The value of physical performance tests for predicting therapy outcome in patients with subacute low back pain: a prospective cohort study

Babak Moradi · Julia Benedetti ·
Anita Zahlten-Hinguranage · Marcus Schiltewolf ·
Eva Neubauer

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Abstract Considering the enormous costs of intensive multidisciplinary treatment, predictive tests for therapy outcome are needed to evaluate patients' performance potential and increase cost effectiveness. Somatic parameters are commonly used to evaluate health status and serve as an additional means of forecasting the prognosis, yet little is known of their validity. In this study, we investigated the prognostic value of somatic parameters regarding the outcome of multidisciplinary treatment in patients with subacute low back pain. The study was designed as a prospective cohort study of 162 patients. Somatic parameters were assessed with three physical performance tests (Villiger test, Oesch test, Biering–Sørensen test) before treatment (T0), after 3 weeks' inpatient therapy (T1) and at 6-month follow-up (T2). Psychometric characteristics of subjective pain perception (VAS), a pain disability index (PDI) and a physical capability index (FFbH-R) were recorded. Correlation coefficients between the physical performance test scores and psychometric characteristics were calculated. To predict therapy outcome, discriminant

analyses were performed. A control group ($n = 30$) was evaluated at similar time points without receiving any therapy. Our results demonstrate good discrimination between patients and controls by means of the investigated performance tests and exhibit a significant negative correlation with the psychometric data. Lower outcome values at study entry correlated with higher pain intensity and disability after multidisciplinary treatment. However, the statistical magnitude of correlation was relatively low and further discriminant analysis did not reveal any predictive value. Consequently the physical performance tests do not have a prognostic value regarding therapy outcome.

Keywords Physical performance test · Prognostic value · Villiger test · Oesch test · Biering–Sørensen test

Introduction

Low back pain (LBP), with its associated disabilities and costs, is a complex problem in western societies and the socioeconomic impact is known to be enormous [1, 2, 4, 8, 29, 41, 48, 49, 54, 58]. Even after an intensive diagnostic work-up, the exact cause of LBP remains unestablished in about 85% of cases [18, 60]. Thus, LBP is multi-factorial with respect to its causes and systematic reviews have shown that multidisciplinary approaches display higher success rates than purely biomedical treatment [14, 60]. Some 80% of the costs incurred by LBP are attributable to the 10% of patients who do not recover within a few weeks of injury and proceed to chronic LBP [46]. The transition from acute to chronic LBP is complex, and multiple risk factors, including somatic parameters, have been described [7, 10–12, 52, 57, 59]. Within this context the assessment of somatic parameters like muscle performance and muscle

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B. Moradi (✉) · J. Benedetti · M. Schiltewolf · E. Neubauer
Orthopaedic Clinic, University Heidelberg,
Schlierbacher Landstraße 200a, 69117 Heidelberg, Germany
e-mail: Babak.Moradi@ok.uni-heidelberg.de

A. Zahlten-Hinguranage
Department of Translational Oncology,
National Center for Tumor Diseases (NCT),
Heidelberg, Germany

endurance through physical performance tests is used most frequently to evaluate health status and as an adjunct method of making judgments of patient's performance potential [32].

In a study by Biering-Sørensen [4], reduced trunk extensor muscle endurance was reported to be a risk factor for the development and chronification of nonspecific LBP (NSLBP) [4, 20–43]. Standardised batteries of physical performance tests, known as functional capacity evaluations (FCE) are purported to measure a patient's safe physical ability for work-related activity and are becoming increasingly common in occupational health care clinics worldwide.

The assessment of somatic parameters through physical performance tests is commonly used to predict outcome, e.g. return to work. In a study by Kool et al. [32] a combination of the Villiger and Oesch tests and behavioural signs was reported to reliably predict non-return to work. The findings of other prospective studies investigating the prognostic value of physical performance tests have varied widely owing to differences in treatment strategies and measured outcome parameters.

To avoid the high costs of intensive multidisciplinary treatment and prevent the personal suffering associated with long-term disability it is necessary to identify factors that can predict the outcome of therapy, i.e. thus distinguish the patients with a good chance of recovery from those at higher risk of chronification.

