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ORIGINAL REPORT

WORLD HEALTH ORGANIZATION DISABILITY ASSESSMENT SCHEDULE VERSUS FUNCTIONAL INDEPENDENCE MEASURE IN TRAUMATIC BRAIN INJURY

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Objective: **In patients with traumatic brain injury, to compare functioning measured using the 12-item patient and proxy World Health Organization Disability Assessment Schedule (WHODAS-12) with assessments made by professionals.**

Patients and methods: **At discharge from rehabilitation, 89 consecutive patients with traumatic brain injury (10 mild, 36 moderate, 43 severe) and their proxies completed the WHODAS-12. Professionals assessed functioning simultaneously using the WHO minimal generic set of domains of functioning and health and Functional Independence Measure (FIM).**

Results: **From mild to severe traumatic brain injury, increasing disability was found in: sum, component and item scores of patient and proxy WHODAS, except for emotional functions in patients' ratings; in sum and item scores of the WHO minimal generic data-set, except for pain; and in FIM total score and sub-scores. The WHODAS participation component was more impaired than activities. Although proxies rated functioning more impaired than patients, the correlation between patient and proxy WHODAS was strong (0.74). The correlation between patient/proxy WHODAS and FIM was also strong (−0.56 and −0.78, respectively). Proxy WHODAS differentiated mild and moderate traumatic brain injury more accurately than the other assessments.**

Conclusion: **We recommend using the WHODAS-12 when planning patient- and family-oriented rehabilitation services after traumatic brain injury.**

Key words: disability; FIM; functioning; rehabilitation; traumatic brain injury; WHODAS.

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LAY ABSTRACT

In this study, 89 patients with traumatic brain injury were enrolled with the aim of comparing the accuracy of the patient- and proxy-rated 12-item World Health Organization Disability Assessment Schedule (WHODAS-12) with the professional-rated World Health Organization (WHO) minimal generic data-set and Functional Independence Measure (FIM) in differentiating mild, moderate and severe traumatic brain injury. Although proxies rated functioning more impaired than patients, all ratings correlated strongly. In all assessments, significantly increasing disability was found from mild to moderate and severe traumatic brain injury. Proxy WHODAS-12 differentiated, however, mild and moderate traumatic brain injury more accurately than the other assessments. In both WHODAS-12 assessments, participation component was found to be more impaired than activities, especially in mild and moderate traumatic brain injury. We recommend using the WHODAS-12 when planning patient and family-centred rehabilitation services after traumatic brain injury.

Worldwide, traumatic brain injury (TBI) is a major source of health loss and disability, even death. Each year, 27–69 million individuals of all ages are estimated to sustain a TBI (1, 2). When patients with different injuries are evaluated, the consequences of TBIs are the most severe (3), causing long-lasting physical, cognitive and emotional health issues and problems in behaviour and communication (4) irrespective of the severity of the injury (5).

Proper assessment is an essential part of effective patient management. A comprehensive assessment requires both subjective and objective perspectives (6, 7). Previously, a variety of measures have been used to categorize patients with TBI (8); hence comparisons between studies, individuals and populations are difficult (9). In spite of its costs, Functional Independence Measure (FIM), created for assessing dependence and need of care in activities of daily living (10), is one of the most widely used functional measures in rehabilitation patients around the world, including rehabilitants with TBI (8, 9, 11). Later, another measure of global disability, the World Health Organization Disability Assessment Schedule (WHODAS), was developed for self-assessment of patients and proxies for perceived difficulties in activities and participation. The World Health Organization (WHO) developed WHODAS to unify the assessment of functioning around the world and to permit comparisons between different health conditions and populations (12, 13). WHODAS is free and accessible for everybody. As participation has been associated with quality of life more strongly than other impairments (14–16) and as many problems after TBI have been linked to participation in addition

to activities (17, 18), participation ability most likely is an important target of rehabilitation if aiming to improve quality of life after TBI.

WHODAS has been found to be a useful and beneficial tool in many diagnostic groups in neurological, psychiatric and rehabilitation patients (19). To date, however, only a few studies have used WHODAS in the context of TBI (20, 21), assessing disabilities after TBI or its consequences (7, 22–24), or comparing TBI with other diagnostic groups (25–27). In chronic TBI, WHODAS has been found to correlate with Community Integration Questionnaire and Quality of Life after Brain Injury Overall Score (28) and with the WHO minimal generic set of domains of functioning and health (7). In a recent study post-stroke, WHODAS has been found to correlate strongly with FIM, the gold standard measure of outcome after rehabilitation (29). In TBI, however, there are no previous studies investigating concurrent validity between these 2 measures. Validation of WHODAS for TBI from a multidisciplinary perspective has been called for (25).

Thus, we decided to initiate a study aiming to investigate the correlation of WHODAS with FIM after rehabilitation of patients with TBI and to compare the accuracy of these 2 measures in discriminating different severities of TBI. To enhance comparability between various populations, we also applied the WHO minimal generic set of domains of functioning and health, as previously recommended (30).

