

2013•2014  
FACULTEIT GENEESKUNDE EN LEVENSWETENSCHAPPEN  
*master in de revalidatiewetenschappen en de  
kinesitherapie*

## Masterproef

Technology-supported rehabilitation for patients with chronic non-specific low back pain. Preliminary results of a pilot study

Promotor :  
Prof. dr. Annick TIMMERMANS

Copromotor :  
De heer Thomas MATHEVE

Sanne Van Genechten , Lien Vanherle  
*Proefschrift ingediend tot het behalen van de graad van master in de  
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Mol, 25 June 2014

Bilzen, 25 June 2014

S.V.G. & L.V.



## **BACKGROUND**

This master thesis is a pilot study which can be situated in the musculoskeletal rehabilitation. It more specifically discusses technology-supported rehabilitation in case of chronic non-specific low back pain (CNSLBP). This study follows the literature study which was carried out last year. It's part of a PhD by Thomas Matheve.

The study has been carried out in the 'Jessa Hospital' (Hasselt) in cooperation with 'Hocoma' (Zurich) by two students in Physiotherapy and rehabilitation sciences.

Despite the fact that there has already been a large number of treatment possibilities for CNSLBP, it remains a common and widespread health related problem. Chronic non-specific low back pain has a large influence on the daily activities and functioning. The prevalence is about 10-20%.<sup>1</sup> In that respect, it is important that further research and studies will be carried out regarding possible treatments.

This study examines the influence of an 18 week lasting technology-supported rehabilitation programme in which postural biofeedback was used in patients with CNSLBP, on pain, disability, quality of life, motivation, credibility and expectancy. Rehabilitation is done in a game-like environment through two motion sensors are attached on the low back.

If the results of the pilot study are promising and if there are no side effects, a randomized controlled trial (RCT) will be carried out by Thomas Matheve.

In advance, the co-promoter had developed the study protocol. The students read this and completed it if necessary. Remarks were formulated and adapted after consideration.

The recruitment of patients was done in association with the co-promoter. Under the supervision of their co-promoter the students carried out the patient history and physical examination. Based on the results, it was decided whether a patient was to be included or not.

Apart from that, the students also supervised and coached the patients during their rehabilitation.

The input of data happened independently of each other in order to prevent possible mistakes and bias. The analysis and interpretation of the data was also described independently of each other.

After this phase, the students compared all the information and assembled it to one work. The students were responsible for the complete writing process, being supervised by their co-promoter.



**Technology-supported rehabilitation for patients  
with chronic non-specific low back pain**  
Preliminary results of a pilot study

HASSELT, 2014

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“Drawn up according to the guidelines of ‘Spine’: <http://edmqr.ovid.com/spine/accounts/ifauth.htm>”





## **ABSTRACT**

**Study Design:** Pilot study.

**Objective:** The aim of this study was to assess the influence of an 18 week lasting technology-supported rehabilitation programme in which postural biofeedback was used in patients with CNSLBP.

**Summary of Background Data:** Previous studies on technology-supported rehabilitation for CNSLBP mostly used analytical exercises. This study aims to incorporate technology into functional exercises.

**Methods:** Four patients participated in a standard therapy consisting of cardio training, learning neutral position of the back, pelvic movements, strengthening and functional exercises and a technology-supported rehabilitation programme consisting of playing games controlled by pelvic movements in different directions. In addition functional exercises and posture corrections were performed with feedback support.

**Results:** Patient one's pain intensity, mental component of the Short Form-36 (SF-36), motivation, credibility and expectancy stayed almost identical as compared with baseline. The patients' physical component of the SF-36 increased and experienced less disability.

Patient two had a minimal clinical important difference (MCID) in pain intensity and disability. The patient improved in the physical component of the SF-36 and slightly increased in motivation. The mental component of the SF-36, credibility and expectancy stayed almost the same.

Patient three had no improvements. The patients' pain intensity, physical component of the SF-36, motivation stayed almost the same. The patient had an increase in disability and decrease in the mental component of the SF-36, credibility and expectancy.

Patient four's pain intensity and quality of life stayed almost identical. The patient increased in disability, credibility and expectancy and slightly increased in motivation.

**Conclusions:** There is a positive trend in several outcome measures and there are no side effects. Therefore the criteria for an RCT are achieved.

**Key Words:** Chronic non-specific low back pain, technology-supported rehabilitation, exercise therapy, postural biofeedback, sensor technology, motivation, quality of life, pain, disability, credibility, expectancy

**Level of evidence:** 2C



## INTRODUCTION

Chronic low back pain (CLBP) is a common health related problem. Ten to twenty percent of the population develops CLBP in the course of life.<sup>1</sup> CLBP has a major impact on the daily functioning and is one of the main reasons for work absenteeism, which leads to high economic and health expenses.<sup>2</sup>

In the rehabilitation of patients with CLBP, exercise therapy within a bio-psychosocial framework can be considered as a very important aspect.<sup>3</sup> This approach may contribute to positive effects on pain, function and quality of life, resulting in a decrease of the financial costs related to long-term illness.<sup>4,5</sup> Despite these positive effects, there still is only little evidence to conclude which sort of exercise programme leads to the best results<sup>6</sup> and thus, CLBP remains one of the most difficult clinical problems to be treated.<sup>7</sup> Due to the growing pressure on the health system, innovative approaches are considered to be fundamental to meet the high and ever increasing care needs.<sup>4,5,8</sup>

In this respect, technology-supported rehabilitation may have an important role by offering an individual exercise programme according to a functional approach. There are several forms of technology-supported rehabilitation methods. For instance, whole body vibration<sup>9,10</sup> and internet-mediated programmes<sup>11,12</sup> have been used in CLBP rehabilitation. In neurological rehabilitation robotics, virtual reality and sensor technology<sup>13-20</sup> are being used.

Technology can offer several possibilities in the rehabilitation of patients with CLBP. Doing so, more training variability will be possible, the patient can receive specific and direct feedback from digital data and there can be a better motivation.<sup>21</sup>

In most cases, patients with low back pain (LBP) have a disturbed intrinsic feedback system<sup>22-24</sup> with a changed muscle reaction<sup>25,26</sup>, a disturbance in the postural control mechanisms<sup>27</sup> and a decreased lumbar-sacral position sense.<sup>28</sup> These changed mechanisms can play a role in maintaining the symptoms and the motor control problems.<sup>23,29,30</sup> The rehabilitation of this sensorial feedback and motor control can form an important part in the rehabilitation of patients with CLBP.<sup>31,32</sup>

A common strategy to restore motor control, is offering extrinsic feedback.<sup>33</sup> "Extrinsic feedback is defined as information from an external source such as another person or an instrument", while "Intrinsic feedback is defined as information of the sensory system".<sup>34</sup>

Magnusson, Chow and Diamandopoulos et al<sup>35</sup> for instance, does research on postural biofeedback through a computer target programme. Patients receive information about three forms of feedback, i.e. visual feedback, auditory feedback and success rates response.<sup>35</sup> Using this feedback and by means of movements of the back, the patients have to match an icon with a target on the computer screen.<sup>35</sup>

Henry and Teyhen<sup>36</sup> does research on real-time ultrasound feedback in order to visualize the contraction of the M.transversus abdominus and the M.multifidus.

