Chapter 6

Determinants of change in perceived disability of patients with non-specific chronic low back pain

Hodselmans AP
Dijkstra PU
Geertzen JHB
Schiphorst Preuper HR
Schans van der CP

Submitted
Abstract

Purpose:
Change in psychophysical capacity, calculated as the ratio between physical capacity and perceived effort, may be a determinant of change in perceived disability. The aim of this study was to identify determinants for change in perceived disability measured with the Roland Morris Disability Questionnaire (RMDQ) in patients with non-specific chronic low back pain (CLBP) after rehabilitation.

Method:
Data of 84 outpatients were gathered. Psychophysical capacity (psychophysical static leg lift, psychophysical static trunk lift, psychophysical dynamic lifting capacity), physical lifting capacity, perceived lifting effort, aerobic capacity and RMDQ were assessed. Associations between change in RMDQ and potential determinants were calculated. Variables associated with change in RMDQ were entered in a multivariate linear regression analysis (backward).

Results:
Change in psychophysical dynamic lifting capacity (r =-0.53) and psychophysical static trunk lift capacity (r =-0.51) and psychophysical static leg lift capacity (r =-0.23) were significantly associated with change in RMDQ. The RMDQ score at baseline (β=-0.438), change in psychophysical dynamic lifting capacity (β=-0.109), psychophysical static trunk lift capacity (β=-0.038), psychophysical static leg lift capacity (β=-0.012) and static leg lift capacity (β=0.007) all contributed significantly to the regression model (r² =52%).

Conclusion:
Improvements in psychophysical lifting capacity are determinants for a reduction of perceived disability.
Determinants of change in perceived disability of patients with non-specific chronic low back pain

Introduction
Disability due to chronic low back pain (CLBP) continues to be a large problem in western society. Rehabilitation programs have been developed and applied in order to reduce the burden placed on patients and society [1 - 5]. Multi modal rehabilitation programs for patients with CLBP aimed at functional restoration reduce pain, improve function and improve return to work status more effectively than exercises alone, advice, or a waiting list [6,7]. However, until now it is unclear which factors contribute to these improvements. CLBP patients have been found to be deconditioned [8] and as a result of this finding, rehabilitation programs were developed aimed at reconditioning, increasing aerobic capacity, of CLBP patients [9 - 11]. Beneficial effects of these rehabilitation programs have been attributed to an increase in aerobic capacity. In fact these rehabilitation programs and their rationale are based on the biomedical model for chronic low back pain. However, the last decade it became apparent that a cognitive, psychosocial model for low back pain might be more appropriate [12,13]. Moreover, it has been found that the level of aerobic capacity in CLBP patients is not associated with the duration and severity of perceived disability, assessed with the Roland Morris Disability Questionnaire (RMDQ) [8,14]. Additionally, improvements in muscle strength are not related to reductions in perceived disability after a physical rehabilitation program [15]. Despite the significantly increase of physical and aerobic capacity in non-specific CLBP patients the perceived disability in 59% of the patients increased and in 17% did not change [15]. Based on these results it can be questioned whether changes in aerobic capacity and muscle strength can explain the beneficial effects of rehabilitation in CLBP patients.

For a successful treatment of CLBP a reduction of subjective feelings of disability and an appropriate perceived effort of physical activities is most important [16]. Additionally, if the perceived effort (Borg score) is high the risk for non-specific CLBP is substantially higher than when the perceived effort is low [17,18]. To assess change in perceived effort in non-specific CLBP patients, a new measure was introduced: Psychophysical lifting capacity, which is calculated as the ratio between physical capacity expressed in Newton (N) and perceived effort expressed in Borg score (B) [19 - 21]. This ratio takes into account both, physical capacity and perceived effort. Different measures of psychophysical lifting capacity were in non-specific CLBP patients significantly lower compared to healthy subjects [20]. In addition, change in psychophysical static trunk lift was significantly related with change in perceived disability assessed with the RMDQ ($r = -0.74$) [19]. On the basis of these results, we hypothesize that improvements in psychophysical capacity may be determinants for reduction of perceived disability measured with the
RMDQ in patients with non-specific CLBP, after rehabilitation. The aim of this study was to identify determinants for change in perceived disability measured with the RMDQ.

