

Changes in the International Classification of Functioning, Disability, and Health Components “Activity/Participation” as Predicted Through Patient-Reported Outcomes Along With Comprehensive Back Pain Rehabilitation

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Objectives: The World Health Organization (WHO) recommended the International Classification of Functioning, Disability and Health (ICF) but its use in clinical practice is sparse. This study investigated the limitations and restrictions in the most relevant brief ICF core set categories for chronic low back pain (cLBP) as automatically predicted from routinely measured outcomes using a novel, validated mapping algorithm.

Materials and Methods: Of 2718 cLBP patients recruited, data from 1541 (64% females) were available from before and at the end of 6 months comprehensive outpatient rehabilitation. Assessments included the Roland Morris Disability Questionnaire (RMDQ) and Pain Disability Index (PDI) questionnaires, the percentage of patients with predicted limitations and restrictions in important activity and participation ICF categories, bodily functional measurements, pain intensity, and anxiety/depression (EQ-5D).

Results: At baseline, both the RMDQ and the PDI measures were within the third of the lowest disability scores whilst 80% of the patients had limitations with “maintaining a body position” and 30% with “walking” ICF categories. Intervention-associated gains in the maximum isometric lumbar extension and flexion strength and the lumbar range of motion were significant overall, but improvements in patients’ ICF limitations/restrictions varied. Anxiety/depression, lumbar range of motion, and extension strength all had a significant impact on the majority of the ICF categories, whereas flexion strength had none.

Discussion: The rate of patients with predicted limitations/restrictions in activity/participation ICF core categories for cLBP partly mirrored disability levels and the impact of the body function scores on these limitations/restrictions in ICF categories was varied. Thus, assessing problems in the ICF activity/participation core categories is of relevance to clinical practice for both treatment goal setting and intervention planning. This may be achieved by computer-generated mapping without additional time burden.

Key Words: international classification of functioning, disability and health, health status, disability evaluation, chronic low back pain

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Clinicians will soon be required to code the relevant body function, activity, and participation categories of the International Classification of Functioning, Disability and Health (ICF) in pain conditions, as such specific assessment will become part of the upcoming 11th International Classification of Diseases (ICD-11).^{1,2} This new requirement has the potential to bridge the gap between the 2 classifications, leading to a more comprehensive health evaluation. The ICF is a framework that describes the functioning in different health domains (structure/function and activities/participation), takes environmental and personal factors into account, enables a reliable language across all disciplines,^{3–5} and is recommended for use before and after therapeutic interventions.^{6,7} The extensive data volume of the ICF was downsized through the brief ICF core set, and the World Health Organization (WHO) has called on stakeholders to adopt its use in order to strengthen rehabilitation at all levels worldwide.^{3,8,9} However, at this point, implementation remains unclear because of concerns regarding the feasibility of the procedure in clinical routine; the practical application of the ICF needs to be demonstrated, without imposing additional time burdens on both patients and health care providers.¹⁰

Unspecific chronic low back pain (cLBP) is diagnosed when organic causes are ruled out. The condition is rarely curable and is thus a leading contributor to disability and a major burden to global health.¹¹ Rehabilitation is the key strategy that focuses on minimizing disability and on optimizing functioning and health, with the overall goal of enabling a person with cLBP to reach optimal involvement in all relevant individual life situations. The Roland Morris Disability Questionnaire (RMDQ) and the Pain Disability Inventory Index (PDI) are widely used and valid outcome measures of functional impairment that have been adapted for non-English speaking patients.^{12–17} A comprehensive

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evaluation of functioning within the different health domains requires that ICF-impaired structures and functions, together with the difficulties/problems within the respective categories listed for different ICF chapters, be assessed with reliable instruments similar to these patient-reported outcomes (PRO). Moreover the bodily functional outcome scores (trunk strength and range of motion measures) are presently required for documentation and reimbursement in clinical practice.

