

Long-term trajectories of persisting post-concussion symptoms and functioning after a mild head injury

Toril Skandsen^{1,2}, Linda Fordal², Turid Follestad³, Alexander Olsen^{1,4}, Simen Berg Saksvik⁵, Helge Skirbekk^{6,7}, Jonas Stenberg^{8,9}

¹ Clinic of Rehabilitation, St. Olavs Hospital, Trondheim University Hospital, ² Department of Neuromedicine and Movement Science, Norwegian University of Science and Technology (NTNU), Trondheim, Norway., ³ Department of Public Health and Nursing, Norwegian University of Science and Technology (NTNU), Trondheim, Norway, ⁴ Department of Psychology, Norwegian University of Science and Technology (NTNU), Trondheim, Norway, ⁵ Department of Research and Development, St. Olavs Hospital, Trondheim University Hospital, ⁶ Department of Nursing and Health Promotion, Oslo Metropolitan University, Oslo, Norway., ⁷ Norwegian Concussion Association, Oslo, Norway., ⁸ Department of Rehabilitation Medicine, Danderyd Hospital, Stockholm, Sweden, ⁹ Department of Clinical Sciences, Danderyd Hospital, Karolinska Institutet, Stockholm, Sweden

Objective: To examine long-term trajectories of persisting post-concussion symptoms (PPCS) after mild head injury.

Materials and methods: Patients (n=191) with PPCS following mild head injury who received evaluation and treatment at an out-patient rehabilitation clinic, were followed prospectively in a longitudinal study with baseline interview at the first outpatient admission and follow-up interviews at 3, 6, 12, 18, 24, 30, 36, 48 and 60 months post-injury, and 5 years post-admission. Main outcome measures were symptoms assessed by Rivermead Post-Concussion Symptoms Questionnaire, functioning via Glasgow Outcome Scale-Extended, and return to full-time work. Linear and logistic mixed models with and without interaction terms evaluated outcome and recovery trajectories, while within-subject change was assessed from participants' first to final assessments.

Results: The sample comprised 800 assessments (mean 4.2 (SD 1.7) per participant). Patients were divided into groups by time from injury to admission (group 1: 0–3 months (n=44); group 2: 3–6 months (n=54); group 3: 6–12 months (n=47); group 4: 12–24 months (n=26); group 5: 24–60 months (n= 20). Although the groups had similar clinical characteristics at admission, their recovery trajectories differed. Substantial symptom reduction and functional improvement were observed over time in groups 1–4, but not in group 5. Most symptom relief across groups occurred in the months following admission. Group 1 (earliest admission) had the highest proportion of improvers across symptoms and functioning, while group 5 (latest admission) consistently had the highest proportion with negative outcomes. Symptom or function worsening was rare among all participants (<5%).

Conclusions: Most patients exhibited great improvement over time and worsening was rare. However, many still experienced symptoms years post-admission, and admission two years or more post-injury was associated with significantly poorer outcomes.