Also electromyography (EMG) biofeedback is a possibility. By means of this feedback, patients learn to decrease the tension of the lumbar paraspinal muscles<sup>37-39</sup> or to strengthen these muscles.<sup>40</sup>

In most of the above mentioned studies, only analytical exercises had been used.<sup>9,10,36-40</sup> As obtaining motor control is a task specific skill, the isolated training of a component of the movement might not be as useful as training of the functional task itself.<sup>41-43</sup>

In this respect, it is important to do additional research concerning technology-supported rehabilitation by means of a functional approach.

The aim of this study is to assess the influence of an 18 week lasting technology-supported rehabilitation programme in which postural biofeedback is used in patients with CNSLBP. The most important outcome measures are pain, disability and quality of life. Additionally, the effects on motivation of the patients and the credibility and expectancy of the programme will be measured. This can be important because, according to Smeets et al<sup>44</sup>, the treatment expectations and the credibility can be linked to the treatment outcomes in case of LBP.

## MATERIALS AND METHODS

### Recruitment

Patients were recruited in the 'Jessa Hospital', campus Virga Jessa at the department of Physical Medicine and Rehabilitation. First of all, the patients were examined by a physical medicine specialist and subsequently by a physiotherapist.

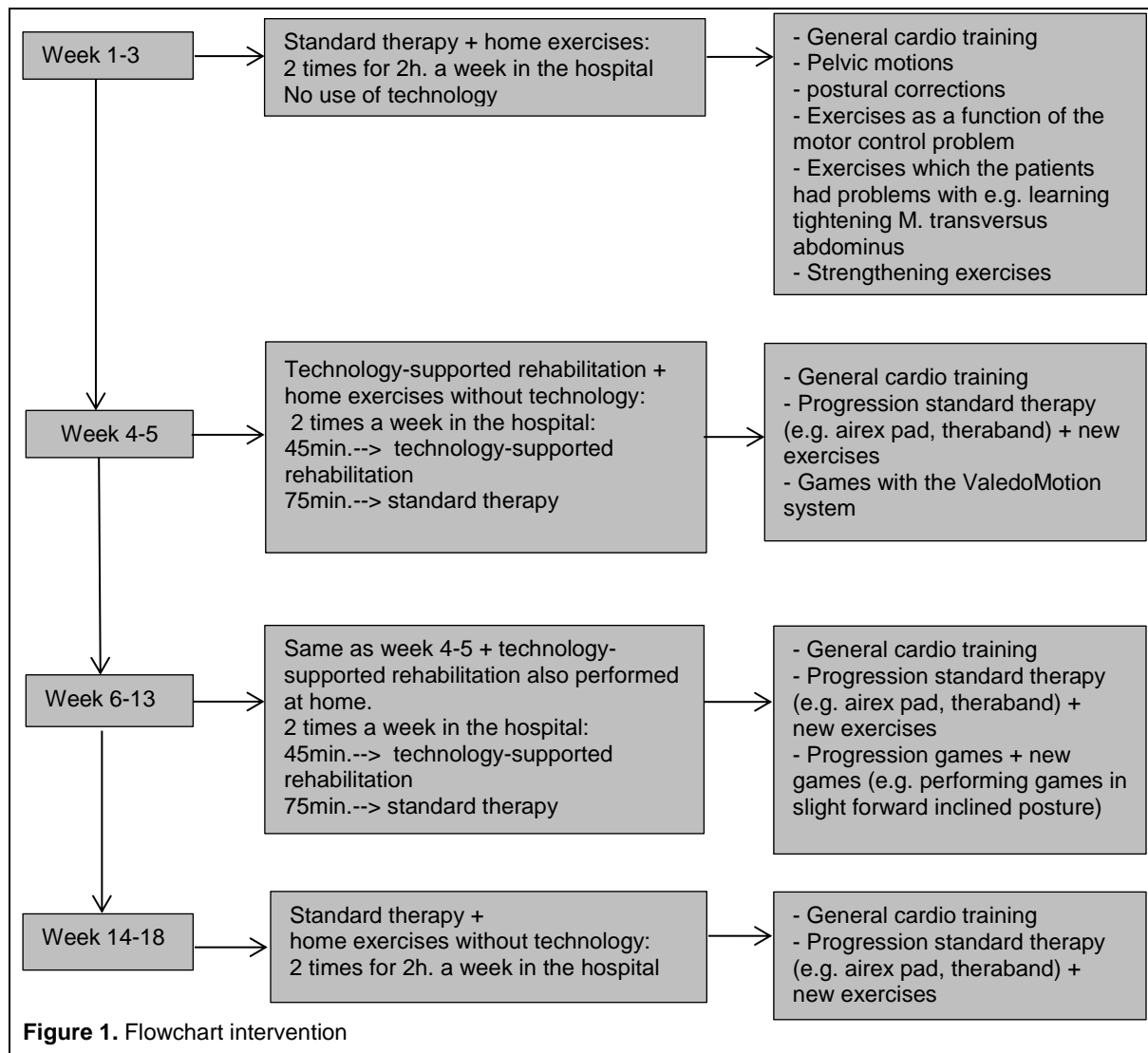
The physiotherapists carried out a patient history. The patient history consisted of specific questions in order to form a clear picture of the patient. Also a clinical examination was carried out, consisting of an inspection, active and passive examination and motor control tests. The motor control test protocol according to Luomajoki et al<sup>45</sup> consists of the waiter's bow, posterior pelvic tilt, one leg stance, sitting knee extension, backward and forward rocking and prone knee flexion. After the individual screening it was decided whether the patients measured up to the inclusion criteria and whether they did not include any exclusion criteria. These are described in table 1. If the patients met the inclusion criteria, they were informed about the study.

All patients signed an informed consent before being included in the study.

<b>Table 1. Inclusion and exclusion criteria</b>
<b>Inclusion criteria</b>
Chronic non-specific low back pain defined as pain between the low ribs and the gluteal region, with or without radiating pain in the legs for at least 3 months
Age between 18-65 year
Sufficient knowledge of the Dutch language
≥ 3 positive motor control tests examined by the physiotherapist according to test protocol Luomajoki. <sup>45</sup>
<b>Exclusion criteria</b>
Operation of the back in the past
Pregnant or recently been pregnant (till 1 year postpartum)
Signs or symptoms of nerve root compression
Confirmed or supposed severe pathology (i.e. fractures, tumors, neurologic disorders, inflammatory illnesses)
Known allergy for tape

## Intervention

The patients participated in an 18 week lasting technology-supported rehabilitation programme as described in figure 1. Based on the results of the examination, it was described whether the patient had a motor control problem towards flexion, extension, rotation or a combination of these. Based on these results an individual rehabilitation programme was made. The patients performed their individual rehabilitation programme twice a week for two hours (h.) in the exercise room of the hospital, under partial supervision of the physiotherapists being available. The patients received a brochure with a detailed description and pictures of the exercises and they were asked to practise daily at home.



STANDARD THERAPY was a multidisciplinary therapy that consisted of exercise therapy and back school. This back school programme existed of five sessions in which psychological advice, ergonomic advice and information on anatomy was given. If the patient required more information, they could always rely on the advice of the complete team of therapists.