In a previous study, our group developed and validated a computer-generated algorithm based on random forests that fits well with the results of ICF linking rules published by other authors.¹⁸ Therefore, routinely used RMDQ and the PDI together can automatically predict if patients demonstrate limitations or restrictions within relevant activity and participation categories of the brief ICF low back pain core set. It should be possible to use this algorithm to identify individual limitations/restrictions in these patients, and to show respective changes along with rehabilitation without imposing an additional time burden to patients and health care providers. Research has revealed that PRO scores and pain ratings significantly improve along with gains in bodily functional scores (lumbar range of motion, maximum isometric lumbar flexion, and extension strength) upon completion of comprehensive biopsychosocial back pain rehabilitation.^{19–21} However, to date no study has evaluated the extent to which limitations/restrictions in the relevant ICF core activity and participation categories for cLBP are associated with such state-of-the-art therapy that is covered by social security in industrialized countries. In addition, it remains unclear how impaired body functions that are typically addressed with rehabilitation interventions would impact improvements in these limitations and restrictions. Examining these questions would enhance our understanding of the specific benefits beyond those of well-documented disablement and bodily functional outcome measures.

The aims of this study were to investigate (1) the degree of disablement as assessed with pain related health scores (RMDQ and PDI), measurement scores of impaired functions (maximum isometric lumbar extension and flexion strength, lumbar range of motion, pain intensity, and anxiety/depression); and (2) the percentages of patients with predicted limitations in the relevant activity and restrictions in the participation categories of the brief ICF low back pain core set before and at the end of a 6 months comprehensive rehabilitation program. Examining the impact of these outcome scores on the rate of patients with limitations/restrictions in these ICF categories was another aim of the study.

MATERIALS AND METHODS

Patients

All employed cLBP patients who had successfully completed 3 weeks of phase 2 inpatient rehabilitation were referred to the outpatient rehabilitation center through the Austrian social security system for phase 3 rehabilitation, and were eligible for this study. Both phase 2 and 3 rehabilitation aim to optimize and stabilize bodily activity, quality of life, and disability and to preserve the ability to work for employed cLBP patients. Phase 2 inpatient rehabilitation provides one-on-one physiotherapy to improve pain free lumbar range of motion, to engage in symptom limited progressive resistance exercise, occupational

therapy, psychological counseling, and modalities to alleviate pain. At the end of phase 2, patients are advised to search for an outpatient rehabilitation facility close to their home or work place and to proceed with phase 3 outpatient rehabilitation within 4 months. At the beginning of phase 3 rehabilitation, patients received a short screening form that assessed the location, duration, and intensity of their pain and some functional limitations and co-morbidities. Thereafter, eligible patients were scheduled for a clinical examination performed by a specialist in physical medicine and rehabilitation.

Between October 2011 and November 2016 a total of 2718 (1768 female, 65%) patients above 18 years of age were consecutively included in this observational cohort study. They were generally healthy and reported low back pain with a minimum of 30 mm and neck pain <30 mm on a visual analog scale (VAS) (0 to 100 mm) during the 12 weeks before screening. The exclusion criteria were as follows: receipt of health care advice for headaches within the past year and more than 5 headache episodes (1 or more lasting more than 2 days); headache within the last 6 weeks²²; peripheral neurological deficit; spinal fracture, infection, or cancer; previous surgery involving the back region; previous experience with trunk muscle strength testing; performance of exercise more than 2 times per week or at a competitive level²³; inability to follow German verbal instructions; pregnancy; and a body mass index exceeding 35 kg/m². Patients were asked not to take analgesic drugs, muscle relaxants, or psychochemicals 2 days before testing. The data collection was performed in accordance with the directives given in the Declaration of Helsinki and was approved by the Ethics committee of the city of Vienna (EK_11_181_VK_NZ). Before inclusion, all patients received oral and written information about the study and signed a consent form.

