score (women: mean 19.0, SD 14.46, mean: 14.73, SD 13.83, $p = 0.391$). As shown in Table 2, the most common symptoms among all the participants with mild TBI were fatigue (51%) and poor concentration (51%). For the women in the study, the most common symptom was feeling frustrated (60%), this symptom being significantly more frequent in women than men (39%, $p = 0.04$). Also, nausea was significantly more frequent in women ($p = 0.01$).

3.3 Glasgow Outcome Scale Extended

A majority (76%) of the participants with mild TBI showed good recovery on the GOSE (lower 25% and upper 51%). Eighteen per cent had a moderate disability (lower 6% and upper 12%), and 6% still have a severe disability (all upper) (Fig. 2).

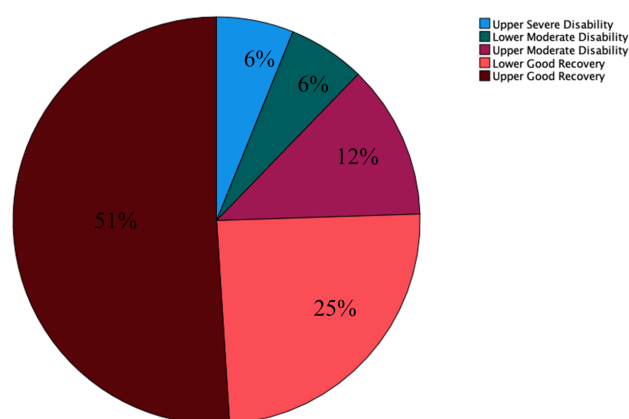


Fig. 2. The percentage of reported Glasgow Outcome Scale Extended (GOSE) for lower or upper severe, mild, and good disability.

Table 2. The number and percentage of reported RPQ symptoms.

	All n = 49 (%)	Women n = 14 (%)	Men n = 35 (%)	p-value (gender)
Somatic symptoms	31 (63)	11 (73)	20 (59)	0.332
Headaches	19 (39)	7 (47)	12 (35)	0.451
Dizziness	17 (35)	8 (53)	9 (27)	0.069
Nausea	7 (14)	5 (33)	2 (6)	0.011
Fatigue	25 (51)	8 (53)	17 (50)	0.830
Cognitive symptoms	28 (57)	10 (67)	18 (53)	0.371
Longer to think	17 (35)	7 (47)	10 (29)	0.242
Forgetful	23 (47)	8 (53)	15 (44)	0.551
Poor concentration	25 (51)	9 (60)	16 (47)	0.404
Vision-related symptoms	24 (49)	8 (53)	16 (47)	0.686
Double vision	6 (12)	1 (7)	5 (15)	0.429
Blurred vision	6 (12)	2 (13)	4 (12)	0.877
Light sensitivity	14 (29)	4 (27)	10 (29)	0.845
Noise sensitivity	20 (41)	7 (47)	13 (38)	0.580
Affective symptoms	27 (55)	10 (67)	17 (50)	0.280
Depressed	9 (18)	4 (27)	5 (15)	0.319
Frustrated	19 (39)	9 (60)	10 (29)	0.043
Restless	14 (29)	5 (33)	9 (27)	0.624
Irritable	19 (39)	7 (47)	12 (35)	0.451
Sleep disturbance	14 (29)	7 (47)	7 (21)	0.063

RPQ, Rivermead Post-Concussion Symptoms Questionnaire. Significant *p*-values (Pearson Chi-Square) are highlighted in bold.

As seen in Figs. 3,4, the outcome was comparable regardless of age group or gender. A trend towards less favourable outcomes due to age can be seen (good recovery in young adults 88%, middle-aged adults 73% and older adults 60%). However, age was not significantly correlated to GOSE ($r = -0.38$, $p = 0.798$). Good recovery was experienced by 73% of the women and 76% of the men.

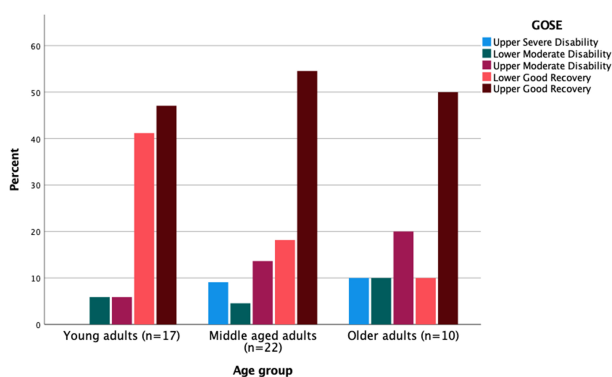


Fig. 3. The percentage of reported GOSE divided by age group.