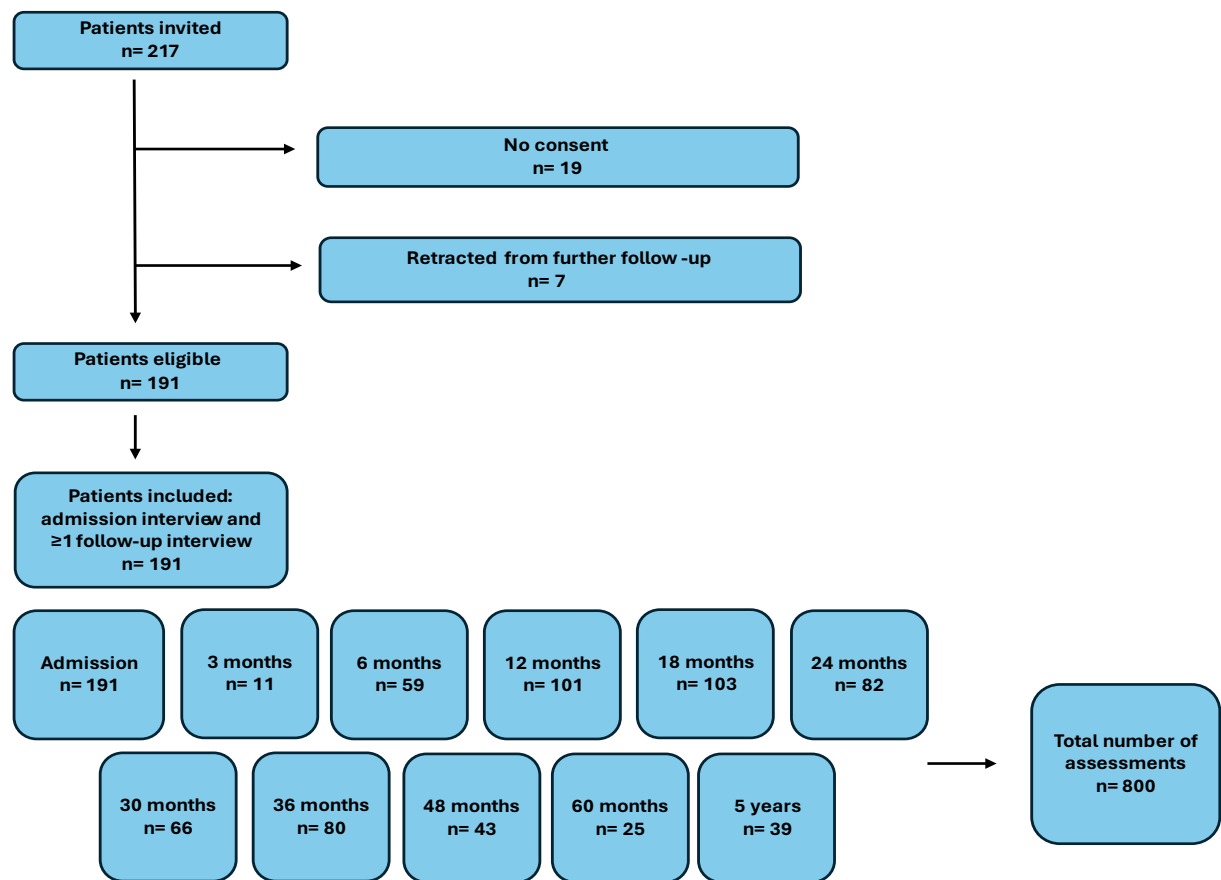


Figure 1. Flowchart of invited and included patients and the number of assessments.

Note. PTA=Post-traumatic amnesia; 24h= 24 hours.

Table 1. Demographic, pre-injury, and injury-related characteristics by admission group.

	Total sample n=191
Age at injury, Md (IQR)	38.0
Sex, female, n (%)	134 (70.2)
Fully employed pre-injury ¹ , n (%)	175 (91.6)
Previous head injury, n (%)	97 (51.6)
Pre-injury headache problem, n (%)	85 (45.2)
Psychiatric history, n (%)	75 (40.5)
Injury severity	
MTBI	82 (55.4)
MHI	66 (44.6)
Cause of injury	
Fall	95 (49.7)
Hit object	57 (29.8)
Traffic accident	29 (15.2)
Violence	10 (5.2)
CT performed, yes, n(%)	107 (56.3)
CT findings, n (%) ²	5 (4.7)
MRI performed, n(%)	115 (61.2)
MRI findings, n (%) ²	2 (1.2)
Level of acute care	
GP	85 (45.2)
Municipal emergency clinic	59 (31.4)
Hospital, not admitted	13 (6.9)
Hospital, observed <24h	15 (8.0)
Hospital, admitted >24h	16 (8.5)
RPQ total score, M (SD)	29.6 (11.1)
GOS-E high, n (%)	35 (18.3)
RTW, yes, n (%)	48 (27.6)

Note: Md=median; IQR=interquartile range; MTBI=mild traumatic brain injury; MHI=minimal head injury; RPQ= Rivermead post-concussion symptoms questionnaire; GOS-E high= Glasgow Outcome Scale Extended, high score (7 or 8); RTW= return-to-work, yes (80% or more of a full-time position, i.e., ≥ 30 hours per month). RTW only includes those participants who worked full-time before the injury. The number of people with missing, unknown, or cannot answer values for each variable are as follows: University/College degree n=3; previous head injury n=3; headache problem=3; psychiatric history n=6; sleep problem n=14; Loss of consciousness n=32; post-traumatic amnesia n=5; CT n=1; MRI n=3; other injuries n=13; symptom debut n=6; level of acute care n=3; RPQ n=9; RTW= ¹Fully employed=works/studies 80% or more. ²Percentage of those who had CT or MRI performed. In the total sample 2.6% (CT) and 1.0% (MRI) had neuroimaging findings. Bold values equal $p \leq .01$.