The exercise therapy consisted of general cardio training like cycling and cross trainer and an individual programme. This exercise programme was composed after the individual screening and was based on the principles of O'sullivan, Sahrman and Comerford and Mottram.<sup>32,46,47</sup> For each patient the programme started with the awareness of a neutral position of the lumbar spine (LS), followed by learning how to do pelvic movements. If the patient had become aware of the neutral position, specific situations were dealt with such as reaching out to and picking up an object through segmentation.<sup>48</sup> Consequently, specific exercises were chosen within the scope of the motor control problem. For instance, with a motor control problem towards flexion, was worked by means of the standing bow. In case of related problems such as difficulties with tightening the M. transversus abdominus, extra exercises were taught. If necessary, also strengthening exercises were added to the programme.

In a further phase, progressions or new exercises were used. For example, a weight could be added or exercises could be carried out on an unstable surface. It was individually evaluated in case of which functional tasks the patient mentioned pain, for instance in case of cleaning the windows. The patient was taught to keep the LS in a neutral position during these tasks.

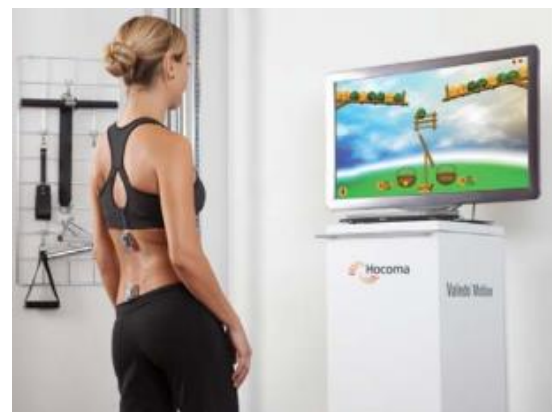
Home exercises were also a part of the standard therapy. The patients were able to carry out the exercises at home using the brochure.

TECHNOLOGY-SUPPORTED REHABILITATION was a continuation of the standard therapy by means of playing games and providing feedback.

The technology used was the ValedoMotion system.<sup>49</sup> The ValedoMotion system uses two motion sensors that are attached with tape, respectively at the level of L1 and S1. These sensors are connected to a computer that registers movements at the level of L1-S1. The device offered two possibilities.

The first possibility was playing games which were controlled by pelvic movements in different directions. The patient was for instance asked to guide the fruit into the correct basket by means of making pelvic movements illustrated in figure 2. Movements of S1 with respect to L1 were used in order to teach the patient to dissociate between low lumbar and high lumbar. In this case, the patient had to steady L1 (high lumbar) while moving S1 (low lumbar).

If the patient did not do the exercise correctly, they obtained a lower score on this game. During this task, extrinsic feedback was being used, i.e. visual, auditive and success rate response. This was given constantly and simultaneously.



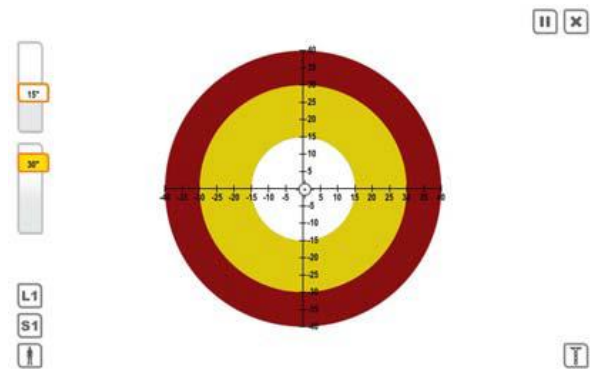
**Figure 2.** Fruits



In a later phase, the degree of difficulty was increased or a more difficult position while carrying out the game was asked. For example, the patient had to play the game in a slight forward inclined position. Also more difficult games were added where the patient had to move in several planes, such as pelvic movement in the sagittal and frontal plane.

In the second possibility, the patient was able to do the same functional exercises and posture corrections as during the standard therapy, but with feedback support.

While doing the exercises, the patient could see a circle and a cursor on the computer screen that represented the movement of the LS as illustrated in figure 3. The goal was to keep the cursor in the middle of the circle, this way indicating the neutral, least loaded posture. If the cursor was moving far away from the central position, the patient could hear a noise. This meant that the patient had too much flexion/extension at the level of the LS. This way, the patient was able to correct himself, thus moving the cursor back to the centre of the circle. Doing so, the patient tried to get control over the LS while doing analytical and functional exercises.



**Figure 3.** Circle cursor

In case of this possibility the exercises were made increasingly more difficult by adapting the timing of feedback, from simultaneous to terminal and less frequent feedback. This way, the patient was stimulated to make more use of the intrinsic feedback. Also new exercises were added as described in the progressions of the standard therapy.

The exercises that could not be trained with the ValedoMotion system were still being done during the standard therapy. The strengthening exercises in supine position, for example, were carried out during the standard therapy. Exercises in supine position were not possible because the sensors were placed on the back. Home exercises were also a part of the technology-supported rehabilitation. The patients could take the technology-supported system home. Using the manual, the patients were able to do the exercises at home.

## Data collection

At the beginning of the study, patients were asked to complete questions including: gender, age, length and weight, level of education, start of low back pain and skills of computer/laptop/tablet or smartphone.

Data of the measuring instruments were assessed at the beginning of the rehabilitation, after three weeks, eight weeks, 13 weeks and 18 weeks. Subsequently, a follow-up measurement will be carried out six months after ending the rehabilitation (table 2). The data were processed independently in order to prevent possible mistakes.

<b>Table 2. Measurements</b>						
	<b>T0</b>	<b>T1</b>	<b>T2</b>	<b>T3</b>	<b>T4</b>	<b>T5</b>
<b>NPRS</b>	X	X	X	X	X	X
<b>Patient satisfaction</b>		X	X	X	X	X
<b>PSEQ</b>	X	X	X	X	X	X
<b>RMDQ</b>	X	X	X	X	X	X
<b>PSFS</b>	X	X	X	X	X	X
<b>TSK</b>	X	X	X	X	X	X
<b>CEQ*</b>	X	X	X	X		
<b>IMI*</b>	X	X	X	X		
<b>SF-36</b>	X	X	X	X	X	X
<b>Drop-outs</b>		X	X	X	X	X

*T0 = start rehabilitation; T1 = end week 3; T2 = end week 8; T3 = end week 13 (end technological-supported rehabilitation); T4 = end week 18 (end full rehabilitation); T5 = 6 months after the end of the rehabilitation.*  
*NPRS: Numeric pain rating scale; PSEQ: pain self-efficacy questionnaire; RMDQ: Roland morris disability questionnaire; PSFS: patient specific functioning scale; TSK: Tampa Scale of Kinesiophobia; CEQ: Credibility and expectancy questionnaire; IMI: Intrinsic motivation inventory; SF-36: Short-Form 36. \*T0 en T1 were examined after the first treatment at week 1 and 4.*

## **Outcome measures**

### **Primary outcome measures**

Numeric pain rating scale (NPRS)<sup>50,51</sup> was used to measure the pain intensity on a scale of 0-10, 10 being the worst conceivable pain.