Experimental Protocol

Comprehensive Outpatient Rehabilitation Program

All patients performed a similar phase 3 outpatient rehabilitation program that lasted ~6 months. The program included 40 training sessions (90 min each), 6 units of psychological interventions (mindfulness, relaxation techniques), 1 unit for information on the spinal function and pathologies, and 2 units for ergonomics and healthy alimentation. Training comprised lumbar extensor, flexor, and rotator muscles and the connected muscle groups in the legs (hip abductors, hip adductors, quadriceps femoris) and arms (scapula fixators). The resistance of the devices (DAVID, Helsinki, Finland) was adjusted according to the results of maximum isometric strength testing at the beginning and at the middle of the program (lumbar extensor and flexor muscles) and to the expertise of experienced therapists (lumbar rotators, hip abductors, hip adductors, quadriceps femoris, and scapula fixators) with 10 to 12 repetitions per muscle group following the recommendations of the American College of Sports Medicine.²⁴ If normal strength according to the manufacturer's age-specific and sex-specific data was regained patients were allowed to train once weekly instead of twice as at the beginning of treatment. Each unit additionally included low-intensity cardiovascular warm-up with bicycle ergometers, sensorimotor training with unstable surfaces (5 min each), and stretching of tightened muscle groups.

Instrumentation and Procedures

Assessment of maximum capacity measures (sagittal range of motion and muscle strength of the lumbar spine). After standardized familiarization with the procedure and several warm-up trials, the range of motion of the lumbar spine between maximum flexion and extension was evaluated. To evaluate the maximum isometric back extension strength, the trunk was flexed 30 degrees anterior relative to the vertical on the same specially constructed test and training device (F110 extension; DAVID). Flexion strength was tested on a different device (F130 flexion; DAVID) with upright trunk position.²⁵ Patients' lower body and hips were fixed in place using foot plates, knee pads, and belts, and their pelvis was stabilized with a dorsal back pad according to the manufacturer's recommendations.

Assessment of PRO Performance Measures (Disability)

Both the RMDQ and the PDI are patient-reported instruments with high utility because they are easy to comprehend and can be administered in a short-time frame. They are both considered reliable and valid for patient-reported disability.¹⁷

RMDQ

The RMDQ comprises 24 questions about back pain related health state limitations with a score range of 0 to 24 (where 0 indicates best back related health and 24 worst). The German version was used in this study after cross-cultural adaptation by previous authors.¹²

PDI

The PDI comprises 7 items focused on participation level (family, recreation, social activities, professional, sexual life, self-care, and life-supporting activities) that assess disability in chronic pain patients on an 11-point scale (where 0 indicates no disability and 10 refers to worst disability possible). The PDI was translated into German.¹⁶

EQ-5D Questionnaire (EQ-5D)

The EQ-5D comprises 5 domains (mobility, self-care, usual care, pain/discomfort, and anxiety/depression). Answers to the fifth question were used for evaluation of

anxiety/depression with 3 ratings of impairment (no, moderate, and extreme problem).

Pain Intensity

Pain was rated on a VAS (0 to 100 mm, 0 no pain, 100 worst pain imaginable).

Patients answered the RMDQ, PDI, and EQ-5D questionnaires, and reported their pain intensity using tablets before (test 1 = t1) and immediately after completion of the 6 months comprehensive outpatient rehabilitation program (test 2 = t2).

Performance related health information derived from the RMDQ and PDI was translated into an ICF classified health profile using the computer processed automatic random forests.¹⁸

In brief, the ICF categories were predicted from the 24 items of the RMDQ and the 7 items of the PDI by applying random forest models for binary classification that were built on a data set of 244 cLBP patients in a preliminary study.^{18,26} Patients' ratings to the ICF categories were dichotomized into "absence of a limitation/restriction" for the response "0" and "presence of a limitation/restriction" for answers from "1" (mild) to "4" (complete).²⁷ The accuracy of the models was validated by comparison of the actual and the predicted ratings to the ICF categories and it revealed satisfactory performance, particularly if administered to populations rather than on an individual level. According to the variable importance measures, which revealed the most important predictors for a specific ICF category, the content of the random forest models was comparable to qualitative linking by applying the ICF linking rules.^{28,29} On the basis of previous research and a consensual discussion, d530 "toileting" was excluded from prediction as it was reported with low frequencies and did not represent major problems for cLBP patients⁴ (Table 1).