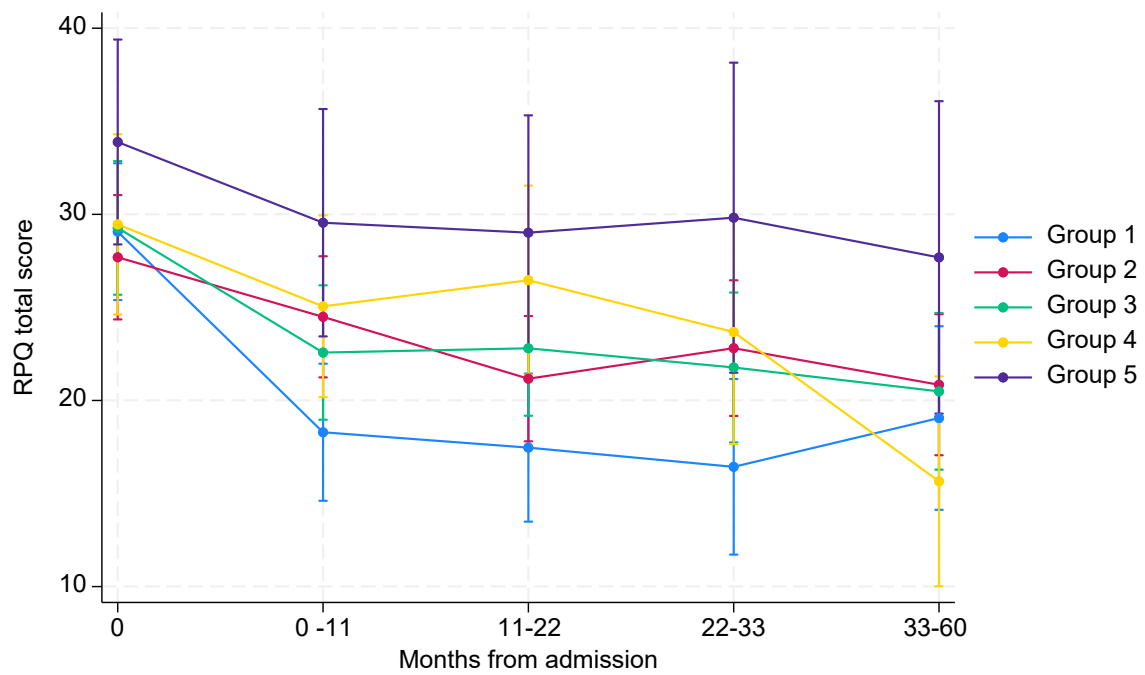


Figure 2. Estimated development over time in RPQ for different admission groups, results from the linear mixed model (corresponding to Table 2).

Note. RPQ= Rivermead post-concussion symptoms questionnaire. Group 1= admission 0-3 months post-injury; group 2= admission 3-6 months post-injury; group 3 = admission 6-12 months post-injury; group 4=admission 12-24 months post-injury; group 5=admission 24-60 months post-injury.

Table 2. Estimated change in RPQ total score from admission to each time category per admission group, results from the linear mixed model (corresponding to Figure 2).