To the authors' knowledge this is the first study to evaluate the value of three commonly used physical performance tests, the Biering-Sørensen, Oesch and Villiger tests, for predicting the success of multidisciplinary pain treatment in patients with LBP.

Materials and methods

Study design

Participants were included in a prospective cohort study with a follow-up time of 6 months. Assessment and treatment of the patients were not altered for this study. Informed consent was obtained from all patients. The study was approved by the ethics committee of the University of Heidelberg. All patients were referred to the clinic by their treating physicians without pre-selection by an insurance company or the clinic.

Control group

Thirty healthy controls were included in the study. Controls had experienced one episode of LBP without being on sick leave. LBP at the time of assessment constituted grounds

for exclusion. The control group was assessed at the same time points without receiving any treatment.

Patients

Patients generally had suffered a long history of LBP and had already undergone all conventional forms of biomedical treatment. In most of the cases patients had been referred to our clinic owing to failure of standard therapy with requests for admission to a (first time) biopsychosocial therapy.

Inclusion criteria

Patients and controls of working age (20–65 years) with equal distribution amongst the different age groups were enrolled into the study. We included patients with the main symptom of LBP, defined as disabling pain of at least 6 weeks' duration that led to sick leave.

Exclusion criteria

Excluded were patients with specific aetiology of LBP: for example, tumour disease; trauma/fracture; inflammatory systemic disease or infection; nucleus pulposus prolapse with corresponding radicular pain; severe degenerative changes; structural pathology of the lumbar spine, e.g. spinal stenosis or spondylolisthesis; rheumatological disease; serious cardiopulmonary, vascular or other internal medical conditions; any sensorimotor and/or neurological deficits in the lower extremity; spinal surgery in the 12 months before commencement of multidisciplinary therapy; or major pain at an additional site other than the lower back.

Multidisciplinary treatment

Patients underwent 3 weeks' multidisciplinary therapy as inpatients, with 8-h sessions on 5 days each week, for a total of 120 h of treatment. This multidisciplinary approach embraces biological, social and psychological considerations. Its goal is to restore the patients' physical and psychosocial abilities, to expand their knowledge of back-protection techniques and protective behaviour, to improve their positive skills for individual coping and emotional control, and to increase their activity levels at home and their day-to-day functioning so as to facilitate a return to the workplace. It integrates physical exercises, ergonomic training, psychotherapy, patient education, behavioural therapy, and workplace-based interventions on an individual basis and in group sessions.

After completion of their treatment programmes, the patients were discharged without further interventions by

the hospital team. They were allowed to contact the physician who had referred them for therapy, but they were encouraged to manage similar further pain episodes on their own without immediately contacting a physician. Further utilisation of medical services after completion of the therapy programme was not monitored.

Evaluation of baseline data

Patients' health status was assessed at the three assessment time points: before treatment (T0), after 3 weeks' inpatient therapy (T1) and at 6-month follow-up (T2). Patients were examined regarding their capacity in the three physical performance tests. Basic psychometric data were collected on a questionnaire completed by the patients. Items were pain duration, subjective pain perception (VAS), pain-related disability (PDI, FFbH-R) and number of sick leave days.

VAS

Patients rated their current pain intensity on a visual analogue scale (VAS) from 0 to 10. Improvement of two points on the VAS at T1 and T2 was defined as success.

PDI

Measures of pain-related disability were assessed with the pain disability index (PDI), in which greater levels of disability are reflected by higher scores on a 10-point scale [6, 51]. The PDI comprises a validated questionnaire consisting of seven items representing the impact of pain on essential life activities. The overall PDI score is an aggregate value of functional capacity and ranges between 0 (minimal disability) and 70 (maximal disability).

FFbH-R

Functional back capacity was assessed with the Funktionsfragebogen Hannover-Rücken (FFbH-R) [31]. This validated questionnaire consists of 12 items representing physical activities of daily living. The overall FFbH-R score is an aggregate value of functional capacity ranging between 0 (minimal capacity) and 100 (maximal capacity).