**Methods**

Data of 84 outpatients diagnosed with non-specific CLBP were included in this historical cohort study. The mean (sd) age of the patients was 39 (10) years and 41 (48.8%) patients were women. The mean (sd) height was 1.77 (0.09) meters, weight 82.1 (15.7) kg and lean body mass was 55.9 (12.1) kg. The mean (sd) duration of complaints was 63.1 (67.1) and sporting hours per week was 1.6 (0.7) months prior to the rehabilitation. The data were collected at the University Medical Centre Groningen, the Netherlands, as part of routine assessment of the patients prior to and after the rehabilitation program. The Medical Ethical Committee of the University Medical Centre of Groningen approved the collection of data in the present study.

Prior to the rehabilitation program patients were assessed by a rehabilitation physician. The patients who participated in the rehabilitation program were between 18 to 65 years of age and were suffering from low back pain for at least three months. The rehabilitation physician used general admittance criteria 1) CLBP (i.e., pain lasting for more than 3 months, LBP without shown organic substrate); and 2) patients were content with the diagnostic process and motivated for the rehabilitation program. Patients were excluded for rehabilitation if 1) they had specific low back pathology, co-morbidity, pregnancy and psychopathology; 2) they had a medical condition that could interfere with physical performance tests such as; major surgery within the previous year, existing infectious disease, cancer, neuralgic or cardiovascular disease; 3) they were in a financially profitable situation caused by their illness; and 4) they were in a conflict situation with employer or insurance company. Patients were assessed twice by a physical therapist; before starting the rehabilitation program, intake (T1), and after completion of the program, the evaluation (T2). The rehabilitation program was a cognitive somatic back school program aimed at improving the patients’ ability, to solve the problem at hand (a physical demanding task) on the basis of the patient’s skill, physical capacity and knowledge to react appropriate on physical symptoms. The cognitive somatic rehabilitation program consisted of 1) education according to the bio-mechanical principles of correct posture, lifting and other activities and education concerning self-treatment of the lower back [22]; 2) education to gain insight into perception of physical symptoms that occur during exposure of physical activities and to learn to react appropriately to these physical symptoms; 3) education concerning overload mechanisms by explaining the influence of
Determinants of change in perceived disability of patients with non-specific chronic low back pain

bio-mechanical and psychosocial factors. Duration and frequency is adjusted to the patient’s need [19]. The mean duration (sd) is 4.1(1.6) months with a mean frequency of 13.1 (6.5) visits of 1 hour.

**Assessments**

**Aerobic capacity**

A Lean Body Mass (LBM)-based Åstrand submaximal bicycle test was performed to estimate aerobic capacity; \( VO_2 \) max in ml/min kg LBM [8,19,20]. We have chosen for the standard LBM-based Åstrand bicycle test of the cognitive somatic rehabilitation program because cycling is a common activity in the Netherlands and the test is reliable and valid [23]. LBM was measured according to the Durnin and Womersly protocol using a skinfold calliper (A) [19,23,24]. The subjects performed the test on a calibrated Cycle ergo meter (B). Heart rate was recorded using a monitor connected to electrodes on the patient’s chest (C). The subjects started cycling under a predetermined workload of 0.5 W/kg LBM at a constant rate of 60 rpm. After 2 minutes cycling the workload was increased to 1.5 W/kg LBM. If the heart rate (HR) remained below 120 beats/min the workload was increased by 0.5 W/kg LBM every 2 minutes. Once HR exceeded 120 beats/min, the patient cycled 6 minutes under a fixed workload to reach a steady state phase, meaning that HR did not vary more than ± 5 beats/min during the final 2 minutes of exercise. The mean heart rate during the final 2 minutes of exercise was calculated. The \( VO_2 \) max was estimated using the Binkhorst calculation based on the linear association between HR and increase in oxygen uptake, for men and women [19, 20, 23, 25].

\[
\begin{align*}
VO_2 \text{ max (men)} &= \frac{174.2 \times \text{load Watts} + 4020}{103.2 \times \text{heart rate} - 6299} \\
VO_2 \text{ max (women)} &= \frac{163.8 \times \text{load Watts} + 3780}{104.4 \times \text{heart rate} - 7514}
\end{align*}
\]

The calculated \( VO_2 \) max was corrected for age using the age correction factor according to Åstrand [26]. The test was terminated if the subject did not attain a heart rate of at least 120 beats/min, if the HR exceeded the predetermined maximum (220-age * 0.85), if the systolic/diastolic blood pressure reached a level of 220/115 mm Hg, or if the subject showed signs of serious cardiovascular or pulmonary difficulties. After 6 minutes cycling under a fixed workload, the load decreased...
over 1 minute to 0.25 W/kg LBM and the subject cycled for 1 minute under this workload of 0.25 W/kg LBM.