The satisfaction about the treatment was measured with the patient satisfaction scale of 0-10, 10 meaning very satisfied.

The self-efficacy questionnaire (PSEQ)<sup>52</sup> measured the self-confidence of the patient. The patient encircled the number that matched the best with their feeling, zero being completely not confident and six meaning completely confident.

To measure the functional disability of the patients, the Roland morris disability questionnaire (RMDQ)<sup>51,53</sup> was used. This consists of 24 statements for which the patients have to indicate whether they apply to them or not.

The patient specific functioning scale (PSFS)<sup>54</sup> was also used to measure three to five specific functional activities being important to the patient and which at the beginning could not be carried out or could only be carried out with difficulty because of their CLBP.

The tampa scale of kinesiophobia (TSK)<sup>51,55,56</sup> gave the impression of pain-related fear. It is a 17-items questionnaire, where the patient have to fill in 'agree' or 'disagree'.

### ***Secondary outcome measures***

The credibility and expectancy questionnaire (CEQ)<sup>44,57</sup> measured the treatment expectancies and the credibility of the rehabilitation programme. In total, six questions are asked about the confidence and the feeling they had with the rehabilitation.

Intrinsic motivation was measured with the intrinsic motivation inventory (IMI).<sup>58</sup> More specifically, it measures by means of 35 questions the patient's interest/enjoyment, perceived competence, effort/importance, pressure/tension, value/usefulness and relatedness.

Also the quality of life and the physical/mental and social health were measured using the short form 36.<sup>51,59</sup> The SF-36 consists of physical functioning, role limitations due to physical health, pain, general health, role limitations due to emotional problems, energy/fatigue, emotional well-being and social functioning. These criteria can be divided in a physical and mental component.<sup>60</sup> The components are calculated on the basis of average values.

The physical component consists of the categories: physical functioning, role limitations due to physical health, pain and general health.

The mental component consists of the following categories: role limitations due to emotional problems, energy/fatigue, emotional well-being and social functioning.

Finally, the drop outs were measured.

## RESULTS

### Patients

Four patients were included after signing the informed consent. In table 3 the baseline socio demographic data are shown. As could be seen in this table, the data were very different for all four participants.

All patients had experience in working with a laptop. In this particular group of patients the average age was 46 and the average duration of low back pain was 18 years.

At this moment the inclusion of other patients is still going on. The study results described below are the results of the patients who were included in the rehabilitation programme at the end April 2014. There will be further results at the end of the study.

<b>Table 3. Baseline socio demographics</b>				
	<b>P1</b>	<b>P2</b>	<b>P3</b>	<b>P4</b>
<b>Age (yr)</b>	59	55	33	35
<b>Height (cm)</b>	163	182	167	186
<b>Weight (kg)</b>	63	80	61	73
<b>Sex</b>	female	male	Female	Male
<b>Education</b>	Primary school	Secondary school	College	College
<b>History of LBP</b>				
<b>First episode of LBP (yr)</b>	25	30	4	13
<b>Current episode of LBP (yr)</b>	25	30	3	13
<b>Computer/laptop/ tablet/ smartphone</b>	laptop	Computer/laptop/smartphone	Computer/laptop/ Tablet/smartphone	Laptop/tablet / Smartphone
<b>Duration computer /laptop/tablet use (min/day)</b>	60	120	90	45
<b>Computer skills</b>	4	5	4	7
P1: patient 1; P2: patient 2; P3: patient 3; P4: patient 4				

### Interpretation of baseline measurements

The baseline and lastly obtained measurements for each patient can be found in table 4.

Patient one gave a pain intensity score of 6/10 which equals moderate pain according to the NRPS, whereas patient two and three gave scores of respectively 7/10 and 8/10. These scores indicate severe pain. Patient four's score indicates mild pain.<sup>61</sup> Patients two and four each get a score higher than 40 on the PSEQ. This means that both patients have enough confidence to carry out the rehabilitation programme.<sup>62</sup> No patient had a score below 20, indicating the patient is more focused on the pain. Patients one and three both scored between 20 and 40.

With respect to the RMDQ, patients one scored 13/24, patient two scored 14/24 and patient three scored 12/24, with 0 being no disability and 24 being maximal disabled. All three patients are moderately disabled. Patient four was an outlier with a score of 4. Patients two, three and four all had fear of movement. This can be deducted from their score on the TSK which is higher than 37. Only patient one was not afraid to move since this particular participant scored 37 on the TSK.<sup>63</sup> This must be interpreted with caution because 37 is the cut-off value.

The credibility of the patients varied between 14 and 24 out of 27. Also the four patients expectations varied strongly between 10.8/27 and 24.4/27. The four patients average intrinsic motivation was 4.6/7. This score meant that the four patients were motivated to participate in the rehabilitation programme. With respect to the SF-36 physical summary component, the score varied between 34.36 to 62.5 out of 100. A higher score for this component indicated better physical quality. On the mental summary component patients one, two and four's scores were about the same (between 81,63 and 87,5), whereas patients three's score was lower (60,75). This indicates that patient three was in less good mental health.

<b>Table 4. Baseline and last LBP measurements</b>								
	<b>P1</b>	<b>P1</b>	<b>P2</b>	<b>P2</b>	<b>P3</b>	<b>P3</b>	<b>P4</b>	<b>P4</b>
	<b>T0</b>	<b>T4</b>	<b>T0</b>	<b>T1</b>	<b>T0</b>	<b>T2</b>	<b>T0</b>	<b>T1</b>
<b>NPRS (0-10)</b>	6	7	8	4	7	8	3	2
<b>PSEQ (0-60)</b>	33	42	44	49	30	23	45	49
<b>RMDQ (0-24)</b>	13	8	14	9	12	15	4	5
<b>TSK (17-68)</b>	37	33	56	46	43	47	48	38
<b>CEQ (3-27)*</b>								
<b>Credibility</b>	22	22 (T3)	24	24	18	13	14	23
<b>Expectancy</b>	19.4	17 (T3)	24.4	20.8	16.6	9.8	10.8	22.8
<b>IMI (1-7)*</b>	5,23	5.21 (T3)	4,4	5.02	4,78	4.46	4,1	4.73
<b>SF-36 (0-100)</b>								
<b>Physical summary component</b>	49,36	57.5	34,36	70.63	38,13	36.88	62,5	61.88
<b>Mental summary component</b>	87,5	92.75	81,63	89.75	60,75	35.13	83,75	83.75
<b>Patient satisfaction</b>	7 (T1)	10	10 (T1)	/	7 (T1)	4	8 (T1)	/
<b>PSFS</b>	5	7	5	8	3,75	3.75	3,33	3.67
<small>NPRS: Numeric pain rating scale; PSEQ: pain self-efficacy questionnaire; RMDQ: Roland morris disability questionnaire; TSK: Tampa Scale of Kinesiophobia; CEQ: Credibility and expectancy questionnaire; IMI: Intrinsic motivation inventory; SF-36: Short-Form 36; PSFS: patient specific functioning scale. /:no data available.*T0 en T1 were examined after the first treatment at week 1 and 4.</small>								