Physical performance tests

Villiger test

The Villiger test was originally designed to evaluate aerobic capacity [56]. The patient is asked to step up and down a 30-cm-high step for 3 min. The initial frequency is 96 steps (24 cycles) per minute (see Electronic

supplementary material). Patients were allowed to reduce speed to a comfortable level. We measured the number of steps and the duration. The test does not increase the stress on the lumbar spine more than climbing stairs. Cessation before 3 min has elapsed is counted as a positive test.

Oesch test

For the Oesch test, the patient lies supine whilst holding two 3-kg weights with straight arms against gravity for 3 min [44] (see Electronic supplementary material). This test does not put any significant load on the lumbar spine or the spinal muscles and can be performed by patients with acute radicular pain. Cessation before 3 min has elapsed is counted as a positive test.

Biering-Sørensen test

The Biering-Sørensen test measures how many seconds the participant is able to keep the unsupported upper part of the body in a horizontal position (Fig. 1). In this test, the load is equal to the weight of the upper part of the body, with torque determined by the lever arm from the pubic symphysis to the upper-body centre of gravity [4]. The patient was positioned prone on a treatment couch with the lower half of the body—below the level of the anterior superior iliac spines—strapped to the couch at the ankles and at the level of the greater trochanter of the femur. The straps were pulled as tight possible without causing undue discomfort to the patient. Before beginning the test the patient was allowed to rest the top half of the body on a chair. Then the trunk was raised to the horizontal position with hands crossed over the chest. The test was continued until the participant could no longer control the horizontal posture, or until he or she reached the limit for fatigue or pain.

Outcome variables

Outcomes were classified as therapy success or failure according to the following outcome criteria:

- Pain intensity and reduction of pain intensity compared to baseline status (VAS). A decrease of two points at T1, T2 was considered as success [8, 9].
- PDI and reduction of disability compared to baseline status. A reduction of a half standard deviation at T1, T2 was considered as success.
- Functional back capacity (FFbH-R) and improvement of function compared to baseline status. A reduction of a half standard deviation at T1, T2 was considered as success.

Fig. 1 Biering–Sørensen test. This test measures how many seconds the participant is able to keep the unsupported upper part of the body in a horizontal position. The test was continued until the participant could no longer control the horizontal posture, or until he or she reached the limit for fatigue or pain

Statistical analysis

Pearson correlation coefficients were used to assess the interrelations between psychometric data and the outcomes of the physical performance tests at the three assessment time points. Discriminant analysis was performed according to the success criteria to determine the prognostic value of the physical performance tests. Results of the physical performance tests displayed the discriminant variables.

A *P* value of 0.05 or less was considered to be statistically significant. All data were analysed using SPSS version 12.0 statistical application for Windows.

Results

Study population

One hundred and sixty-two patients (86 men, 76 women) and 30 healthy controls (22 men, 8 women) were enrolled into this study. Patients and controls did not differ significantly regarding average of age and BMI (Table 1). Patients suffered from LBP as their main symptom with an average duration of pain of 2.3 ± 0.8 years. The average duration of sick leave was 50.1 ± 95.4 days (Table 1).

Physical performance tests

Villiger test

Patients' performance (number of steps) improved significantly after multidisciplinary therapy ($P < 0.05$), and this improvement was still evident at T2 (Table 2a, Fig. 2a, b). No significant difference could be shown in test duration. Controls performed significantly better in both number of steps and test duration without showing any statistically significant difference between the two assessment time points. The correlation analysis revealed a significantly positive correlation in outcome values of patients and controls, indicating that better results at the first assessment indicated a better outcome at T1 and T2.

Table 1 Sociodemographic variables and symptoms in patients and healthy controls

	Patients	Healthy controls
<i>N</i>	162	30
Men:women	86:76	22:8
Mean age ($\pm$ SD)	46 ± 11 years	42 ± 9 years
Mean duration of pain ($\pm$ SD)	2.3 ± 0.8 years	–
Mean duration of sick leave ($\pm$ SD)	50.1 ± 95.4 days	–
Body mass index ($\pm$ SD)	25.1 ± 3.6	24.9 ± 3.2

Oesch test

As expected, patients achieved significantly lower outcome values than the healthy control group ($P < 0.05$), who reached the maximum holding time (180s). Patients' performance in the Oesch test did not improve after multidisciplinary therapy, in contrast to the Villiger and Biering–Sørensen tests (Table 2a–c, Fig. 2). There was also a significantly positive correlation between the three assessment time points, as shown in Table 2b.