	Coefficient*	95% CI	<i>p</i>
RPQ total score, group 1			
RPQ total score at admission	29.07	25.39 to 32.74	
0-11 months after admission	-10.77	-13.84 to -7.71	<.001
11-22 months after admission	-11.60	-15.01 to -8.19	<.001
22-33 months after admission	-12.63	-16.87 to -8.39	<.001
33 to 60 months after admission	-10.01	-14.49 to -5.54	<.001
RPQ total score, group 2			
RPQ total score at admission	27.69	24.35 to 31.03	
0-11 months after admission	-3.20	-5.90 to -.50	.020
11-22 months after admission	-6.52	-9.36 to -3.69	<.001
22-33 months after admission	-4.88	-8.05 to -1.71	.003
33 to 60 months after admission	-6.85	-10.18 to -3.51	<.001
RPQ total score, group 3			
RPQ total score at admission	29.27	25.68 to 32.86	
0-11 months after admission	-6.70	-9.70 to -3.70	<.001
11-22 months after admission	-6.47	-9.48 to -3.45	<.001
22-33 months after admission	-7.50	-10.99 to -4.01	<.001
33 to 60 months after admission	-8.78	-12.48 to -5.08	<.001
RPQ total score, group 4			
RPQ total score at admission	29.46	24.62 to 34.30	
0-11 months after admission	-4.40	-8.55 to -.26	.037
11-22 months after admission	-3.00	-7.38 to 1.39	.180
22-33 months after admission	-5.78	-11.30 to -.26	.040
33 to 60 months after admission	-13.80	-18.91 to -8.69	<.001
RPQ total score, group 5			
RPQ total score at admission	33.89	28.38 to 39.39	
0-11 months after admission	-4.34	-9.61 to .94	.107
11-22 months after admission	-4.87	-10.50 to .76	.090
22-33 months after admission	-4.07	-11.81 to 3.68	.303
33 to 60 months after admission	-6.20	-14.01 to 1.61	.120

Note. RPQ=Rivermead Post-Concussion Symptoms Questionnaire ; CI=confidence interval. Group 1= admission 0-3 months post-injury; group 2= admission 3-6 months post-injury; group 3 = admission 6-12 months post-injury; group 4=admission 12-24 months post-injury; group 5=admission 24-60 months post-injury. The number of people with missing, unknown, or cannot answer values for each variable are as follows: RPQ=20. Bold values equal $p \leq .01$. *The coefficient refers to the estimated change in RPQ total score per time category and admission group (e.g., -10.77 points). The first row for each group is the reference point, i.e. the RPQ total score at admission (e.g., 29.07).

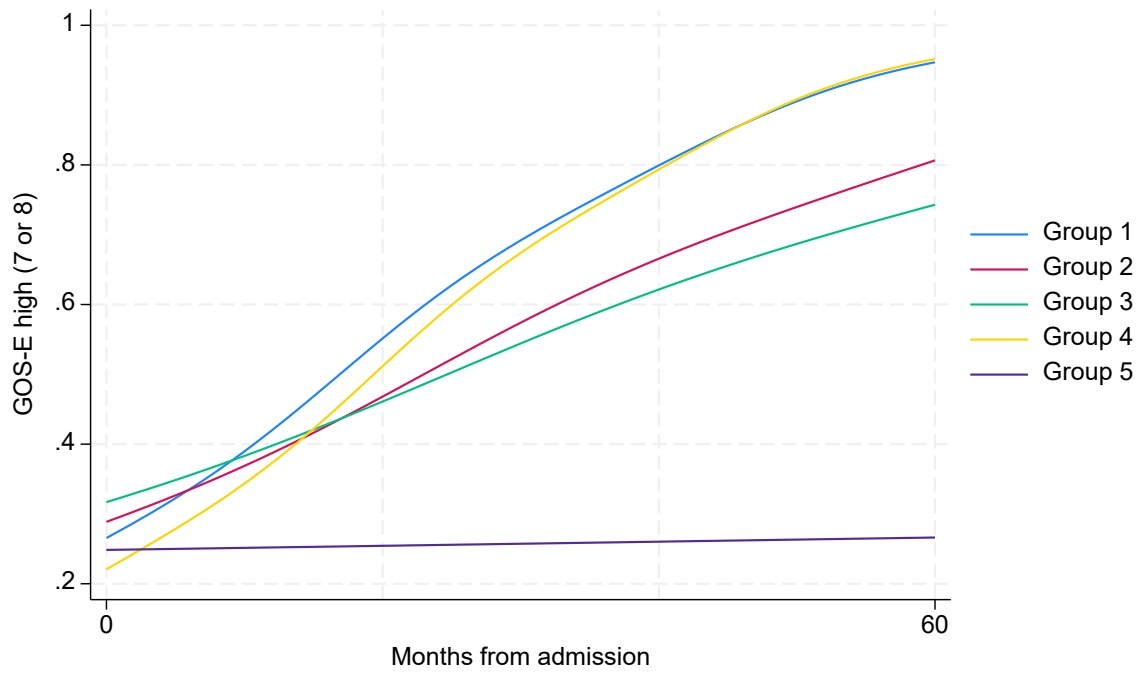


Figure 3. Probability of a high GOS-E score for the different admission groups, results from the mixed-effects logistic model (corresponding to Table 3).