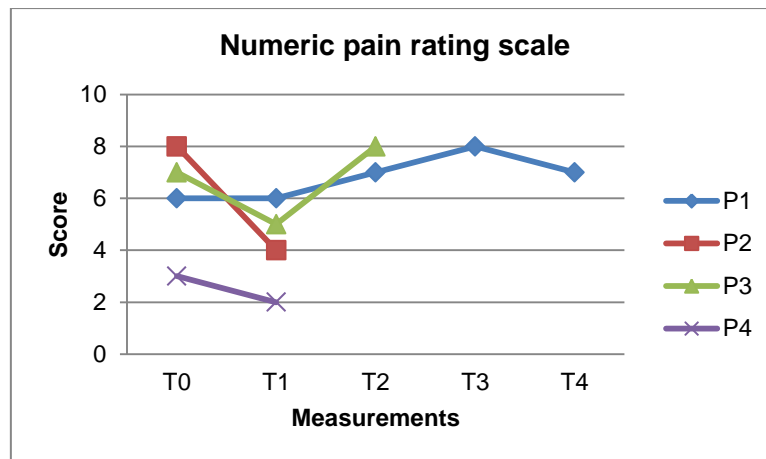
### Primary outcome measures

In interpreting the results the value measured at the last measurement was compared to the baseline value found in table 4. The results were described descriptively, this gave a clear picture of the outcomes of each patient throughout the rehabilitation programme. Note that not all patients were at the same stage in the rehabilitation programme. Patient one had completed measurement four, patient two and four had completed measurement one and patient three measurement two.

### **Pain**

The results of the NPRS are shown in figure 4.

The pain intensity of patient one, three and four stayed almost the same because a change by one point is clinical not relevant. Patient two showed a decrease in pain by four points, which exceeds the MCID.<sup>64</sup>

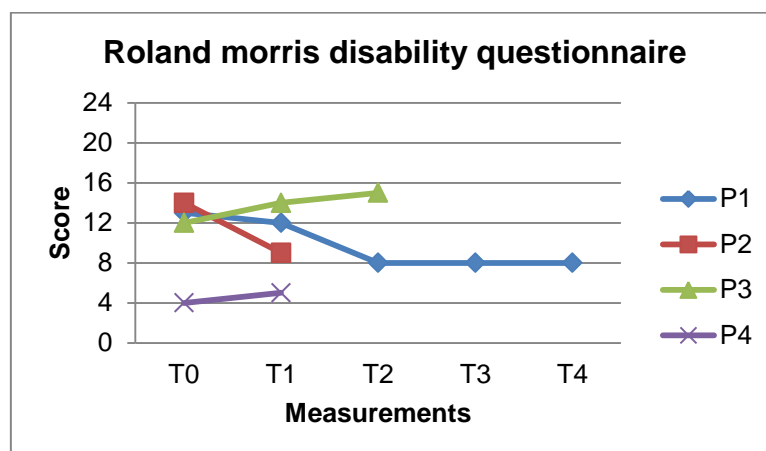


**Figure 4.** Numeric pain rating scale

### **Disability**

The results of the RMDQ are shown in figure 5.

The results from patient one and two indicate a clinically relevant decrease in disability. A change of at least 3.5 points is considered as MCID according to Maughan and Lewis.<sup>64</sup> Patient one's score decreased from 13 to 8 and patient two's score from 14 to 9. Patients three and four showed an increase in functional disability. Patient three's results showed an increase of three points and patient four's results indicated a slight increase by one point. The results of patient three and four are clinical less relevant because the changes are lower than 3,5<sup>64</sup> Note that patient four indicated a low disability score before the rehabilitation.



**Figure 5.** Roland morris disability questionnaire

### ***Patient satisfaction***

The results of the patient satisfaction are shown in figure 6.

Patient one showed an increase in satisfaction in contrast to patient three who became less satisfied.

Note that patient one was at the end of the rehabilitation programme whereas patient three was only in week eight of the rehabilitation programme. At this moment, patients two and four only have taken one satisfaction measurement, so conclusions concerning patient satisfaction cannot be drawn yet.

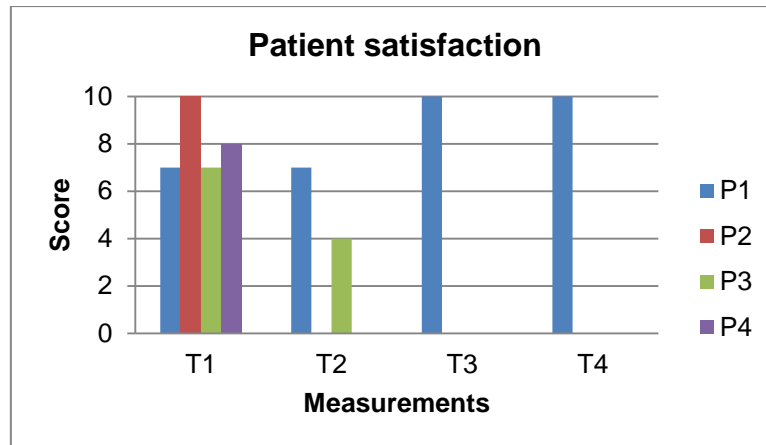


Figure 6. Patient satisfaction

### ***Kinesiophobia***

The results of the TSK are shown in figure 7.

At baseline, patients two, three and four scored more than 37 points on the TSK, indicating kinesiophobia.<sup>63</sup> However, patients two and four showed a decrease by 10, but still had kinesiophobia, because there is a score higher than 37 points. Patient three stayed almost the same, indicating kinesiophobia. Patient one did not have kinesiophobia before starting the rehabilitation programme. Because patient one scored the cut-off value the results must be interpreted with caution. After finishing the rehabilitation patient one even showed a drop by five points on the TSK which meant patient one have now less pain related fear.

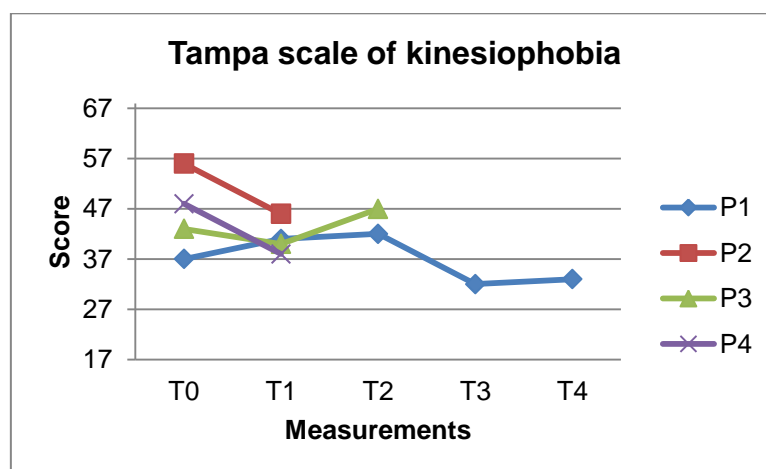


Figure 7. Tampa scale of kinesiophobia

### Self-efficacy

The results of the PSEQ are shown in figure 8.

Patients two and four's confidence was high enough (>40) to carry out the rehabilitation programme.<sup>62</sup> During the rehabilitation their confidence increased even further.