Outcomes

Main outcomes were: the percentages of cLBP patients with a limitation/restriction in the different activity and participation categories as derived from the RMDQ and the PDI scores at t1 (before rehabilitation) and at t2 (after rehabilitation), and the changes of these percentage values along with rehabilitation. Other outcomes comprised the maximum isometric lumbar extension and flexion strength

TABLE 1. Percentages of Patients With Limitations/Restrictions in Activity and Participation Categories Before and After Rehabilitation

	t1, n (%)	t2, n (%)	Changes From t1 to t2, n (%)
ICF activity categories			
d240 Handling stress and other psychological demands	1071 (69.50)	789 (51.20)	282 (-26.33)*
d410 Changing basic body positions	1034 (67.10)	692 (44.91)	342 (-33.08)*
d415 Maintaining a body position	1239 (80.40)	980 (63.60)	259 (-20.90)*
d430 Lifting and carrying objects	1003 (65.08)	774 (50.23)	229 (-22.83)*
d450 Walking	477 (30.95)	284 (18.43)	193 (-40.46)*
d540 Dressing	804 (52.17)	534 (34.65)	270 (-33.58)*
d640 Doing housework	860 (55.81)	626 (40.62)	234 (-27.21)*
ICF participation categories			
d760 Family relationships	950 (61.65)	697 (45.23)	253 (-26.63)*
d845 Acquiring, keeping and terminating a job	836 (54.25)	593 (38.48)	243 (-29.07)*
d850 Remunerative employment	1001 (64.96)	714 (46.33)	287 (-28.67)*
d859 Work and employment, other specified and unspecified	955 (61.97)	705 (45.75)	250 (-26.18)*

"d530 Toileting" was excluded from calculation.

Changes indicate changes in patient numbers and percentages with limitations/restrictions from t1 to t2 (percentages refer to 100% patients at t1); t1, assessment before rehabilitation; t2, assessment after rehabilitation.

*Mc Nemar's test used for changes from t1 to t2 (level of significance Bonferroni corrected: $P < 0.0045$).

(Nm), the lumbar range of motion (degrees), the pain intensity (0 to 100), and anxiety/depression part of the EQ-5D (0-2).

Statistical Analysis

The number of patients with a limitation/restriction within the different ICF core categories was reported for both assessments. For other outcome measurements, medians together with the respective interquartile ranges were presented. Changes between the predicted ICF categories were reported in absolute numbers of patients with a limitation/restriction as well as in percentages. Significance of outcome measurement changes were calculated through Wilcoxon signed-rank tests and significant changes in the different ICF categories were measured with McNemar's tests. Generalized linear mixed models were calculated to test the impact of body functions (maximum isometric lumbar extension and flexion strength, the lumbar range of motion, and anxiety/depressive mood as derived from the EQ-5D) on the percentage of patients identified with a limitation/restriction within the activity/participation categories, as well as the respective changes between the start and the end of the rehabilitative intervention. On the basis of purely statistical arguments, we had to exclude the VAS pain ratings from the set of explanatory variables, and consequently fitted the generalized linear mixed models without them. Our exploratory analyses revealed the VAS pain ratings as highly correlated with the other regressors in our statistical model. In this case, a "regression paradox" occurred when our regression model was adjusted to control for additional explanatory variables and the sign of a coefficient reversed.^{30,31} Such phenomenon is typically caused by multicollinearity, that is, one regressor is accurately predicted by the remaining regressors in the statistical model—and in our application the "sign switch" happened for the VAS pain ratings. All reported *P*-values were Bonferroni corrected and the level of significance was set at *P* < 0.0045. All statistical analyses were performed in the R environment for statistical computing.³²

RESULTS

Of the 2718 included cLBP patients, 589 (21.7%) dropped out of rehabilitation. These drop outs reported significant worsening of back pain, deterioration of their health status unlinked with back pain, personal and family related reasons, and lack of time. A further 182 questionnaires (6.7%) had 1 or 2 and another 406 (14.9%) questionnaires had more than 2 missing answers and were therefore also excluded. In the end, data from 1541 patients (56.7%, 982 [64%] of them females) were used for statistical analyses (Fig. 1). A statistical comparison of the bodily functional scores, pain, anxiety/depression, and body mass index between patients who dropped out or had missing data and those who remained in the study revealed non-significant differences between these groups.