**Psychophysical static lifting capacity tests**
The psychophysical static lift capacity test was performed by pulling up a horizontal bar connected to a pillar which is adjustable in height [19]. The vertical force was measured with a force transducer (D) and was registered on a plotter (E). Two static lifting tests, the leg lift and trunk lift, described by Chaffin were performed [27]. During the trunk lift the horizontal distance between patient and horizontal bar was 375 mm. The horizontal distance for the leg lift was 0 mm. The vertical distance was during the leg lift and trunk lift 500 mm. In case of the psychophysical approach the patient is in control and determines which termination is acceptable. The patient was instructed to stop the test when the patient believes the acceptable maximal effort (AME) was reached and a Borg score (range 0.5 – 10) was recorded directly after reaching the AME of the static lifting tests [17,19,20,21,28,29]. The Borg score was modified by changing the 0 score in 0.5 which corresponds to not at all, 1=very light, 2=light, 3=moderate, 4=slightly heavy, 5=heavy, 6=less than 7, 7=very heavy, 8 =less than 9, 9=less than 10, 10=very terrible heavy (almost maximum). The psychophysical static lifting capacity was calculated as the ratio of physical lifting capacity and the Borg score by the formula AME divide by the perceived effort expressed in Newton/Borg (N/B) [19,20]. The rehabilitation professional can determine whether the perceived effort score of the patient agrees with the AME. So a high psychophysical capacity reflects low to normal perception relative to the actual AME; a low psychophysical capacity reflects a high perceived effort relative to the actual AME. The test is a reliable measurement in patients with non-specific CLBP [20].

**Psychophysical dynamic lifting capacity test**
To measure the psychophysical dynamic lifting capacity, the standardized Progressive Isoinertial Lifting Evaluation (PILE) protocol, described by Mayer was used [30, 31]. During 20 s the patient had to lift a box with weights, four times from the ground on to a table. Stepwise, after each session, during the 20 s rest, the weight of the box increased with 2.25 kg for women and 4.5 kg for men respectively. Heart rate was measured (F) [19,20]. The observer stopped the test when the patient had reached the heart rate safety limit (220 - age x 85%) [19,20,32]. The patient was instructed to stop the physical lifting capacity test when the AME was reached [19,20,21]. Perceived lifting effort was recorded directly after reaching the AME, the cardiac safety limit (formula 220 - age x 85%) or the ceiling of the test of 402 N [32,33]. The psychophysical
dynamic lifting capacity was calculated as the ratio of physical lifting capacity and Borg score, expressed in Newton/Borg (N/B) [19,20]. The test is a reliable measurement in non-specific CLBP patients [20].

**Perceived disability**

Perceived disability was assessed by means of the Roland Morris Disability Questionnaire (RMDQ) [34,35]. The RMDQ is frequently used in studies of CLBP and is reliable, valid, and sensitive in persons with CLBP [34 - 36]. It provides an assessment of a patient’s specific perceived disability with scores expressed on a scale from 0 (no perceived disability) to 24 (maximal perceived disability) [36].