Patient one also had a score over 40 after 18 weeks of rehabilitation. This means that patient one is more likely to benefit from the rehabilitation's long term effects.<sup>65</sup> In contrast to patients one, two and four, who showed an increase in confidence, patient three reported a decrease in confidence.

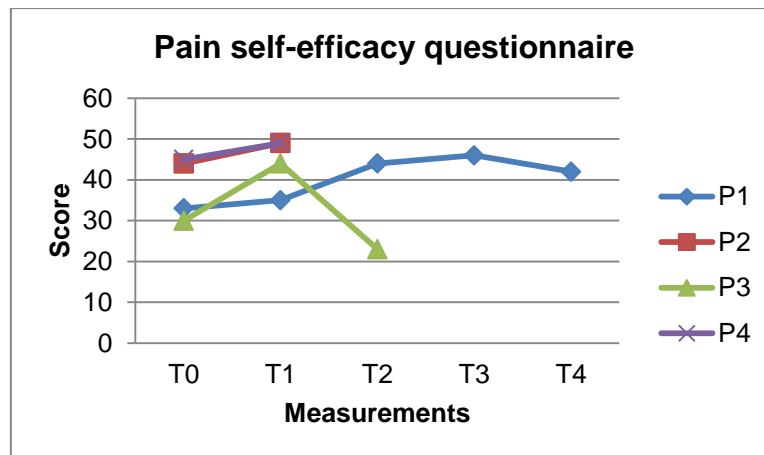


Figure 8. Pain self-efficacy questionnaire

### Specific functioning

The results of the PSFS are shown in figure 9.

The scores of the PSFS are based on the average (0-10) of three to five tasks. The score of patient two increased from 5/10 to 8/10, indicating a clinical relevant improvement because the MCID is 2.<sup>54</sup>

Patient one had also an improvement but not clinical relevant. Patient three revealed no improvement and patient four stayed almost the same.

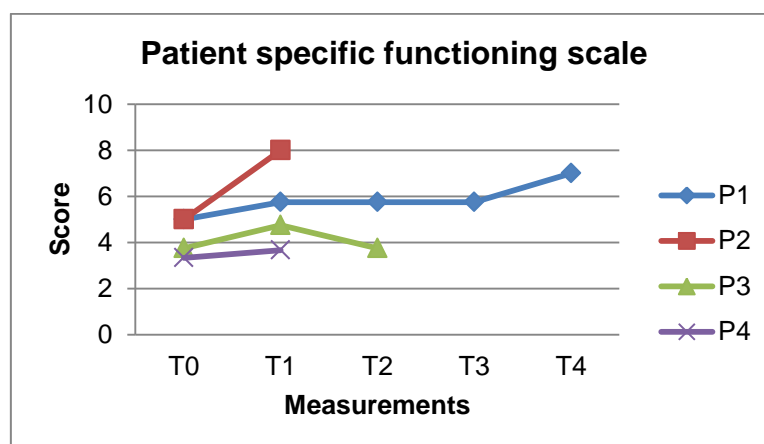


Figure 9. Patient specific functioning scale



## Secondary outcome measures

### Quality of life

The results of the SF-36 are shown in figure 10 and 11.

Patient one and two showed an increase in the physical component but both patients stayed almost the same for the mental component.

The physical component score of patient three remained almost the same, in contrast to the mental component that decreased. The results of patient four remained almost the same for both components.

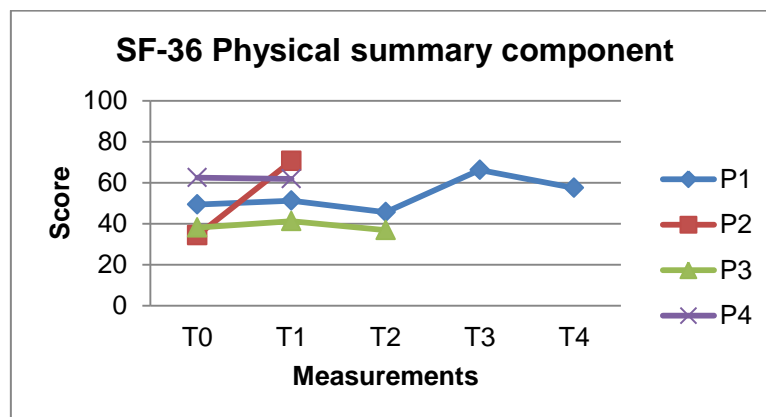


Figure 10. SF-36 Physical summary component

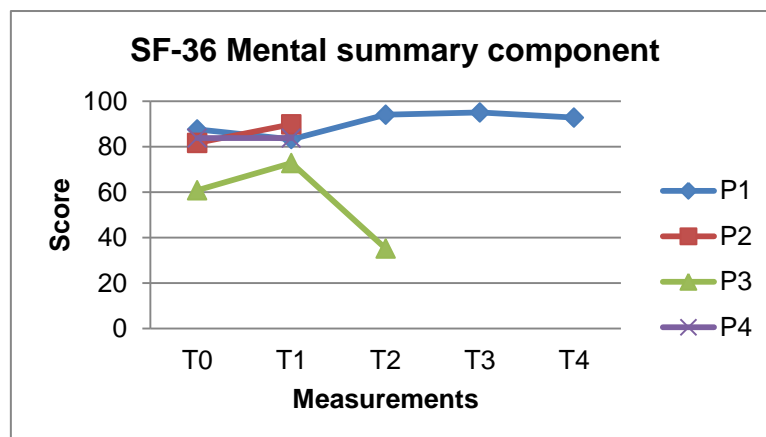
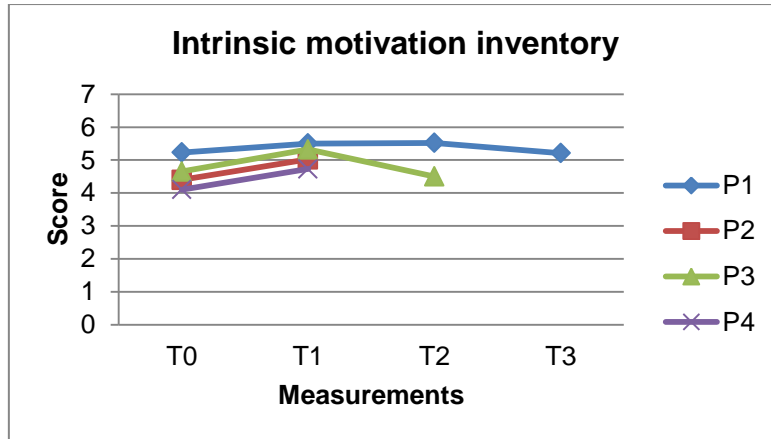


Figure 11. SF-36 Mental summary component

### **Motivation**

The results of the IMI are shown in figure 12.

Average values were taken from the different components. Overall, patients one and three's intrinsic motivations stayed the same, in contrast to patient two and four who showed a slight increase.



**Figure 12.** Intrinsic motivation inventory

### Credibility and expectancy

The results of the CEQ are shown in figure 13 and 14.

The credibility of the rehabilitation increased for patient four. It stayed the same for patients one and two and it decreased for patient three.