Baseline scores and longitudinal changes in the PRO and the bodily functional scores (Table 2). The VAS pain intensity, EQ-5D, RMDQ, and PDI measures were all within the lower half of the score ranges at baseline. These as well as the measures of body function (maximum trunk extension and flexion strength, lumbar range of motion) improved significantly with rehabilitation. Baseline percentage values and longitudinal changes in the patients with

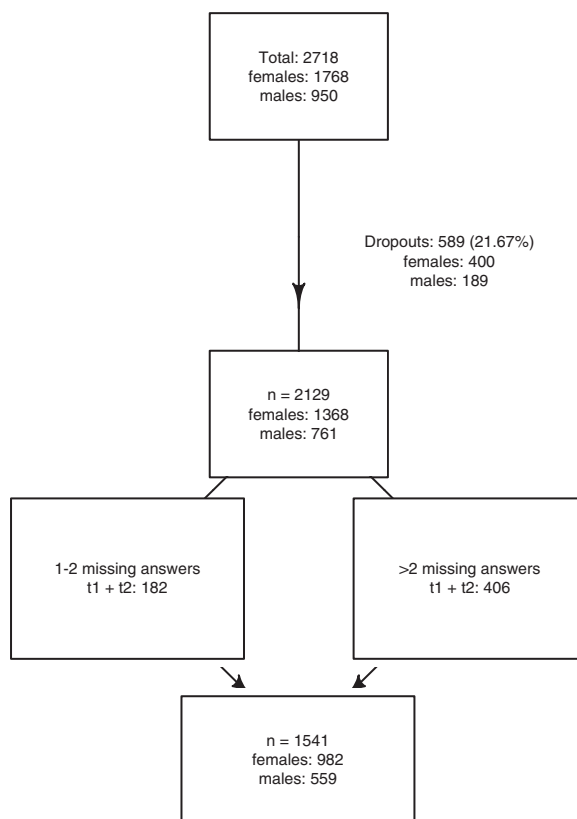


FIGURE 1. Patient flow chart. t1 indicates assessment before rehabilitation; t2, assessment after rehabilitation.

limitations/restrictions in ICF activity and participation categories as predicted from the RMDQ and PDI scores.

The predicted percentage-rates of patients with limitations/restrictions in the ICF core categories was more substantial with variable numbers in the 7 activity (80.4% of the patients in category "maintaining a body position" [d415] and 30.9% in "walking" [d450]) and rather similar ones in the 4 participation categories before the start of the intervention (Table 1). Upon completion of rehabilitation the PRO and the bodily functional scores together with the predicted numbers of patients with limitation/restriction revealed significant improvements in all the categories investigated (Tables 1 and 2). However, their relative changes were found to be varied because RMDQ and PDI improved by 33.3% and 25.0%, respectively, whereas the rate of patients identified with a limitation/restriction within an ICF core category decreased to a variable extent in a range from 20.9% ("maintaining a body position" d415) to 40.5% ("walking" d450) in the activity and 26.2% ("work and work employment" [d859]) to 29.1% ("acquiring, keeping, and terminating a job" [d845]) in the participation domain.