METHODS

On a university hospital specialized inpatient rehabilitation ward, 89 consecutive patients with TBI (diagnosis according to the International Classification of Diseases 10th revision (ICD-10) criteria) were enrolled between August 2015 and November 2022. The patients were mostly referred to the neurological rehabilitation unit for assessment and/or rehabilitation from the neurosurgical unit or neurological outpatient clinic of the same university hospital. Sometimes the patient had to wait after the acute care on a general ward for stabilization of their medical condition before intensive rehabilitation or due to lack of capacity of the rehabilitation unit. After acute care, a proportion of the patients with milder severity of TBI had been discharged into the community to wait for admission to the rehabilitation unit.

The rehabilitation programme included home-training visits, especially during weekends, accompanied by significant other(s), who completed an unofficial questionnaire on the rehabilitants capabilities and needs during the home stay. Before home-training visits/ weekends, a rehabilitation planner made a home call accompanied by the rehabilitant, significant other(s) and 1 or 2 other members of the multi-professional team. Patients with milder TBI could be partly outpatient rehabilitants. Significant others were also encouraged to participate in daily activities, in different therapy and social work sessions on the rehabilitation ward and in at least 1 meeting with the entire multiprofessional team, to discuss the current medical and functional status of the rehabilitant and the future goals and plans including discharge destination.

After rehabilitation, the patients were discharged back to community either without social services or with the aid of services, or to an institution, which usually meant discharge to a residential health care centre where assisted living residence or other long-term facility was arranged locally. Sometimes, however, the permanent facility was arranged directly from the rehabilitation ward.

Inclusion criteria were previously independent living and age 16 years or more at the time of injury. Patients with a current major medical or psychotic condition or another neurological diagnosis including spinal cord injury, and those with medical reasons for interrupted rehabilitation were excluded.

Mild TBI (miTBI) was classified according to the American Congress of Rehabilitation Medicine (31) and WHO (32) criteria, i.e. focal neurological deficit(s) that may or may not be transient, but the severity of the injury does not exceed the following: loss of consciousness of approximately 30 min or less; after 30 min, an initial Glasgow Coma Scale (GCS) of 13–15; and post-traumatic amnesia (PTA) not greater than 24 h. TBI was considered moderate (moTBI) if the GCS at admission was 9–12 or duration of PTA 1–7 days, and severe (sTBI) if GCS at admission was 8 or lower or duration of PTA longer than 1 week. All the patients had a history of a clear head trauma and a period of loss of consciousness or loss of memory or other transient neurological abnormality and GCS 15 or less.

In addition, socio-demographic data including age in years, gender (male, female or other), living situation (cohabiting, yes/ no), years of official education, and working status (work or study, yes/ no) were collected. Informed consent and information regarding the study were also included. Clinical information (date of diagnosis and comorbidities according to ICD-10) was collected from the participants and hospital medical files, and the total number of comorbidities was counted (33).

A rehabilitation nurse qualified in agreement with the Uniform Data System standards assessed the level of dependence of each rehabilitant at admission and discharge using an electronic FIM® tool. At discharge, a neurologist assessed functioning using the WHO minimal generic data-set. The rehabilitants and their significant others completed the 12-item patient and

proxy WHODAS 2.0. To avoid missing data, in a few cases the participants were assisted by a clinician, either technically completing the questionnaire or by explaining the WHODAS items and severities using examples. However, 6 patients were not capable of responding themselves due to severe cognitive impairment or aphasia. Proxy responses were collected, however, from all 89 participants. The participants were blinded for each others' responses to avoid any influence.

Measurement scales

FIM (http://udsmr.org) is the most widely used instrument to measure rehabilitation outcome. It was designed to measure physical and cognitive disability among rehabilitation inpatients in 18 items on a scale of 1–7, ranging from "total dependence" to "complete independence". It is focused on need for assistance in activities of daily living. The total score varies between 18 and 126, motor sub-score (self-care routines, sphincter management, transfers, locomotion) between 13 and 91 and cognitive sub-score (communication and social cognition) between 5 and 35 (8, 9, 34).

The WHODAS 2.0 (http://www.who.int/classifications/icf/whodasii/en/) is a generic International Classification of Functioning, Disability and Health (ICF)-based measure. The WHODAS-12 includes 12 items from 6 domains in 2 components, i.e. Activities: cognition (learning and concentration), mobility (standing and walking), and self-care (washing and dressing oneself); and Participation: relationships (dealing with strangers and maintaining friendships), life activities (doing housework and ability to work or study), and social participation (emotional functions and engaging in community). Each of these 12 items is rated according to a 5-point Likert-type scale, which grades the difficulty experienced by the participant in performing a given activity. Each of the 12 items is scored from 0 to 4, where 0 means no (0–4%), 1 means mild (5–24%), 2 means moderate (25–49%), 3 means severe (50–95%), and 4 means extreme or complete (96–100%) difficulty in this specific activity. The total score of WHODAS is the sum of all these 12 sub-scores, ranging from 0 to 48, with lower scores indicating better functioning. Total scores of 1–4 belong to mild disability, 5–9 to moderate disability, and 10–48 to severe disability (13, 35–38).