<table>
<thead>
<tr>
<th>Table I: Outcome variables before treatment, after treatment, change between T1 and T2 and the effect size (n=84)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Variables</strong></td>
</tr>
<tr>
<td>LBM-based Åstrand (ml/kg LBM * min⁻¹)</td>
</tr>
<tr>
<td>Psychophysical static Leg lift (N/B)</td>
</tr>
<tr>
<td>Psychophysical static Trunk lift (N/B)</td>
</tr>
<tr>
<td>Psychophysical dynamic PILE (N/B)</td>
</tr>
<tr>
<td>Static Leg lift (Newton)</td>
</tr>
<tr>
<td>Static Trunk lift (Newton)</td>
</tr>
<tr>
<td>Dynamic PILE (Newton)</td>
</tr>
<tr>
<td>Borg score Leg lift</td>
</tr>
<tr>
<td>Borg score Trunk lift</td>
</tr>
<tr>
<td>Borg score PILE</td>
</tr>
<tr>
<td>RMDQ</td>
</tr>
</tbody>
</table>

*T1: measurement before treatment, T2: measurement after treatment, ∆: change between T2 and T1 ( T2 - T1), ES: effect size, sd: standard deviation, LBM: Lean Body Mass, N/B: Newton/Borg score, PILE: progressive isoinertial lifting evaluation, RMDQ: Roland Morris Disability Questionnaire

Results of paired sample t-test: *: P < 0.01, **: P < 0.001.
Data analysis
Descriptive statistics were calculated for the scores of the two test-sessions. Kolomogorov-Smirnov test revealed no significant differences from the normal distribution. Changes in scores between T1 and T2 were analyzed using t-tests for dependent samples. Effect sizes (ES) were calculated as mean change/sdT1 [37, 38]. Pearson’s correlation between change in RMDQ score and the measurement results of T1 (aerobic capacity, psychophysical lifting capacity, physical lifting capacity and Borg scores) and the changes scores of these measurements were calculated.

In a multivariate linear regression analysis (backward), variables significantly associated with the change in RMDQ scores were entered as potential predictors for the change in RMDQ (outcome). Data analyses were performed using the Statistical Package of Social Sciences (SPSS 14.0). \( \alpha \leq 0.05 \) was considered significant.

Results
Psychophysical lifting capacity, aerobic capacity, physical lifting capacity, perceived lifting effort and RMDQ scores improved significantly \( (p<0.001) \) after completion of the rehabilitation program (Table I). The ES for RMDQ scores was 1.35 and the average of reduction was 5.4 points. The ES for the psychophysical static leg lift capacity, psychophysical static trunk lift capacity, psychophysical dynamic lifting capacity (PILE) and aerobic capacity ranged between 0.36 and 0.62. The ES for the physical static leg lift capacity, static trunk lift capacity and dynamic lifting capacity (PILE) ranged between 0.22 and 0.43 (Table I).

Psychophysical static leg lift capacity increased in 71\% of the patients, psychophysical static trunk lift capacity in 81\% of the patients and psychophysical dynamic lifting capacity in 78\% of the patients. The majority of the patients increased in psychophysical lifting capacity by an increase in physical lifting capacity without change in perceived physical effort or an increase in physical lifting capacity with a decrease in perceived physical effort. The correlations between changes in RMDQ and changes in psychophysical lifting capacity were all significant (Table II) with the strongest correlation being with the change in psychophysical dynamic lifting capacity \( (r = -0.528) \). Table III summarizes the results of the regression analysis. The following predictors contributed significantly to the regression equation; RMDQ score at baseline, change in psychophysical dynamic lifting capacity, change in psychophysical static trunk lift capacity, change in psychophysical static leg lift capacity, and change in static leg lift capacity \( (r^2 \text{ of the model 52\%}) \).
Determinants of change in perceived disability of patients with non-specific chronic low back pain

Table II: Pearson correlation coefficients between change in Roland Morris Disability Questionnaire scores and patient characteristics, T1 scores of RMDQ, LBM-based Åstrand submaximal bicycle test and psychophysical capacity, physical capacity tests, Borg scores and change values of these variables.

<table>
<thead>
<tr>
<th></th>
<th>Δ RMDQ</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>0.190</td>
</tr>
<tr>
<td>Gender</td>
<td>0.214</td>
</tr>
<tr>
<td>Duration complaints in months</td>
<td>0.034</td>
</tr>
<tr>
<td>Total number of therapy</td>
<td>0.004</td>
</tr>
<tr>
<td>Duration therapy in months</td>
<td>0.014</td>
</tr>
<tr>
<td>T1 RMDQ</td>
<td>-0.367**</td>
</tr>
</tbody>
</table>