Biering–Sørensen test

Results of the Biering–Sørensen test show that patients' performance improved significantly at T1 and improved values could also be displayed at T2 (Table 2c, Fig. 2d). Holding times of controls were significantly higher, and both patients and controls showed a significantly positive correlation of outcomes between the assessment time points. Outcomes of the Biering–Sørensen test displayed the highest difference of the three performance tests between patients and healthy controls.

Psychometric data (VAS, PDI, FFbH-R)

Basic psychometric data are shown in Table 3 and Fig. 3. Subjective pain intensity (VAS) showed a mean value of 5.37 ± 1.97 at T0. At study entry, the mean

Table 2 The results of the three physical performance tests and correlation analysis at the three assessment time points (T0–T2) for patients and controls

(a)	Number of steps		Test duration (s)	
	Patients	Controls	Patients	Controls
Villiger test				
T0	55.5 ± 18.2	78.8 ± 15.2	167.7 ± 32	180
T1	61.1 ± 21.6*	–	161.9 ± 41.5	–
T2	60.3 ± 28.1*	76 ± 19.0	159.3 ± 7.4	173 ± 35
Pearson correlation				
T0/T1	0.84**	–	0.65**	–
T0/T2	0.61**	0.34*	0.3*	0.18*
T1/T2	0.63**	–	0.3**	–
(b)	Holding time (s)			
	Patients		Controls	
Oesch test				
T0	167.5 ± 34.6		180	
T1	169.9 ± 30.6		–	
T2	160.4 ± 50		180	
Pearson correlation				
T0/T1	0.49**		–	
T0/T2	0.41**		–	
T1/T2	0.48**		–	
(c)	Holding time (s)			
	Patients		Controls	
Biering–Sørensen test				
T0	52.6 ± 48.4		161.8 ± 63	
T1	67.7 ± 54.4**		–	
T2	70.2 ± 62.2**		148.5 ± 65	
Pearson correlation				
T0/T1	0.72**		–	
T0/T2	0.58**		0.73**	
T1/T2	0.75**		–	

The mean values and standard deviation (SD) are shown

* $P < 0.05$, ** $P < 0.001$

PDI and FFbH-R scores were 26.66 ± 12.3 and 64.5 ± 19.14 .

As described above, therapy success was defined for each outcome parameter (VAS, PDI, FFbH-R) and patients were divided into two groups (therapy success and therapy failure) according to their outcome after multidisciplinary therapy.

VAS

The subjective pain intensity decreased significantly after multidisciplinary therapy ($P < 0.05$), and values decreased

further at the 6-month follow-up. There was no significant difference between T1 and T2. Values at the three assessment time points displayed a positive correlation: patients with higher pain perception at T0 also presented higher values at T1 and T2. A decrease of two points after multidisciplinary therapy was considered as therapy success, and 52.6% of the patients in the study group reached this goal.

PDI

The PDI decreased significantly after multidisciplinary therapy and decreased values were also displayed at the 6-month follow-up (Table 3, Fig. 3). Therapy success, defined as a reduction of half a standard deviation, was achieved by 55.5% of the study group.

FFbH-R

The FFbH-R scores improved significantly ($P < 0.05$) after multidisciplinary treatment with 71.46 ± 19.35 at T1 and 73.72 ± 21.68 at the 6-month follow-up. Therapy success, i.e. a reduction of half a standard deviation, was found in 55.3% of the study group.

Correlation analysis and discriminant analysis

Correlation analysis was performed between the outcome values of the physical performance tests and the psychometric data (VAS, FFbH-R, PDI) after multidisciplinary treatment and discriminant analysis to determine interrelations and to evaluate the predictive value of these tests for therapy outcome. The results, shown in Table 4, demonstrate that the three investigated performance tests exhibit a significant negative correlation with the psychometric data: lower performance correlated with higher pain intensity and disability.