The WHO minimal generic set of domains of functioning and health (the WHO minimal generic data-set) consists of 7 domains in 3 ICF components, i.e. body functions, activities and participation: energy and drive functions, emotional functions, sensation of pain, carrying out daily routine, walking, moving around, and remunerative employment. Generic means that this assessment is applicable to all people despite their health conditions. Minimal means that the scale consists of the least number of domains of functioning that can be used to explain significant differences between people with health issues. The scoring system is similar to WHODAS, the sum score ranging from 0 to 28, with lower scores indicating better functioning (30).

To investigate the accuracy of these measures/assessments in distinguishing different severities of TBI, the patients were divided into 3 severity groups, i.e. mild, moderate and severe (severe TBI subgroups: those with severe TBI who could respond to WHODAS, all who had severe TBI, and those with severe TBI who needed constant surveillance, guidance and/or assistance). In patients with TBI, concurrent (criterion) validity of WHODAS in measuring rehabilitation outcome compared with FIM has not been established previously. To be able to score functioning with FIM and WHODAS simultaneously, it was decided to collect WHODAS responses as early as at discharge from rehabilitation. Hence, WHODAS ratings were made according to the current functional status at the time of discharge, not in the preceding 30 days.

Statistical analysis

The comparison between the 3 patient groups (miTBI, moTBI and sTBI) was carried out within categorical variables using χ^2 test, or, in the case of too many small cell frequencies, Fisher's exact test. In numerical variables the comparisons between the 3 patient groups were carried out by the Kruskal–Wallis test. Normality assumptions were evaluated visually using Q-Q-plot, box-plot and histogram. Subgroup comparisons were carried out with Mann–Whitney U test or with χ^2 test or Fisher's exact test. Bonferroni correction was used with subgroup analyses.

Univariate associations between the discharge disposition (home without service, home with service and institution) and patient WHODAS, proxy WHODAS and FIM were calculated using multi-nominal logistic regression analysis. The same method was used with TBI (mild, moderate and severe with response).

The difference between patient and proxy WHODAS sum scores was analysed using paired t-test.

The Spearman correlation coefficient was used to test the correlation between variables. The correlations of $0-0.29$ were considered weak, 0.30–0.49 moderate, $0.50-0.79$ strong, and ≥ 0.80 very strong.

Cronbach alpha's was calculated for patient and proxy WHODAS sum scores and for the WHO minimal generic data-set and FIM total score and subscores.

Statistical analyses were performed using SAS 9.4 for Windows. p-values below 0.05 (2-tailed) were considered statistically significant.

RESULTS

Of the 89 patients, who met the inclusion criteria and participated in the study, 10 patients had miTBI, 36 moTBI and 43 sTBI. Eleven patients with sTBI needed constant surveillance, guidance and/or assistance at discharge, and 5 were unable to respond to the WHODAS questionnaire due to severe cognitive impairment. One additional patient with sTBI was unable to respond due to aphasia.

Of the 89 participating significant others, 43 were spouses, 22 were parents, 6 were children, 4 were siblings, 2 were other relative, 11 were close friends and 1 was a trained caregiver.

Of the accidents 40 were falls, 18 of which were on the same level and 22 > 1.5 m and 39 accidents were traffic-related, mostly motor vehicle accidents as a driver or a passenger (in 4 cases the patient had been a pedestrian when the collision with a motor vehicle occurred, and in 10 cases the patient had been cycling, in 6 out of these 10 accidents the cyclist had a collision with a motor vehicle). The remainder were blows to the head, 7 due to violence or assaults, and 3 were work-related blows.

Patients with severe TBI were oldest and most often non-working, they had the longest time since injury at admission and discharge and the longest length of stay in rehabilitation, and they were most often institutionalized after rehabilitation. No between-groups differences were found in gender, co-habiting or comorbidities (Table I).

In the WHO minimal generic data-set assessment (Table II) and in patient and proxy WHODAS (Table III) significant differences between miTBI, moTBI and sTBI were found in all item level comparisons, except for emotional functions in patients' ratings and pain.

Significant differences ($p < 0.0001$) were also found between the 3 TBI severity groups in sum scores of the WHO minimal generic data-set and patient and proxy WHODAS, in both WHODAS components activities and participation and in FIM total score and motor and cognitive sub-scores. However, the between-group differences in miTBI and moTBI were most significant in proxy WHODAS sum and component scores, followed by the WHO minimal generic data-set, FIM total score and sub-scores and patient WHODAS sum and component scores in declining order of significance (Table IV).

Correlation between patient and proxy WHODAS was strong (0.74). The strongest correlation (0.93) was found between proxy WHODAS sum and the WHO minimal generic data-set assessment, lower but still strong (0.56 – 0.79) correlations were found between the other assessments (Table V).

Proxy WHODAS sum (median) was scored more impaired in moTBI and sTBI groups compared with patient WHODAS self-ratings (Table IV). The mean difference between patient and proxy WHODAS sum scores ($n = 83$) was 4.4 (range –8 to 24, percentile (Pctl) –1, 7), 95% confidence interval (95% CI) 3.0 to 5.9, $p < 0.0001$.