There were significant negative correlations between GOSE and the number of RPQ symptoms ($r = -0.795$, $p < 0.01$) and between GOSE and total RPQ-score ($r = -0.834$, $p < 0.01$).

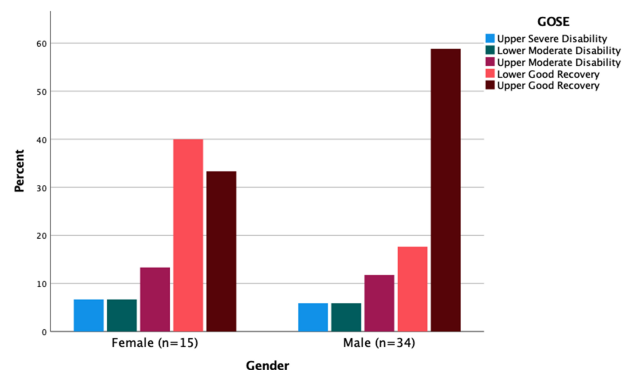


Fig. 4. The percentage of reported GOSE divided by gender.

None of the pre-injury healthy individuals had a severe disability at follow-up compared with 43% of those with severe systemic disease (Fig. 5).

In total, 27% of the individuals had suffered at least one more head trauma. All participants with a severe disability on the GOSE had repeated TBI (Fig. 6).

No significant relationship could be seen between GOSE and pathological CT result during acute management ($r = -0.79$, $p = 0.588$, Fig. 7).

3.4 Rehabilitation

Only nine individuals (21%) reported they had received rehabilitation but there was no information about what type or intensity of rehabilitation they had undergone.

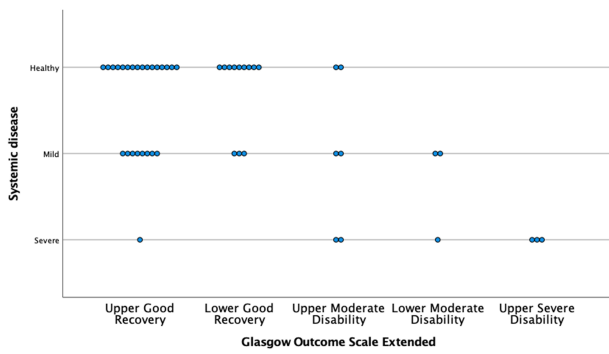


Fig. 5. Correlation between systemic disease and GOSE. $p \geq 0.001$, $r = -0.456$. Spearman rank correlation coefficient.

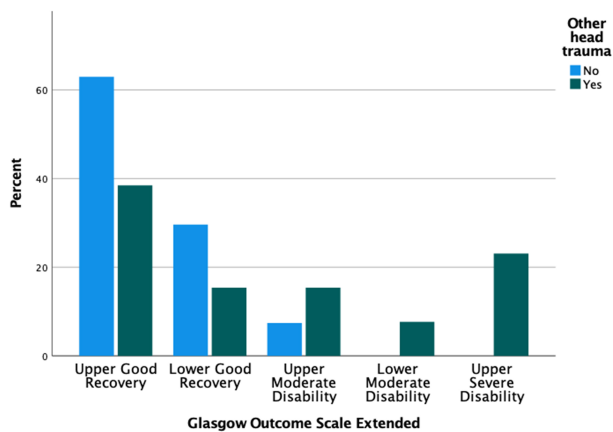


Fig. 6. The percentage of reported GOSE divided by additional head trauma.

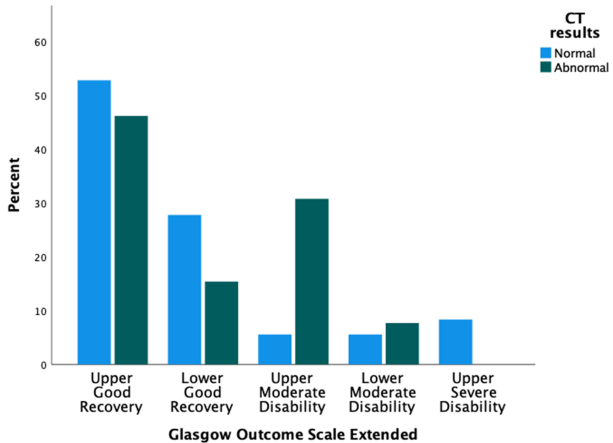


Fig. 7. The percentage of reported GOSE divided by normal and pathological CT results.