Note. GOS-E high= Glasgow Outcome Scale Extended, high score (7 or 8). Group 1= admission 0-3 months post-injury; group 2= admission 3-6 months post-injury; group 3 = admission 6-12 months post-injury; group 4=admission 12-24 months post-injury; group 5=admission 24-60 months post-injury.

Table 3. Change in GOS-E, RTW and RPQ categories from admission to final assessment

	Stable high GOS-E	Stable low GOS-E	GOS-E Improvers	GOS-E Worseners
Group 1, n (%)	4 (9.1)	15 (34.1)	24 (54.5)	1 (2.3)
Group 2, n (%)	8 (14.8)	20 (37.0)	24 (44.4)	2 (3.7)
Group 3, n (%)	10 (21.3)	19 (40.4)	17 (36.2)	1 (2.1)
Group 4, n (%)	4 (15.4)	10 (38.5)	12 (46.2)	0
Group 5, n (%)	4 (20.0)	13 (65.0)	2 (10.0)	1 (5.0)
Total sample	30 (15.7)	77 (40.3)	79 (41.4)	5 (2.6)
	Stable RTW	Stable no RTW	RTW Improvers	RTW Worseners
Group 1, n (%)	5 (12.8)	12 (30.8)	22 (56.4)	0
Group 2, n (%)	11 (22.9)	14 (29.2)	20 (41.7)	3 (6.3)
Group 3, n (%)	13 (30.2)	17 (39.5)	10 (23.3)	3 (7.0)
Group 4, n (%)	7 (28.0)	11 (44.0)	7 (28.0)	0
Group 5, n (%)	3 (16.7)	11 (61.1)	3 (16.7)	1 (5.6)
Total sample	39 (22.5)	65 (37.6)	62 (35.8)	7 (4.0)
	Stable low RPQ	Stable high RPQ	RPQ Improvers	RPQ Worseners
Group 1, n (%)	7 (17.5)	17 (42.5)	16 (40.0)	0
Group 2, n (%)	3 (6.0)	32 (64.0)	10 (20.0)	5 (10.0)
Group 3, n (%)	2 (4.8)	26 (61.9)	12 (28.6)	2 (4.8)
Group 4, n (%)	0	14 (66.7)	7 (33.3)	0
Group 5, n (%)	0	15 (83.3)	3 (16.7)	0
Total sample	12 (7.0)	104 (60.8)	48 (28.1)	7 (4.1)

Note. Change in GOS-E status (score high (7-8) or low (5-6)), RTW status (RTW/ no RTW) and RPQ (low <16 /high ≥ 16) refers to between admission and each participant's final assessment. GOS-E= Glasgow Coma Scale Score-Extended. Stable high GOS-E=high GOS-E score at both the first and the final assessment. Stable low GOS-E= low GOS-E score at both the first and the final assessment. Improvers= low GOS-E score at the first assessment, high GOS-E score at the final assessment. Worseners= high GOS-E score at the first assessment, low GOS-E score at the final assessment. Change in RTW status between admission and each participant's final assessment. RTW= return-to-work (80% or more of a full-time position, i.e. ≥ 30 hours per month. RTW only includes those participants who worked full-time before injury. Stable RTW= had returned to full-time work by the first assessment and also worked full-time at the final assessment. Stable no RTW= had not returned to full-time work at either the first or the final assessment. Improvers= had not returned to full-time work at the first assessment yet had returned to full-time work by the final assessment. Worseners= had returned to full-time work at the first assessment yet no longer worked full-time at the final assessment. Stable low RPQ; <16 points on the total score; Stable high RPQ= ≥ 16 points; RPQ Improvers= ≥ 16 points on the 1st assessment and <16 points on the final assessment; RPQ Worseners= <16 points on the 1st assessment and ≥ 16 points on the final assessment. The number of people with missing, unknown, or cannot answer values for each variable are as follows:RPQ=20; RTW=18 (did not work full-time before injury, therefore not part of analyses).