Participation was scored more impaired than activities, the mean difference between participation and activity mean scores in patient WHODAS ($n = 83$) being 0.3 (range –1.8 to 1.8; 25, 75 Pctl 0.0, 0.7), 95% CI 0.1 to 0.4, $p = 0.0001$ and in proxy WHODAS ($n = 89$) 0.5 (range –1.0 – 1.8; 25, 75 Ptcl 0.2, 0.8), 95% CI 0.3 to 0.6, $p < 0.0001$.

The ratio between mean scores of participation and activity was 2.1 (SD 2.1, $p < 0.0001$) in patients' ratings and 1.8 (SD 1.2, $p < 0.0001$) in proxies' ratings. In TBI severity groups miTBI, moTBI and sTBI with

Table I. Demographic and clinical data of the patients with mild, moderate, and severe traumatic brain injury

Variables median (range) or *n* (%)	Mild ($n = 10$)	Moderate with response ($n = 36$)	Severe with response ($n = 37$)	*p*-value	All severe ($n = 43$)	*p*-value	Constant surveillance ($n = 11$*)
Age at injury onset, years	31.5 (19.9–67.2)	36.7 (16.5–71.2)	53.4 (16.2–79.7)	0.002	53.4 (16.0–79.7)	0.006	60.6 (16.0–79.7)
Gender, male	8 (80)	30 (83.3)	30 (81.1)	1.0	36 (83.7)	1.0	8 (72.7)
Education, years	13 (7–20)	12 (8–20)	11 (6–24)	0.3	11 (6–24)	0.09	10 (8–20)
Working/ studying	9 (90)	27 (75)	17 (46)	0.006	21 (48.8)	0.01	6 (54.6)
Cohabiting	4 (40)	18 (50)	19 (51.4)	0.9	21 (48.8)	0.9	6 (54.6)
Comorbidities 0	8 (80)	20 (55.6)	13 (35.1)	0.1	17 (39.5)	0.2	5 (45.5)
1–2	2 (20)	14 (38.9)	5 (45.5)		5 (45.5)		5 (45.5)
≥ 3	0 (0)	2 (5.6)	3 (8.1)		3 (7.0)		1 (9.1)
Charlson Index 0	10 (100)	32 (88.9)	30 (81.1)	0.3	34 (79.1)	0.2	9 (81.8)
1–2	0 (0)	4 (11.1)	7 (18.9)		9 (20.9)		2 (18.2)
≥ 3	0 (0)	0 (0)	0 (0)		0 (0.0)		0 (0.0)
Time since injury on admission, days	24.5 (4–268)	38 (8–300)	70 (19–544)	< 0.0001	76 (19–544)	< 0.0001	131 (29–544)
Length of stay, days	5 (2–15)	11 (7–32)	19 (3–85)	< 0.0001	18 (3–110)	< 0.0001	16 (4–110)
Time since injury at discharge, days	32 (18–273)	52 (18–309)	112 (33–576)	< 0.0001	112 (33–576)	< 0.0001	160 (45–576)
Discharge disposition: home, no service	10(100)	27 (75)	3 (8.1)	< 0.0001	3 (7.0)	< 0.0001	0 (0.0)
Home with service	0 (0)	7 (19.4)	19 (51.4)		20 (46.5)		0 (0.0)
Institution	0 (0)	2 (5.6)	15 (40.5)		20 (46.5)		11 (100.0)

*6/11 patients belong to the group "severe with response", 5/11 were not able to respond.

Table II. Patient and proxy World Health Organization Disability Assessment Schedule (WHODAS) item scores in mild, moderate, and severe traumatic brain injury at discharge from rehabilitation