4. Discussion

In this follow-up study on TBI patients, the majority (93%) of the participants were classified as mild, therefore only this group was studied further. Out of this population, as many as three of four patients still reported post-TBI

symptoms five years after the initial injury. The number of symptoms was significantly correlated to the level of disability on the GOSE. No significant difference was found between women and men regarding the number and severity score of symptoms. Both repeated TBI and pre-injury systemic disease were significantly related to the level of disability.

In the current study, the proportion of mild TBI is in line with previous research that has estimated that 80–90% of all cases of TBI are mild [15]. Likewise, previous studies have shown that fatigue is the most common symptom in all participants [16]. Interestingly, there was a difference between women and men, the most common symptoms in women being frustration and poor concentration. In addition, two of the symptoms were significantly more frequent in women than in men. There are mixed findings regarding gender differences, where some studies have found an association between women and post-concussion symptoms [13,17], while other studies report no significant difference between gender [18]. The reasons for possible gender differences are unclear.

Surprisingly, 6% of the mTBI patients reported a severe disability, meaning they could not live entirely independently. GOSE is considered as the “golden standard” for assessing outcomes after TBI [19]. In the current study, post-concussion symptoms correlated significantly with disability. This finding has also been shown in previous studies that have used the RPQ questionnaire, a specific instrument for the assessment of disability after mild TBI [20]. Furthermore, there was good correlation between GOSE and both repeated TBI and pre-injury systemic disease. Multiple head injuries are described as having a cumulative effect on function, which may be the reason for the higher level of disability in this group. Within the TBI research area, there is more evidence of a prevailing association between TBI and neurodegeneration [21] which can be influenced by repeated trauma.

CT scans of the brain remain a standard diagnostic tool for assessing TBI patients and are used to predict outcome. No significant correlation was seen between GOSE and CT results which is in line with previous studies by Smith *et al.* [22] that showed limitations of CT results as a prognostic factor of long-time consequences. Similar findings were reported in a study on severe TBI from our hospital, namely that CT results were significantly related to GOSE three months after injury, but not after one year [23].

Only a minority of the participants had received some form of rehabilitation. Since mild TBI is considered to be a “mild injury”, this could be a reason why this category of patient was not offered treatment and rehabilitation. However, in a recent meta-analysis by Möller *et al.* [12], it was concluded that “persons with mild traumatic brain injury who are at risk of, or who experience, prolonged symptoms should be considered for specialist treatment”.

5. Strengths and Limitations

One strength of this study is that it is based in part on the neurotrauma CENTER-TBI project with defined inclusion and exclusion criterion. Therefore, we gathered a large amount of randomised patient material, with high generalizability, including representatives from a wide range of ages. Another strength is that validated questionnaires with instruments designed for TBI were used and patients were recruited from the same hospital. This study suffers from a few limitations. Firstly, there was no healthy control group, which makes it difficult to draw conclusions based on the overall percentage of reported symptoms. It should be noted that post-concussion symptoms do not occur exclusively in patients with mTBI but are also frequently reported in the general population and for patients with migraine, chronic pain or those who have suffered whiplash injuries [24]. Another limitation is the relatively long follow-up period which may lead to recall bias. Therefore, we cannot rule out systematic distortions as other factors might have influenced the results. Only a few studies have investigated long-term follow-up after TBI and therefore studying the long-term consequences of mild TBI was an interesting aspect of this study.

6. Conclusions

This study shows that five years after sustaining mild TBI, patients reported high frequencies of symptoms and disabilities. These findings indicate that it might be clinically meaningful to quantify symptoms earlier after the injury in order to identify patients in need of rehabilitation and to tailor specific treatment and rehabilitation interventions. The relationship between multiple trauma and disability highlights the importance of informing patients to be more careful in risky situations. In a future perspective, further research within this area may result in a way to identify subgroups of patients and study gender differences.

Availability of Data and Materials

The data are not publicly available due to ethical restrictions.

Author Contributions

BMS, EA and BMM designed the research study. EA performed the research. EA analyzed the data. EA, BMM and BMS wrote the manuscript. BMS and BMM provided help and advice on writing and editing the manuscript. All authors contributed to editorial changes in the manuscript. All authors read and approved the final manuscript. All authors have participated sufficiently in the work and agreed to be accountable for all aspects of the work.

Ethics Approval and Consent to Participate

The study was approved by the Swedish Ethical Review Authority (Dnr 2019-05337). All participants gave

informed consent prior to their enrolment. The study was performed in accordance with the principles of the Declaration of Helsinki.

Acknowledgment

We sincerely thank Maud Stenberg, M.D, PhD for her help in writing the manuscript.

Funding

This research received no external funding.

Conflict of Interest

The authors declare no conflict of interest.

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