Impact of body function measurement scores (anxiety/depression, maximum isometric lumbar flexion and extension strength, and lumbar range of motion) on problems in the ICF activity/participation core categories (Table 3). Anxiety and depression as assessed by the EQ-5D had a significant impact on the predicted number of patients found with a limitation/restriction in any of the activity/participation core categories. The same was true for the lumbar

TABLE 2. Demographics and Differences in Outcome Scores Between Before and After Rehabilitation

	t1, n/Median (IQR)	t2, Median (IQR)	Difference t1 to t2, Median (IQR)	Difference t1 to t2, (in %) Median
Number of patients	1541			
Age (y)	51.7 (9.0)			
Gender (% of females)	982 (64%)			
BMI (in kg/m ²)	26.14 (5.69)	26.29 (5.28)	0.0 (0.62)*	0.0
Pain intensity (VAS 0-100)	50.0 (31.0)	20.0 (26.0)	-24.0 (25.0)*	-59.26
RMDQ (sum score)	8.0 (8.0)	4.0 (6.0)	-2.0 (4.0)*	-33.33
PDI (sum score)	18.0 (18.0)	12.0 (18.0)	-3.0 (10.0)*	-25.00
ROM (degrees)	68.0 (20.0)	76.0 (14.0)	6.0 (14.0)*	9.38
Lumbar flexion strength (Nm)	99.0 (64.0)	120.0 (68.0)	21.0 (29.0)*	20.00
Lumbar extension strength (Nm)	146.0 (106.0)	187.0 (120.0)	40.0 (66.0)*	27.65
EQ-5D (anxiety/depression)	1.0 (1.0)	1.0 (0.0)	0.0 (0.0)*	0.00

BMI indicates body mass index; IQR, interquartile range; PDI, Pain Disability Index; RMDQ, Roland Morris Disability Questionnaire; ROM, sagittal lumbar range of motion; t1, assessment before rehabilitation; t2, assessment after rehabilitation.

*Wilcoxon test for significant changes between assessments (Bonferroni corrected $P < 0.0062$).

range of motion scores, except for the category “maintaining a body position” (d415). The impact of back extension strength was found to be significant in all participation and in three of the activity categories but not in “changing basic body positions” (d410), “Lifting and carrying objects” (d430), “walking” (d450), or “dressing” (d540). By contrast, the impact of the lumbar flexion strength scores did not reach the level of significance in any of the activity/participation categories tested.

DISCUSSION

This study is the first to investigate the use of automatically and validly predicted limitations and restrictions in the relevant activity and participation categories of the brief ICF low back pain core set as well as the respective changes with widely used comprehensive rehabilitation in more than 1500 patients. It is also the first to examine the impact of bodily function scores on the rate of patients found with limitations/restrictions in these ICF categories. Results revealed differences in the rates of limitations and restrictions within the individual activity/participation core

categories, as well as their respective changes in a cohort of cLBP patients whose RMDQ and PDI scores indicated a moderately impaired back related health state before and after rehabilitation. All the measurement scores assessing impaired functions except for lumbar flexion strength exhibited a significant impact on the different ICF activity/participation core categories.

Computerized prediction offers a feasible way to classify cLBP patients into those with and others without limitations/restrictions in the important activity and participation core categories listed for cLBP. This is important, as routinely used ICD-11 classification cannot be coded without assessment of the specific ICF categories in chronic pain conditions. Whilst scores indicated overall moderate disability levels before rehabilitation, the number of patients with limitations/restrictions in ICF categories was more prominent with a higher variation in activity than in participation levels. Such discrepancy could be partly related to the fact that most (7) of the categories (d240-d640, Table 1) represented the activities (mainly predicted from RMDQ) and only 4 (d760-d 859, Table 1) represented the participation (mainly predicted from PDI) component.