Variables (median; 25, 75 percentile)	Patients				Proxies						
	Mild ($n=10$)	Moderate ($n=36$)	Severe with response ($n=37$)	p-value	Mild ($n=10$)	Moderate ($n=36$)	Severe with response ($n=37$)	p-value	Proxies all severe ($n=43$)	p-value	Proxies constant surveillance ($n=11$)
Standing (0–4)	0.0 (0.0, 0.0)	0.0 (0.0, 1.0)	2.0 (1.0, 3.0)	<0.0001	0.0 (0.0, 0.0)	0.0 (0.0, 1.0)	2.0 (1.0, 4.0)	<0.0001	2.0 (1.0, 4.0)	<0.0001	4.0 (4.0, 4.0)
Household tasks	0.0 (0.0, 1.0)	0.5 (0.0, 1.0)	2.0 (1.0, 3.0)	<0.0001	0.0 (0.0, 0.0)	1.0 (0.0, 1.0)	3.0 (2.0, 4.0)	<0.0001	3.0 (2.0, 4.0)	<0.0001	4.0 (4.0, 4.0)
Learning	0.5 (0.0, 1.0)	1.0 (0.0, 1.0)	2.0 (1.0, 2.0)	0.0006	0.0 (0.0, 0.0)	1.0 (1.0, 2.0)	3.0 (2.0, 3.0)	<0.0001	3.0 (2.0, 3.0)	<0.0001	3.0 (3.0, 3.0)
Community life	0.0 (0.0, 1.0)	1.0 (0.0, 2.0)	1.0 (1.0, 2.0)	0.027	0.5 (0.0, 1.0)	1.0 (0.0, 1.0)	2.0 (2.0, 3.0)	<0.0001	2.0 (2.0, 3.0)	<0.0001	3.0 (3.0, 3.0)
Emotional functions	0.5 (0.0, 1.0)	1.0 (0.0, 2.0)	1.0 (1.0, 3.0)	0.073	0.5 (0.0, 1.0)	1.0 (0.0, 2.0)	2.0 (1.0, 3.0)	0.0006	2.0 (1.0, 3.0)	0.0001	2.0 (2.0, 3.0)
Concentrating	0.0 (0.0, 1.0)	0.5 (0.0, 1.0)	1.0 (0.0, 2.0)	0.029	0.0 (0.0, 0.0)	1.0 (0.0, 2.0)	2.0 (1.0, 3.0)	<0.0001	2.0 (1.0, 3.0)	<0.0001	3.0 (2.0, 3.0)
Walking	0.0 (0.0, 0.0)	0.0 (0.0, 1.0)	2.0 (1.0, 4.0)	<0.0001	0.0 (0.0, 0.0)	0.0 (0.0, 1.0)	3.0 (1.0, 4.0)	<0.0001	3.0 (1.0, 4.0)	<0.0001	4.0 (4.0, 4.0)
Washing oneself	0.0 (0.0, 0.0)	0.0 (0.0, 0.0)	1.0 (0.0, 2.0)	<0.0001	0.0 (0.0, 0.0)	0.0 (0.0, 0.0)	1.0 (1.0, 2.0)	<0.0001	1.0 (1.0, 3.0)	<0.0001	4.0 (3.0, 4.0)
Dressing oneself	0.0 (0.0, 0.0)	0.0 (0.0, 0.0)	1.0 (0.0, 2.0)	<0.0001	0.0 (0.0, 0.0)	0.0 (0.0, 0.0)	1.0 (0.0, 2.0)	<0.0001	1.0 (0.0, 3.0)	<0.0001	3.0 (3.0, 4.0)
Dealing with strangers	0.0 (0.0, 0.0)	0.0 (0.0, 0.0)	0.0 (0.0, 2.0)	0.020	0.0 (0.0, 0.0)	1.0 (0.0, 1.0)	2.0 (1.0, 3.0)	<0.0001	2.0 (1.0, 3.0)	<0.0001	3.0 (3.0, 3.0)
Maintaining friendships	0.0 (0.0, 0.0)	0.0 (0.0, 1.0)	1.0 (0.0, 2.0)	0.020	0.0 (0.0, 0.0)	0.0 (0.0, 1.0)	1.0 (1.0, 2.0)	<0.0001	2.0 (1.0, 3.0)	<0.0001	3.0 (2.0, 4.0)
Working ability	1.0 (1.0, 2.0)	2.0 (1.0, 3.0)	3.0 (2.0, 4.0)	0.0009	1.0 (1.0, 2.0)	3.0 (3.0, 4.0)	4.0 (4.0, 4.0)	<0.0001	4.0 (4.0, 4.0)	<0.0001	4.0 (4.0, 4.0)

response, the ratio between mean scores of participation and activities in patients' ratings were 2.7 (SD 2.4), 2.8 (2.7) and 1.2 (SD 0.8), respectively (between-group difference $p=0.004$) and in proxies' ratings 2.6 (SD 1.9), 2.4 (SD 1.3) and 1.3 (SD 0.4) ($p<0.0001$), respectively. Eight patient-ratings and 6 proxy-ratings were excluded due to a value 0 in either component.

When patient or proxy WHODAS sum increased by 1 point, the odds ratio (OR) of being institutionalized instead of discharged to community with social services was 1.07, 95% CI 1.00 to 1.14 and 1.11, 95% CI 1.04 to 1.20, respectively ($p<0.0001$), the corresponding OR being 0.90, 95% CI 0.84 to 0.97 ($p<0.0001$) when applying FIM. When proxy WHODAS increased by 1 point, the OR of belonging to the sTBI (with response) instead of moTBI group was 1.65, 95% CI 1.27 to 2.14 ($p<0.0001$), the corresponding figures being 1.21, 95% CI 1.10 to 1.32 ($p<0.001$) and 0.74, 95% CI 0.63 to 0.86 ($p<0.0001$) when using patient WHODAS and FIM, respectively.

Cronbach's alpha value for reliability (internal consistency) of the sum score of patient WHODAS was 0.89 and proxy WHODAS 0.94. The corresponding figures for the WHO minimal generic data-set and FIM total score, motor and cognitive sub-scores were 0.85, 0.94, 0.94 and 0.78, respectively.