T1 LBM-based Åstrand ml/kg LBM * min⁻¹ | 0.213  
T1 Psychophysical static Leg lift (N/B) | -0.103 
T1 Psychophysical static Trunk lift (N/B) | -0.057 
T1 Psychophysical dynamic PILE (N/B) | -0.080 

Δ LBM-based Åstrand ml/kg LBM * min⁻¹ | 0.017 
Δ Psychophysical static Leg lift (N/B) | -0.238* 
Δ Psychophysical static Trunk lift (N/B) | -0.509** 
Δ Psychophysical dynamic PILE (N/B) | -0.528** 

T1 static Leg lift (Newton) | -0.231* 
T1 static Trunk lift (Newton) | -0.182 
T1 dynamic PILE (Newton) | 0.029 

Δ static Leg lift (Newton) | -0.013 
Δ static Trunk lift (Newton) | -0.273* 
Δ dynamic PILE (Newton) | -0.422** 

T1 Borg score static Leg lift | -0.094 
T1 Borg score static Trunk lift | 0.007 
T1 Borg score dynamic PILE | -0.041 

Δ Borg score static Leg lift | 0.287** 
Δ Borg score static Trunk lift | 0.437** 
Δ Borg score dynamic PILE | 0.162 

Δ: T2 – T1, RMDQ: Roland Morris Disability Questionnaire, LBM: Lean Body Mass, N/B: Newton/Borg score, PILE: progressive isoinertial lifting evaluation, *: P < 0.05, **: P < 0.01.
Discussion
The results of our study support the hypothesis that improvements in perceived disability of patients with non-specific CLBP after a cognitive somatic rehabilitation are related to improvements in psychophysical capacity. The regression equation explained 52% of variance in change of perceived disability (RMDQ) after rehabilitation and the improvements in psychophysical lifting capacities are the predictors next to the strongest determinant the initial RMDQ score. Interaction effects of the static leg and trunk lift capacity, dynamic lift capacity and the Borg score were explored but did not contribute significantly to the regression equation. This means that a high initial perceived disability (RMDQ) in non-specific CLBP patients explains partly the change in RMDQ. Nevertheless, rehabilitation professionals can only influence psychophysical capacity and not the initial score of the RMDQ. Clinically, these findings indicate that rehabilitation programs should focus on improving psychophysical capacity rather than solely on physical capacity or aerobic capacity to reduce perceived disability (RMDQ). In a previous study we also have found that the improvement in psychophysical static trunk lift had a significantly association with a decrease in perceived disability and the coefficient of determination was moderate [19]. Physical trunk lift capacity was not associated with a decrease in perceived disability [19]. The results are similar, corroborating and strengthening the findings. In addition, in a previous study we found that change in social function and change in emotional disability were not associated with change in RMDQ [19]. This supports that there is no reason to believe that there is a strong potential for bias by the subjects reporting in a negative or positive manner or both.

The explanation is that psychophysical capacity and perceived disability (RMDQ) both measure a part of perception of activity that load the lower back. Because psychophysical capacity is a ratio between exposure and perception of that exposure that load the lower back and the RMDQ is an instrument which measures disability due to low back pain. Furthermore, the majority of the patient’s psychophysical capacity increased. This means that the perceived effort is decreased relative to the physical lifting capacity resulting in an increased psychophysical capacity and larger effect sizes of psychophysical lifting capacity than the effect sizes of physical lifting capacity.

The increased physical lifting capacity and aerobic capacity in our study cannot be attributed to physiological training principles by the rehabilitation program, because the frequency of rehabilitation sessions was less than once per week on average. The increased physical lifting capacity and aerobic capacity in patients is probably based on the fact that patients do more activities at home and at work, as a result of the
Determinants of change in perceived disability of patients with non-specific chronic low back pain

rehabilitation program, which induces physiological training effects in lifting and endurance. Support of this statement is that the actual physical activity in daily living (PAL) in non-specific CLBP patients is less than their habitual PAL resulting in deconditioning [39]. The philosophy of our cognitive somatic rehabilitation is that recondition is attributable to functioning included PAL. In a previous study we have found that the cognitive somatic rehabilitation improves functioning assessed with the RAND-36 [19].