The expectations concerning the rehabilitation process remained almost the same for patients one and two. Patient three's expectations lowered, whereas patient four's expectations increased during the rehabilitation.

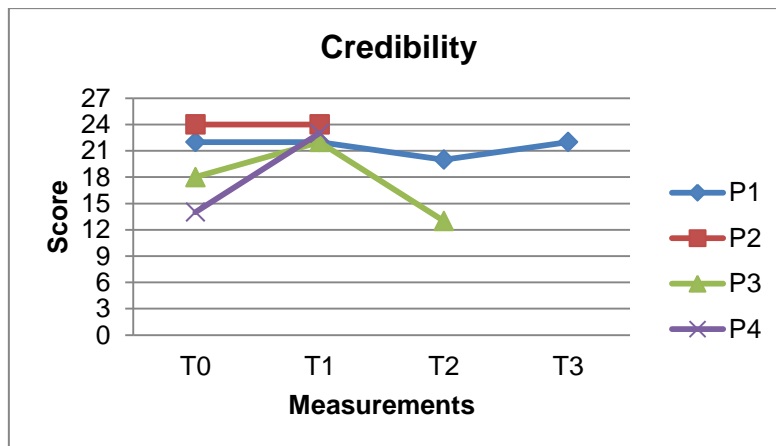


Figure 13. Credibility

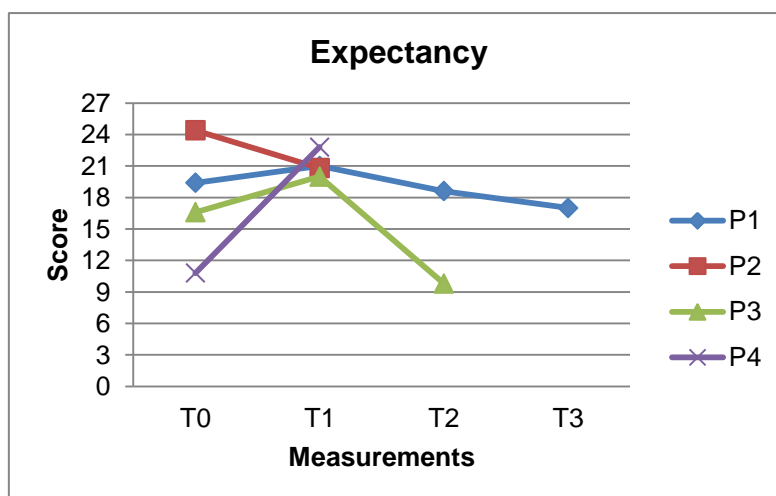


Figure 14. Expectancy

### Drop outs

During the rehabilitation there was one drop out. Patient two dropped out because of personal reasons not related to the rehabilitation programme.

## DISCUSSION

The purpose of this study was to find out what the influence was of an 18 week lasting technology-supported rehabilitation programme in which postural biofeedback was used in patients with CNSLBP, on pain, disability and quality of life. In addition, the programs effects on motivation and the patients' credibility and expectancy of the programme were examined.

The technology-supported programme used the ValedoMotion system in which patients rehabilitate using games and feedback focused on functional activities. These functional activities are the main difference with other studies that can be found in the literature. Many other studies use analytical exercises in their rehabilitation programme.

A first technology-supported rehabilitation programme is real-time ultrasound feedback. Henry and Teyhen<sup>36</sup> does research about real-time ultrasound feedback to visualize the contraction of the M.transversus abdominus and M.multifidus. This research suggests that it is a useful tool to improve motor learning of the Transversus Abdominus and Multifidus muscles in patients with LBP. However, further research is needed for more results. Another technology-supported rehabilitation programme is the use of EMG biofeedback. EMG biofeedback can offer feedback to help patients reduce the tension on their lumbar paraspinal muscles.<sup>37,38,39</sup> Or EMG biofeedback can be used to strengthen these muscle groups.<sup>40</sup> This particular form of feedback shows a significant reduction in pain and depression in patients suffering from CLBP.<sup>37,38,39</sup> However, some studies also show that EMG biofeedback is not better than cognitive behaviour therapy or no therapy at all.<sup>37,39</sup>

The studies mentioned above used technology-supported rehabilitation programs and feedback but in contrast to the current study, they used another technology device and used feedback in analytical exercises. The technology used in the current study provide feedback during functional activities. The tasks and games the patients had to carry out were chosen in function of their transfer to everyday life and activities. In doing so it was easier for patients to keep motor control over their everyday activities. Further research is needed to confirm these findings.

Magnusson, Chow and Diamandopoulos et al<sup>35</sup> does use a similar technology concept as the current study but with analytical exercises. This study does research on postural biofeedback by using a computer target programme.<sup>35</sup> Patients are given three kinds of feedback: visual feedback, auditory feedback and succes rates response. While using these kinds of feedback, patients have to match an icon seen on their computer screen by moving their back. The study results indicate that using postural biofeedback gives better outcomes than conventional CLBP therapy. More specifically, postural biofeedback means an improvement in kinematic measurements and visual analogue scale. In contrast to the study of Magnusson, Chow and Diamandopoulos et al<sup>35</sup>, a relevant decrease in pain was found by one of the four patient in the current study. A possible explanation for this could be that not all patients have completed the rehabilitation programme yet. Further research is needed to draw conclusions as to the evolution of patients pain.

Nevertheless there were some findings to present, such as patient one's results indicated that even though the patient's pain did not improve, there were some positive effects. For example, the patients' confidence increased and was more satisfied with the treatment. Furthermore patients' functional disabilities were reduced, kinesiophobia decreased and overall the quality of life improved. These results indicated that, in order to achieve positive results through this kind of rehabilitation programme, it was not necessary to reduce the pain intensity.

Furthermore, patient three's pain scores showed a decrease at first, but later in the programme the patients' pain increased again. This trend was also seen in other outcome measures. A possible explanation can be found in the amount of work load the patient was having at the time of the measurement. At the time patient three was filling in the questionnaires for T2, the patient was experiencing a higher work load. This might have made patient three's experience the pain as worse compared to moment T1. Work load and the stress could influence measurement results.

All patients were at different stages of the rehabilitation. In this respect patient one's results gave a clearer picture of the programs final outcomes than patients two, three and four.

At the moment patient two has interrupted the programme because of personal reasons not related to the rehabilitation programme. Apart from patient two there were no other drop outs or interruptions of the programme.

In general there was a positive trend in several outcome measures and there were no side effects. The criteria for an RCT were reached.

However there were some strengths and limitations of the current study. A strength of the current study was that the patients already worked with the technology in the hospital before using it at home. Due to the fact that the patients already used the technology, there were no problems in using it.

The limitations should be adapted with regards to an RCT. The main limitation was the small sample size. There were some difficulties recruiting patients. In this study patients were sent by a physical medicine specialist to a physiotherapist who performed a patient history and a clinical examination. A lot of patients could not be included in the study because of exclusion criteria, such as previous operations. Part of this problem could be solved if the physical medicine specialist would be better informed as to which patients were suitable for the programme.

Another limitation was that there was no use of statistics, but only descriptive data.