DISCUSSION

In this study of 89 consecutive patients with TBI, a significant increase in disability was found from mild to severe TBI: in patient and proxy WHODAS sum and item scores, except for emotional functions in patients' ratings; in both WHODAS component scores (activities and participation); in sum and item scores of the WHO minimal generic data-set, except for pain; and in FIM total score and motor and cognitive sub-score. The median patient and proxy WHODAS sum scores were rated as mild, moderate and severe in the corresponding TBI severity groups, participation being more impaired than activities, especially in miTBI and moTBI. The most significant between-group differences were found in proxy WHODAS sum and component scores, followed by the WHO minimal generic data-set, FIM total score and sub-scores, and patient WHODAS assessments in declining order of significance. Proxy WHODAS differentiated mild and moderate TBI most accurately. Even if proxies rated functioning more impaired than patients, especially in moTBI and sTBI, the correlation between patient and proxy WHODAS was strong (0.74). Very strong correlation was found between proxy WHODAS and the WHO minimal generic data-set (0.93), the correla-

Table III. The World Health Organization minimal generic data-set item scores in traumatic brain injury at discharge from rehabilitation

Variable (median, range; 25,75 percentile)	Mild ($n=10$)	Moderate ($n=36$)	Severe with response ($n=37$)	p-value	All severe ($n=43$)	p-value	Constant surveillance ($n=11$)
Energy and drive functions	1 (0–2; 0, 1)	1 (0–2; 1, 2)	2 (1–4; 2, 3)	<0.0001	2 (1–4; 2, 3)	<0.0001	3 (2–4; 2, 4)
Emotional functions	0 (0–1; 0, 1)	1 (0–2; 0, 1)	2 (0–4; 1, 2)	<0.0001	2 (0–4; 1, 3)	<0.0001	2 (0–3; 1, 3)
Sensation of pain	1 (0–2; 0, 2)	0 (0–2; 0, 0.5)	0 (0–3; 0, 1)	0.064	0 (0–3; 0, 1)	0.077	0 (0–3; 0, 1)
Daily activities	0 (0–1; 0, 1)	1 (0–2; 1, 2)	3 (1–4; 2, 3)	<0.0001	3 (1–4; 2, 3)	<0.0001	4 (3–4; 3, 4)
Walking	0 (0–0; 0, 0)	1 (0–1; 0, 1)	2 (0–4; 1, 3)	<0.0001	2 (0–4; 1, 3)	<0.0001	3 (1–4; 3, 4)
Moving around	0 (0–2; 0, 0)	1 (0–1; 0, 1)	3 (0–4; 2, 3)	<0.0001	3 (0–4; 2, 3)	<0.0001	4 (2–4; 4, 4)
Remunerative employment	1 (0–4; 1, 2)	3 (1–4; 2, 4)	4 (4–4; 4, 4)	<0.0001	4 (4–4; 4, 4)	<0.0001	4 (4–4; 4, 4)

Table IV. Patient and proxy World Health Organization Disability Assessment Schedule (WHODAS) scores, the World Health Organization (WHO) minimal generic data-set scores and Functional Independence Measure (FIM) scores in mild, moderate, and severe traumatic brain injury at discharge from rehabilitation

Variable (median, range; 25,75 percentile)	Mild ($n=10$)	Moderate ($n=36$)	Severe with response ($n=37$)	p^a	All severe ($n=43$)	p^a	p^b	p^c	p^d	Constant surveillance ($n=11$)*
WHODAS patient sum	3.5 (1–9, 2, 6)	8.0 (0–20, 5, 11.5)	20 (1–41, 13, 25)	<0.0001			0.05	<0.0003	<0.0003	29.5 (18–41, 24, 34)
Activities	0.2 (0.0–0.5, 0.2, 0.2)	0.4 (0.0–2.2, 0.2, 0.7)	1.7 (0.0–3.3, 0.8, 2.2)	<0.0001			0.08	<0.0003	<0.0003	2.5 (2.0–3.3, 2.2, 2.8)
Participation	0.4 (0.0–1.3, 0.2, 0.8)	0.9 (0.0–2.5, 0.3, 1.3)	1.5 (0.0–3.7, 1.0, 2.0)	<0.0001			0.2	0.0018	0.0006	2.2 (1.0–3.5, 1.7. 3.0)
WHODAS proxy sum	3.0 (0.0–8.0, 2, 6)	10.5 (6–21, 7.0–14.0)	25 (15–40, 20, 33)	<0.0001	27 (15–44, 20, 34)	<0.0001	<0.0003	<0.0003	<0.0003	40 (26–44, 34, 40)
Activities	0.1 (0.0–0.3, 0.0, 0.2)	0.5 (0–1.7, 0.3, 0.8)	1.8 (0.7–3.7, 1.5, 2.3)	<0.0001	2.2 (0.7–3.7, 1.5, 3.0)	<0.0001	<0.0003	<0.0003	<0.0003	3.3 (2.5–3.7, 3.0, 3.7)
Participation	0.4 (0.0–1.3, 0.2, 0.8)	1.1 (0.5–2.5, 0.8, 1.7)	2.2 (1.3–3.7, 2.0, 2.8)	<0.0001	2.3 (1.3–3.7, 2.0, 3.2)	<0.0001	0.0006	<0.0003	<0.0003	3.2 (2.2–3.7, 2.7, 3.5)
WHO minimal generic data-set	3 (1–8; 3, 7)	8 (4–13; 6, 9)	16 (10–22; 13, 16)	<0.0001	16 (10–23; 13, 18)	<0.0001	0.002	<0.0003	<0.0003	20 (16–23; 18, 22)
Discharge FIM total	125.5 (120–126; 123, 126)	121.5 (111–125; 120, 124)	108 (48–124; 99, 117)	<0.0001	105 (44–124; 93, 115)	<0.0001	0.008	<0.0003	<0.0003	57 (44–93; 54, 89)
FIM motor	91 (88–91; 90, 91)	89.5 (78–91; 88, 90)	81 (28–91: 74, 87)	<0.0001	80 (28–91; 70, 87)	<0.0001	0.04	<0.0003	<0.0003	36 (28–73; 33, 62)
FIM cognitive	34.5 (32–35; 32, 35)	33 (28–35; 31, 34)	28 (17–35; 23, 30)	<0.0001	27 (9–35; 22, 30)	<0.0001	0.1	<0.0003	<0.0003	21 (9–27; 18, 22)