Table III: Results of stepwise regression analysis (backward) with change in Roland Morris Disability Questionnaire scores as outcome variable

<table>
<thead>
<tr>
<th>Predictors</th>
<th>Beta</th>
<th>95% CI</th>
<th>Explained variance (r²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1 RMDQ</td>
<td>-0.438</td>
<td>-0.632 to -0.243</td>
<td></td>
</tr>
<tr>
<td>Δ Psychophysical dynamic PILE (N/B)</td>
<td>-0.109</td>
<td>-0.159 to -0.058</td>
<td></td>
</tr>
<tr>
<td>Δ Psychophysical static Trunk lift (N/B)</td>
<td>-0.038</td>
<td>-0.058 to -0.018</td>
<td></td>
</tr>
<tr>
<td>Δ Psychophysical static Leg lift (N/B)</td>
<td>-0.012</td>
<td>-0.023 to -0.001</td>
<td></td>
</tr>
<tr>
<td>Δ static Leg lift (Newton)</td>
<td>0.007</td>
<td>0.001 to 0.013</td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>1.938</td>
<td>-0.510 to 4.387</td>
<td></td>
</tr>
</tbody>
</table>

95% CI: 95% confidence interval RMDQ: Roland Morris Disability Questionnaire, Δ: T2 - T1, PILE: progressive isoinertial lifting evaluation, N/B: Newton/ Borg score.

In contrast to what was expected, change in physical static leg lift capacity contributed negatively to the reduction in perceived disability. Thus an increase in physical static leg lift capacity resulted in a poorer perceived disability. This effect of the physical static leg lift capacity cannot be explained adequately. However, this effect was very small and it contributed very little to the explained variance (0.02%). Change in perceived disability correlated stronger with the change in psychophysical static trunk lift and psychophysical dynamic lifting than with change in psychophysical static leg lift probably because the RMDQ assesses perceived disability of the lower back and not perceived disability of the legs.

The effect size of the RMDQ scores was 1.35, indicating a
considerable clinically relevant reduction in perceived disability [40]. Additionally 49% of the patients exceeded the limits of agreement of ± 5.4 for RMDQ scores [36]. This considerable reduction in perceived disability provides evidence that a successful treatment in non-specific CLBP was achieved. The mean improvement of 5.4 points is substantially higher compared to mean improvements after active physical treatment (2.2), cognitive behavioural treatment (2.6) and a combination treatment consisting of physical and cognitive behavioural treatment (2.2) [5]. Return to work in CLBP patients is predominantly determined by the level of perceived disability [41]. Therefore, our rehabilitation program may have contributed to return to work in a considerable number of patients. However, a limitation of our study is that we were not able to gather these data because of the historical character of the study.

The results of the current study can be generalized to the population of chronic low back pain patients. The characteristics of the patients regarding duration of complaints and perceived disability score in the current study are similar to those found in other studies on chronic low back pain. Mean duration of complaints was 63 months in the current study while in other studies the mean duration was 62 months [8], 57 months [5], 68 months [5], and 56 months [5]. Mean RMDQ score at baseline in the current study was 11.5 while in other studies these scores were 10.2 [14], 14.2 [8], 14.1 [5], 13.7 [5], and 13.5 [5]. In conclusion, improvements in three psychophysical lifting capacity tests are determinants for a reduction of perceived disability (RMDQ).
Determinants of change in perceived disability of patients with non-specific chronic low back pain

References


Determinants of change in perceived disability of patients with non-specific chronic low back pain

41. Faber E, Burdorf A, Bierma-Zeinstra SMA, Miedema HS, Koes BW. Determinants for improvement in different back pain

**Suppliers**
A. Servier Nederland B.V., Leiden, the Netherlands.
B. Excalibur Sport, Lode B.V., Groningen, the Netherlands.
C. Polar Favour, Kempele, Finland.
D. EBN 8500-1250, Depex type brosia; GmbH & Co, Tettnang, Germany, range 0 to 2500 N; linearity 0.02% and an amplifier, (Elan-Schaltelemente MBP 6218; Kurt Maecker GmbH, Neuss 1, Germany, range 500 µm/m to 5000 µm/m.
E. PM 8043 Eindhoven, The Netherlands, range 2 mV/cm to 1V/cm.
F. Sport tester PE-3000; Polar Electro, Kempele, Finland.