TABLE 3. Impact of Bodily Functional Outcomes and Depression to the Health Status Categories (Generalized Linear Mixed Models)

Outcome/ ICF	Explanatory Variables														Random Effect	
	Test Number		Lumbar Extension Strength†			Lumbar Flexion Strength†			Lumbar Sagittal Range of Motion†			Anxiety/Depression (EQ-5D)			Subject	
	Estimate	Z	P	Estimate	Z	P	Estimate	Z	P	Estimate	Z	P	Estimate	Z	P	SD
d240	-0.71	-5.84	<0.001*	-0.48	-4.61	<0.001*	-0.03	-0.32	0.748	-0.20	-2.86	0.004*	0.82	10.62	<0.001*	1.55
d410	-1.19	-8.17	<0.001*	-0.19	-1.57	0.118	-0.06	-0.53	0.596	-0.69	-7.75	<0.001*	0.77	8.49	<0.001*	2.08
d415	-1.47	-6.82	<0.001*	-0.52	-3.62	<0.001*	-0.05	-0.33	0.740	-0.27	-2.61	0.009	0.83	6.87	<0.001*	2.44
d430	-0.95	-6.74	<0.001*	-0.33	-2.81	0.005	-0.15	-1.23	0.218	-0.59	-6.69	<0.001*	0.93	9.83	<0.001*	2.06
d450	-0.67	-4.90	<0.001*	-0.22	-1.75	0.080	-0.14	-1.14	0.255	-0.72	-8.24	<0.001*	0.76	9.12	<0.001*	2.09
d540	-0.92	-6.11	<0.001*	-0.01	-0.10	0.919	0.20	1.54	0.124	-0.90	-9.16	<0.001*	0.74	7.98	<0.001*	2.40
d640	-0.83	-6.01	<0.001*	-0.43	-3.72	<0.001*	-0.19	-1.58	0.114	-0.48	-5.66	<0.001*	0.94	10.10	<0.001*	1.97
d760	-0.74	-5.48	<0.001*	-0.50	-4.29	<0.001*	0.10	0.89	0.380	-0.44	-5.33	<0.001*	0.91	9.99	<0.001*	1.99
d845	-0.49	-3.57	<0.001*	-0.46	-3.62	<0.001*	0.33	2.65	0.008	-0.77	-8.60	<0.001*	0.98	10.80	<0.001*	2.19
d850	-0.55	-4.53	<0.001*	-0.34	-3.28	0.001*	0.25	2.38	0.017	-0.41	-5.73	<0.001*	0.74	10.15	<0.001*	1.65
d859	-0.64	-4.82	<0.001*	-0.37	-3.21	0.001*	-0.29	-2.43	0.015	-0.44	-5.38	<0.001*	0.92	10.26	<0.001*	1.98

ICF indicates International Classification of Functioning, Disability and Health.

*Significant effects on ICF categories (Bonferroni corrected $P < 0.0045$).

†Metric variables where standardized for optimizer convergence.

On the basis of the evidence available, it appears that an exercise dominated phase 3 rehabilitation program lasting for 6 months would likely improve back strength and reduce the disability levels in cLBP patients well above minimum clinically important differences,^{25,33} as was the case in this study. However, without specifically addressing limitations/restrictions in individuals' activity and participation core categories, the beneficial effects of the exercise dominated rehabilitation program appeared to translate to these categories in a variable manner. This observation was substantiated by our findings of a variable change in the decline of the percentage rate of individual limitations/restrictions, and the significant impact of the bodily function measures "depression," "range of motion," and to a certain extent "lumbar extension strength." Other research has shown that cLBP patients had lower spinal control and body perception and that exercise could reverse that and lead to an improvement in negative emotions and depression.^{34,35} These results might especially apply if the intervention continues long enough and patients have time to adapt, that is, 6 months, as in phase three rehabilitation. Our own findings from a previous cLBP study demonstrated that fear avoidance behavior dominantly affected the "working capacity" category.³⁶ With these prior studies in mind, it appears important to note that 3 of the 4 brief ICF low back pain participation categories are work-associated (d845, d850, and d859; Table 1). Hence, the rehabilitation-driven positive effects on muscle strength in association with the reduction of negative psychological symptoms and improvements in sensory-motor performance were expanded to benefits in the activity/participation domain. However, patients' benefits in the different functioning aspects were not proportional to their individual baseline deficits.