[a]All 3 severities. [b]Mild vs moderate. [c]Moderate vs severe. [d]Mild vs severe,
In between-group comparisons Bonferroni correction has been used. Activities and participation scores used were mean values of the 6 items in the component in question. *p*-values between different severity groups were equal when using either "severe with response" or "all severe" groups. *Patient WHODAS assessment $n=6$.

tion between patient WHODAS or FIM and the WHO minimal generic data-set being lower, but still strong (0.72 and –0.79, respectively). The correlation between patient/proxy WHODAS and FIM was strong (–0.56 and –0.78, respectively), as well.

The fact that disability levels measured with WHODAS increased significantly with increasing severity of TBI is in accordance with a large Taiwanese register study (25) and our previous study in patients with chronic TBI, which showed that the overall WHODAS disability scores and the WHO minimal generic data-set scores were higher in those with more severe TBI compared with milder injuries, and in more severe TBI physical motor functions were impaired in addition to cognitive and emotional functions (7). In the current study, individuals with mild, moderate and severe TBI were found to have, in median mild, moderate and severe disability according to WHODAS disability categories, between-group differences exceeding the minimal clinically important difference of WHODAS-12 derived in mild TBI (39). WHODAS was also found to be associated with discharge destination supporting previous research (25) showing that WHODAS is able to predict institutionalization after TBI (22). Even if proxies rated functioning more impaired than patients, the correlation between patient and proxy WHODAS was strong, which is in accordance with previous literature (40). Obviously, in case of brain injury, individuals with more severe injury may lack insight into the consequences of injury and the most subtle and least observable, but still important difficulties perceived by patients with mild injury, on the other hand, might be more difficult for proxies to notice. In patients with more severe injury and severe cognitive impairment or aphasia, the proxy version might be more suitable than patient's self-rating.

Previously, it has been shown that individuals with TBI have higher disability scores on WHODAS than those without TBI (20, 21). Patients with TBI and high overall disability have been found to perceive more difficulties and rated higher WHODAS scores than those with spinal cord injury of equally high overall disability assessed with the WHO minimal generic data-set (26). However, when comparing the sTBI group in the current study and rehabilitants in our previous study with severe stroke and equally high disability assessed with the WHO minimal generic data-set (29), the 2 groups (i.e. individuals with sTBI and those with severe stroke) rated compatible WHODAS sum scores. Compared with other diagnostic groups with severe disability (25), the consequences of brain injury regardless of injury type (41) might be perceived as particularly disabling.

In the current study, both activity limitations and participation restrictions were found to increase significantly with increasing severity of TBI. In addition to activities of daily living, it is crucial to measure the participation component of functioning, such as ability to participate in

Table V. Spearman correlation coefficients of sum scores ($n=89$ except for in patient WHODAS assessment $n=83$)

	Scored at discharge		The WHO minimal generic data-set	FIM total	FIM motor subscore	FIM cognitive subscore
	WHODAS patient sum	WHODAS proxy sum				
WHODAS patient sum		0.74	0.72	–0.56	–0.55	–0.48
Proxy sum	0.74		0.93	–0.78	–0.70	–0.69
The WHO minimal generic data-set	0.72	0.93		–0.79	–0.74	–0.69

All correlations were significant at the level of $p<0.001$. WHODAS: World Health Organization Disability Assessment Schedule; WHO: World Health Organization; FIM: Functional Independence Measure

relationships, in the community and work, as participation ability has been found to be associated with quality of life even more strongly than other impairments (14–16). Also, previously, patients with chronic TBI have reported perceiving a diversity of significant difficulties in both WHODAS activities and participation components irrespective of the severity of the injury, and even after miTBI patients may have reported remarkable cognitive and emotional difficulties (7). High long-term disability on WHODAS in individuals with miTBI has been found to be associated with various psychiatric anxiety and depressive disorders (42). In miTBI and/or post-traumatic stress disorder, cognitive test performances have been less associated with WHODAS scores than mood and post-concussion syndrome (24). Vestibular dysfunction has been found to be directly and independently associated with post-concussive symptoms and functional disability assessed with WHODAS (23). At 3 months after injury, pain interference, but not cognition, has been found to partially explain the impact of miTBI on functional outcomes measured with WHODAS (43). In the current study, pain was mostly mild or non-existent with no significant differences between the TBI severity groups. Impairment in emotional functions was found to increase with increasing severity of TBI in assessments made by professionals and proxies, and a similar pattern was found in patients' self-ratings. Post-traumatic stress disorder or other injuries, such as musculoskeletal trauma or vestibular dysfunction, which can potentially exacerbate the early psychosocial outcome of TBI (44), were not diagnosed. Thus, in the current study, patients with miTBI were found to have significantly lower overall WHODAS scores than those with moTBI or sTBI.