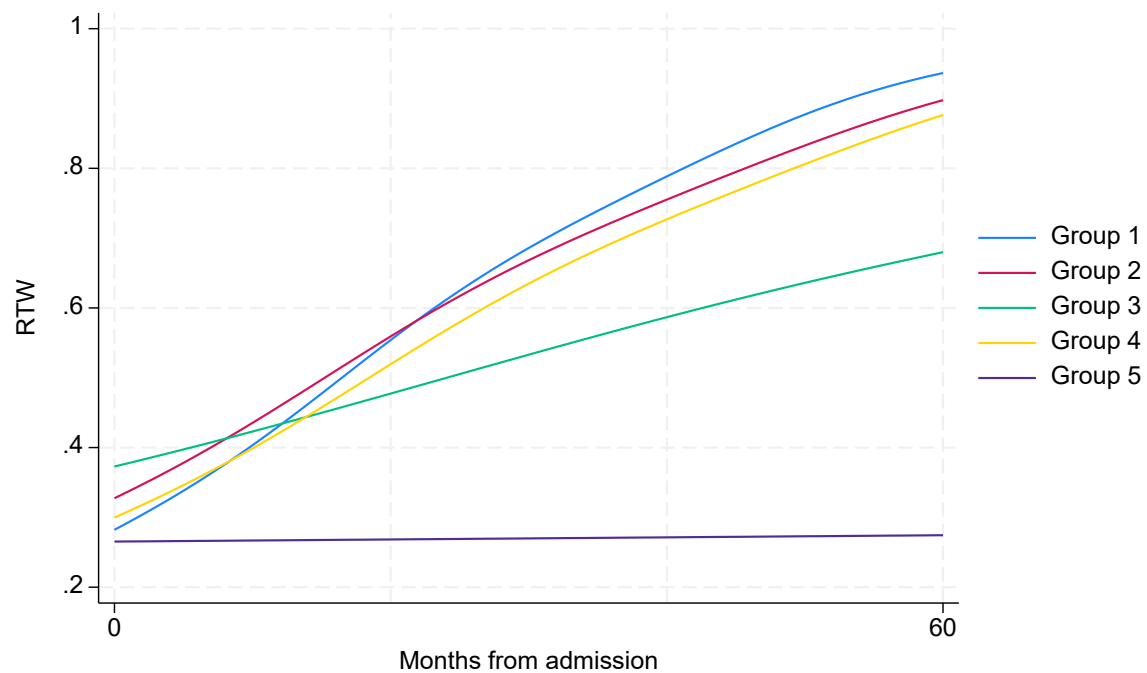


Figure 4. Probability of Return-to-work (RTW) for the different admission groups, results from the mixed-effects logistic model (corresponding to Table 4).

Note. RTW= return-to-work (80% or more of a full-time position, i.e., ≥ 30 hours per month. RTW only includes those participants who worked full-time before the injury. Group 1= admission 0-3 months post-injury; group 2= admission 3-6 months post-injury; group 3 = admission 6-12 months post-injury; group 4=admission 12-24 months post-injury; group 5=admission 24-60 months post-injury.

Table 4. Estimated development of a high GOS-E score and for returning to work, for the different admission groups. Results from the mixed logistic model (corresponding to Figure 3 and 4)

	Odds ratio	<i>p</i>	95% CI
GOS-E high			
Group 1	1.14	<.001	1.08 to 1.21
Group 2	1.09	<.001	1.05 to 1.12
Group 3	1.07	<.001	1.03 to 1.10
Group 4	1.15	<.001	1.08 to 1.23
Group 5	1.00	.914	.94 to 1.07
RTW, yes			
Group 1	1.13	<.001	1.07 to 1.19
Group 2	1.10	<.001	1.06 to 1.14
Group 3	1.04	.007	1.01 to 1.08
Group 4	1.10	.001	1.04 to 1.16
Group 5	1.00	.958	.94 to 1.07

Note. GOS-E high= Glasgow Outcome Scale Extended, high score (7 or 8). RTW= return-to-work, yes (80% or more of a full-time position, i.e., ≥30 hours per month). RTW only includes those participants who worked full-time before the injury. CI= confidence interval. Group 1= admission 0-3 months post-injury; group 2= admission 3-6 months post-injury; group 3 = admission 6-12 months post-injury; group 4=admission 12-24 months post-injury; group 5=admission 24-60 months post-injury. Odds ratio refers to one time unit of change= one month. Bold values eq