As investigated by means of discriminant analysis, the results of the physical performance tests at T0 did not differ significantly between the two subgroups (therapy success and therapy failure), demonstrating that these tests do not predict therapy outcome.

Discussion

In this study, we investigated the prognostic value of somatic parameters as assessed by three physical performance tests regarding the outcome of multidisciplinary treatment in patients with subacute LBP. The need for screening tests with a high predictive ability in order to distinguish patients with from those without a good chance of recovery is evident. The aim of this study was, therefore,

Fig. 2 a–d The results of the three physical performance tests at the three assessment time points (T0–T2) for patients and controls. **a, b** Number of steps and test duration (maximum 180 s). **c, d** Holding time. The mean values and standard deviation are shown

Table 3 Psychometric data

	VAS	PDI	FFbH-R
T0	5.37 ± 1.97	26.66 ± 12.3	64.5 ± 19.14
T1	3.24 ± 2.1**	17.34 ± 12.03**	71.46 ± 19.35**
T2	3.04 ± 2.58**	17.55 ± 14.15**	73.72 ± 21.68**
Therapy success	52.6%	55.5%	55.3%
Pearson correlation			
T0/T1	0.5**	0.47**	0.54**
T0/T2	0.46**	0.43**	0.43**
T1/T2	0.34**	0.38**	0.42**

The average VAS, PDI and functional back capacity index (FFbH-R) values and the correlation analysis between the three assessment time points. The mean values and standard deviation are shown

** $P < 0.001$

to examine whether somatic parameters can serve as such a screening tool. To our knowledge, the prognostic value of these tests regarding the success of multidisciplinary pain treatment has not yet been assessed.

In agreement with other recently published studies, patients' subjective pain perception as assessed by VAS, PDI and FFbH-R improved significantly after treatment, showing the effectiveness of this programme [5, 15, 24]. Improved values were also found at the 6-month follow-up, confirming the long-term effect of the therapy as previously reported [16, 49]. The individual parameters displayed a positive correlation amongst the three assessment time points: higher subjective pain perception at T0

forecast higher pain perception at T1 and T2. This correlation demonstrates that the assessment of subjective pain perception alone already displays a prognostic value for therapy outcome.

The three investigated performance tests have been reported to display good discriminative ability and high reliability [4, 20, 28, 32, 34, 36, 43]. This is in accordance with our results: the control group presented significantly higher outcome values in all performance tests, indicating good discriminative ability of these tests. The performance of the controls displayed no significant change at the different assessment time points, showing good reliability of the tests as previously reported.

The Biering-Sørensen test is an isometric back muscle endurance test and has itself been reported to be a risk factor for NSLBP [4]. The Villiger and Oesch tests do not place any significant load on the lumbar spine or the spinal muscles, and can be considered as general performance tests.

Apart from the Oesch test, patients' performance improved significantly after the multidisciplinary treatment programme and this improvement could still be discerned at the 6-month follow-up, confirming good therapy efficiency with a long-term effect in accordance with subjective parameters of pain perception.

The Biering-Sørensen test displayed a greater difference between patients and healthy controls than the Villiger and Oesch tests. One potential explanation is that the Biering-Sørensen test is the only test assessing the back muscle endurance and places a significant load on the lumbar spine.

Fig. 3 Psychometric data. The average VAS, PDI and functional back capacity index (FFbH-R) values of patients at the three assessment time points. The mean values and standard deviation are shown

Table 4 Correlation analysis

Correlation analysis	Biering–Sørensen test	Villiger test		Oesch test
	Holding time (s)	Number of steps	Test duration (s)	Holding time (s)
VAS/T0	$r = -0.20^*$	$r = -0.26^{**}$	$r = -0.22^{**}$	$r = -0.17^*$
VAS/T1	$r = -0.28^{**}$	$r = -0.43^{**}$	$r = -0.36^{**}$	$r = -0.34^{**}$
VAS/T2	$r = -0.38^{**}$	$r = -0.32$	$r = -0.15$	$r = -0.26^{**}$
FFbH-R/T0	$r = -0.31^{**}$	$r = -0.40^{**}$	$r = -0.36^{**}$	$r = -0.30^{**}$
FFbH-R/T1	$r = -0.40^{**}$	$r = -0.41^{**}$	$r = -0.34^{**}$	$r = -0.33^{**}$
FFbH-R/T2	$r = -0.53^{**}$	$r = -0.54^{**}$	$r = -0.36^{**}$	$r = -0.36^{**}$
PDI/T0	$r = -0.24^*$	$r = -0.4^{**}$	$r = -0.35^{**}$	$r = -0.32^{**}$
PDI/T1	$r = -0.25^*$	$r = -0.37^{**}$	$r = -0.30^{**}$	$r = -0.40^{**}$
PDI/T2	$r = -0.30^{**}$	$r = -0.34^{**}$	$r = -0.33^{**}$	$r = -0.30^{**}$