A large number of studies have investigated the concurrent validity of WHODAS. In chronic TBI, a moderate inverse relationship has been found between WHODAS and Community Integration Questionnaire, and a strong inverse correlation between WHODAS and Quality of Life after Brain Injury Overall Score (28), and a strong to very strong correlation has been found between patient and proxy WHODAS and the WHO minimal generic data-set (7). In various populations, WHODAS has also been found to correlate with other self-reported measures of lived health, such as the World Health Organization Quality of Life and the Short-Form Health Survey, the correlations ranging from moderate to strong. Furthermore, WHODAS has been found to correlate with many disease-specific measures of activity limitations in various diagnostic groups, in general population samples in diverse countries and cultures, and in rehabilitation patients, the reported correlations varying from moderate to strong (19). In our previous study post-stroke, a strong to moderate correlation was found between WHODAS and the WHO minimal generic data-set, FIM and a stroke-specific measure National Institutes of Health Stroke Scale (NIHSS) at discharge from stroke rehabilitation (29). The findings of the current study show a very strong correlation between WHODAS and the WHO minimal generic data-set, even slightly stronger than in our previous studies in chronic TBI (7) and in subacute stroke (29). Compared with stroke rehabilitants, however, evidence of similar concurrent validity between WHODAS and FIM has been lacking in patients with TBI.

As far as we know, this is the first study to investigate concurrent validity of WHODAS compared with FIM after TBI. For this reason, the assessments were made simultaneously at discharge from rehabilitation. In this study, WHODAS and FIM were found to correlate strongly in spite of their differences in functional items and perspectives. The correlation between proxy WHODAS and FIM was even stronger than between patient WHODAS and FIM. Almost as strong correlations were found in our previous study after subacute stroke rehabilitation (29). In addition, the current study showed that proxy WHODAS sum score and component scores differentiated miTBI from moTBI more accurate than FIM total and subtotal scores and the other assessments. While FIM describes the burden of care from the point of view of the healthcare system, WHODAS is more patient- and family-centred describing problems perceived by patients and their significant others. FIM score defines how much assistance a person may need in order to achieve the optimal level of his or her functioning rather than the actual performance in everyday life without any assistance. Compared with FIM, a scale based on the ICF is meant to define difficulty level and may be more comprehensive for assessing the level of functioning, as it is able to take into account both concepts of capacity and performance (45). As FIM is a measure of dependence in activities of daily living, WHODAS, on the other hand, measures perceived activity limitations and participation restrictions. Many problems after TBI have been linked with participation (18, 25). In the current study, WHODAS participation component was found to be even more impaired than activities, especially in miTBI and moTBI, unlike in our previous study post-stroke with more equal distribution of difficulties in the 2 components (29). In more severe TBI, in addition to participation difficulties also physical motor impairment is prominent, leading to increasing difficulties in activities of daily living. Assessing participation in addition to activities is crucial when assessing consequences of TBI across different severities and when planning rehabilitation targets for individuals with TBI. Thus, in clinical practice, the

impact of WHODAS as a valid, reliable and usable patient and proxy-reported outcome measure seems to be significant.

Study limitations

Although the number of participants in the study was limited, it was large enough for the purpose of this research and to achieve useful results. The patients with severe TBI were older than those with milder severities; however, the median age in all severity groups was in working age range and the range was also equally wide in each group. The data were collected from a single academic hospital in Finland only, and therefore may not be generalizable to other settings as medical, social and cultural features and administrative practices may differ worldwide. Nevertheless, WHODAS and the WHO minimal generic data-set have been developed to study comparability across different populations and nations. The application of cross-sectional study design does not allow confirmation of causal relationships of disability. However, the study included only rehabilitants with premorbid independent living and comorbidities were assessed carefully. As WHODAS was compared with FIM after rehabilitation, both measures had to be applied simultaneously at discharge from rehabilitation. The participants in different severity groups responded to WHODAS in median from 1 to just over 2 months after TBI. Hence, WHODAS was applied according to the current functional status at the time of discharge, not in the preceding 30 days.

Conclusion

At discharge from rehabilitation, strong correlation was found between patient and proxy WHODAS and FIM. However, proxy WHODAS was more accurate than FIM in differentiating mild and moderate TBI. Proxy WHODAS-12 seems to be superior to FIM in assessing disabilities in patients with TBI. We recommend using the short and understandable 12-itemWHODAS 2.0, when assessing the consequences of TBI, in order to enhance more individualized approach for setting rehabilitation goals and making future plans.

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The study was approved by the Ethics Committee of the University and University Hospital (19.5.2015, 73/2015). The ethics standards of the World Medical Association Helsinki Declaration of 1975, as revised in 1983 were followed.

The authors accept and agree with the United Nations' Declaration of Human Rights.

The authors have no conflicts of interest to declare.

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