Lumbar range of motion and anxiety/depression were dominant factors interacting with limitations/restrictions in activities and participation in our cLBP patients. This suggests that reducing fear and anxiety while improving range of motion would also improve the limitations and restrictions in the activity and participation domain. Previous research appears to corroborate our observations and reveals that fear leads to smaller excursions of the lumbar spine and that individuals avoid lumbar spine motion even at 6 weeks following pain onset, thereby confirming the close interaction of fear with specific motor behavior.³⁷ In contrast, lumbar extension strength had a significant impact on only half of the activity categories, but did not impact the category "lifting and carrying objects" (d430). Strength is an important target for exercise interventions and test scores are considered representative for clinical outcome.³⁸ However, authors' findings are somewhat controversial, as a recently published meta-analysis of more than 5000 patients came to the conclusion that back muscle strength and, even to a greater extent, abdominal strength showed no significant association with low back pain.³⁹ These findings fit well with our own results, where flexion strength had no significant impact on limitations/restrictions in any of the activity or participation categories. This result can serve as further proof that in cLBP rehabilitation one cannot easily translate clinically important improvements in relevant body function outcome scores to decreases in limitations/restrictions in activity/participation categories. In a similar manner, one cannot conclude that rehabilitation-induced gains in patients' (bodily) function outcomes is a guarantee for overall better performance of patients in their environment.

Limitations

While participating in this study, patients passed through phase 3 rehabilitation. They were all volunteers, middle-aged, not retired, and covered by social security. Therefore, the results of this study might not be a representative sample for all cLBP patients, particularly those undergoing phase 2 rehabilitation. The prediction of ICF categories was limited to "no limitations/restrictions" and "with limitation/restriction" and was not designed to build an outcome scoring system. However, machine learning algorithms have been shown to be suitable for mapping patients' rating on the RMDQ and PDI to most of the ICF activity and participation categories of the brief core set for low back pain if administrated at large on a population level. Thus, such categorization does allow one to focus on categories with limitations/restrictions for further evaluation excluding those without. If put into practice, such a procedure would help save resources urgently needed for patient treatment. Moreover, the algorithm supports the intentions of the upcoming ICD-11 to shorten the gap between disease, impairment, disability, and health for a more comprehensive evaluation.

One could argue that our methodological approach, which used a dichotomized classification of the activity and participation categories into "not impaired" and "impaired," might be problematic as disability cannot be dichotomized. This argument is based on the assumption that disability is always on a continuum, and the degree of disability depends on the environment, which was not assessed in this study. Context factors are either barriers or facilitators and are of particular importance to interpret a person's disability level, if a person's capacity is measured in the activity and participation domain. However, the information collected by the PROMS (RMDQ and PDI) in this study represents the patient's performance perspective and the information in the predicted limitations/restrictions in the activity and participation core categories; these measures therefore indirectly consider the context factors relevant to the person. Disablement is defined as the experienced functioning and health state of a person. This definition also supports our method of employing a binary distinction between the presence and absence of a limitation/restriction, which is clear cut and disregards the continuum of the severity of an individual's limitation or restriction. The statistics used and the large sample size are appropriate to answer the research questions raised in this research.

CONCLUSIONS

This algorithm-based prediction of limitations/restrictions in activity and participation categories from patient-reported disability measuring instruments was feasible in cLBP rehabilitation practice. The number of patients with limitations/restrictions in the activity and participation ICF categories only partly mirrored those observed in the body function categories. In addition, the impact of different body function based outcome measures on patients' problems with activities/participations was varied. Consequently, such discrepancies endorse the comprehensive assessment of cLBP patients' functioning and health according to the ICF as being of utmost importance for the clinical decision-making process as it enables specific goal setting and treatment guidance. Future research should apply the algorithm to predict limitations/restrictions using the vast quantity of patient-reported functional measurements that have already

been collected in rehabilitation practices. Such research would shed light on the overall effects of the rehabilitation to different cLBP patient subgroups and the effects of different therapeutic strategies in the past and present. Furthermore, research should help to establish the ICF itself as an outcome scoring instrument, to foster its use in clinical practice worldwide.

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