The coherence of the physical performance tests' scores and the psychometric data was analysed at the three assessment time points, showing a significant negative correlation

** $P < 0.001$, * $P < 0.05$

The individual measures of the physical performance tests displayed a positive correlation between the three time points in patients and controls, indicating that low performance in the tests at study entry was followed by low performance at T1 and T2 (Table 2a–c).

Correlation analysis and discriminant analysis were performed to determine the interrelations and to evaluate the predictive value of these tests regarding therapy outcome. The three performance tests exhibited a significant negative correlation with the psychometric data: lower performance at T0 correlated with higher pain intensity and disability at study entry (T0) and after therapy (T1, T2). Discriminant analysis demonstrated that the outcome values of the three physical tests at T0 did not differ significantly between the two subgroups (therapy success and therapy failure), demonstrating that these tests do not predict therapy outcome. On the basis of the relatively low correlations, the performance tests could serve as cautiously used risk indicators for estimating the effectiveness of multidisciplinary therapy. As described above, the evaluation of subjective pain perception at study entry already displayed a prognostic value for therapy outcome. In this context the assessment of physical parameters did not yield any additional information.

Our data are in accordance with recent studies demonstrating that physical variables such as performance, endurance, or mobility discriminate well between patients

and controls but present a low prognostic value regarding outcome parameters, e.g. return to work [3, 13, 17, 19, 21–23, 35, 37].

Even though these performance tests assess somatic parameters, the inability to perform these tests cannot be explained only by musculoskeletal pathology. The presentation of patients with chronic LBP [33] is strongly affected by psycho-behavioural considerations and thus performance on physical tests is in fact a function of a combination of somatic, behavioural and psychological factors. Thus, low performance may reflect illness behaviour and psychosocial factors. The fact that the Villiger test displayed the same prognostic value as the Biering–Sørensen test, even though they assess different muscle groups, lends support to the theory that these performance tests measure not only musculoskeletal pathology but also patients' motivation and their willingness to meet demands made upon them. This is in accordance with the results of other studies, which concluded that disability in chronic LBP is maintained primarily by factors other than objective medical data [38, 40].

Consequently the improvement in performing these tests after therapy does not only result from a decrease in physical disability owing to exercise. The positive outcome is affected by psychological processes that accompany physical activation, i.e. reduction of fear-avoidance beliefs [39]. Other studies have also shown that improvements

during an exercise regime occur independently of changes in fitness [47], or more rapidly than real changes in muscle size could take place [27].

The fact that physical performance factors were not strongly associated with disability reduction does not mean that exercises are unimportant. The effects of exercise might be related to other factors such as improving self-belief and the challenging of misconceptions [26, 30, 45]. Consequently the therapy of chronic LBP should not only focus on restoration of functional abilities and muscle deficits [55], but also emphasise the positive experiences with activity as a powerful agent to decrease perceptions of a link between disability and pain [25, 42].

In conclusion, our study demonstrates that physical parameters do not have a prognostic value with regard to outcome of treatment. Furthermore, our data confirm that patients' subjective estimation of pain and disability already displays a prognostic value for therapy outcome that cannot be increased significantly by the assessment of physical parameters [50, 53]. This finding makes it questionable whether the administrative burden associated with the assessment of somatic parameters and the conduct of performance tests is worth the small increase in predictability.

As a practical consequence, the evaluation of somatic parameters can be viewed as a procedure to address the somatic complaints of patients and as a platform on which to base interaction and motivation.

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