Because of the small number of participants in this particular study it is hard to determine what the results will be for a larger population. But, even though further research is needed to generalize the findings of the current study.

## CONCLUSION

So far in this pilot study there is a positive trend in several outcome measures and there are no side effects.

### ➤ Key Points

- ❑ This study was important for further research because there are rarely results available for technology-supported rehabilitation with functional exercises.
- ❑ There was a positive trend on several outcome measures.
- ❑ Further research with larger sample size is necessary to generalize the findings of the current study.



## Reference background

1. Maher CG. Effective physical treatment for chronic low back pain. *The Orthopedic clinics of North America* 2004;35:57-64.

## References article

1. Maher CG. Effective physical treatment for chronic low back pain. *The Orthopedic clinics of North America* 2004;35:57-64.
2. Dagenais S, Caro J, Haldeman S. A systematic review of low back pain cost of illness studies in the United States and internationally. *The spine journal : official journal of the North American Spine Society* 2008;8:8-20.
3. Airaksinen O, Brox JI, Cedraschi C, et al. Chapter 4. European guidelines for the management of chronic non-specific low back pain. *European spine journal : official publication of the European Spine Society, the European Spinal Deformity Society, and the European Section of the Cervical Spine Research Society* 2006;15 Suppl 2:S192-300.
4. Bevan S. MR, and Quadrello T. Musculoskeletale aandoeningen en de Belgische arbeidsmarkt *Fit For Work* 2009.
5. van Zundert J, van Kleef M. Low back pain: from algorithm to cost-effectiveness? *Pain practice : the official journal of World Institute of Pain* 2005;5:179-89.
6. Garcia AN, Gondo FL, Costa RA, et al. Effectiveness of the back school and mckenzie techniques in patients with chronic non-specific low back pain: a protocol of a randomised controlled trial. *BMC musculoskeletal disorders* 2011;12:179.
7. Leclere H, Beaulieu MD, Bordage G, et al. Why are clinical problems difficult? General practitioners' opinions concerning 24 clinical problems. *CMAJ : Canadian Medical Association journal = journal de l'Association medicale canadienne* 1990;143:1305-15.
8. Hermens HJ, Vollenbroek-Hutten MM. Towards remote monitoring and remotely supervised training. *Journal of electromyography and kinesiology : official journal of the International Society of Electrophysiological Kinesiology* 2008;18:908-19.
9. Perraton L, Machotka Z, Kumar S. Whole-body vibration to treat low back pain: fact or fad? *Physiotherapy Canada. Physiotherapie Canada* 2011;63:88-93.
10. del Pozo-Cruz B, Hernandez Mocholi MA, Adsuar JC, et al. Effects of whole body vibration therapy on main outcome measures for chronic non-specific low back pain: a single-blind randomized controlled trial. *Journal of rehabilitation medicine : official journal of the UEMS European Board of Physical and Rehabilitation Medicine* 2011;43:689-94.
11. Krein SL, Kadri R, Hughes M, et al. Pedometer-based internet-mediated intervention for adults with chronic low back pain: randomized controlled trial. *Journal of medical Internet research* 2013;15:e181.
12. Del Pozo-Cruz B, Adsuar JC, Parraca J, et al. A web-based intervention to improve and prevent low back pain among office workers: a randomized controlled trial. *The Journal of orthopaedic and sports physical therapy* 2012;42:831-41.
13. Brewer BR, McDowell SK, Worthen-Chaudhari LC. Poststroke upper extremity rehabilitation: a review of robotic systems and clinical results. *Topics in stroke rehabilitation* 2007;14:22-44.
14. Norouzi-Gheidari N, Archambault PS, Fung J. Effects of robot-assisted therapy on stroke rehabilitation in upper limbs: systematic review and meta-analysis of the literature. *Journal of rehabilitation research and development* 2012;49:479-96.
15. Hesse S, Tomelleri C, Bardeleben A, et al. Robot-assisted practice of gait and stair climbing in non-ambulatory stroke patients. *Journal of rehabilitation research and development* 2012;49:613-22.
16. Holden MK. Virtual environments for motor rehabilitation: review. *Cyberpsychology & behavior : the impact of the Internet, multimedia and virtual reality on behavior and society* 2005;8:187-211; discussion 2-9.
17. Timmermans AA, Lemmens RJ, Geers RP, et al. A comparison of treatment effects after sensor- and robot-based task-oriented arm training in highly functional stroke patients. *Conference proceedings : ... Annual International Conference of the IEEE Engineering in Medicine and Biology Society. IEEE Engineering in Medicine and Biology Society. Conference* 2011;2011:3507-10.
18. Timmermans AA, Seelen HA, Geers RP, et al. Sensor-based arm skill training in chronic stroke patients: results on treatment outcome, patient motivation, and system usability. *IEEE transactions on neural systems and rehabilitation engineering : a publication of the IEEE Engineering in Medicine and Biology Society* 2010;18:284-92.
19. Lange B, Chang CY, Suma E, et al. Development and evaluation of low cost game-based balance rehabilitation tool using the Microsoft Kinect sensor. *Conference proceedings : ... Annual International Conference of the IEEE Engineering in Medicine and Biology Society. IEEE Engineering in Medicine and Biology Society. Conference* 2011;2011:1831-4.
20. Oess NP, Wanek J, van Hedel HJ. Enhancement of bend sensor properties as applied in a glove for use in neurorehabilitation settings. *Conference proceedings : ... Annual International Conference of the IEEE Engineering in Medicine and Biology Society. IEEE Engineering in Medicine and Biology Society. Conference* 2010;2010:5903-6.



21. Wade E, Winstein CJ. Virtual reality and robotics for stroke rehabilitation: where do we go from here? *Topics in stroke rehabilitation* 2011;18:685-700.
22. Descarreaux M, Blouin JS, Teasdale N. Repositioning accuracy and movement parameters in low back pain subjects and healthy control subjects. *European spine journal : official publication of the European Spine Society, the European Spinal Deformity Society, and the European Section of the Cervical Spine Research Society* 2005;14:185-91.
23. Panjabi MM. A hypothesis of chronic back pain: ligament subfailure injuries lead to muscle control dysfunction. *European spine journal : official publication of the European Spine Society, the European Spinal Deformity Society, and the European Section of the Cervical Spine Research Society* 2006;15:668-76.
24. Brumagne S, Janssens L, Knapen S, et al. Persons with recurrent low back pain exhibit a rigid postural control strategy. *European spine journal : official publication of the European Spine Society, the European Spinal Deformity Society, and the European Section of the Cervical Spine Research Society* 2008;17:1177-84.
25. Sterling M, Jull G, Wright A. The effect of musculoskeletal pain on motor activity and control. *The journal of pain : official journal of the American Pain Society* 2001;2:135-45.
26. Jacobs JV, Henry SM, Nagle KJ. People with chronic low back pain exhibit decreased variability in the timing of their anticipatory postural adjustments. *Behavioral neuroscience* 2009;123:455-8.
27. Hodges PW. Changes in motor planning of feedforward postural responses of the trunk muscles in low back pain. *Experimental brain research* 2001;141:261-6.
28. Brumagne S, Lysens R, Spaepen A. Lumbosacral repositioning accuracy in standing posture: a combined electrogoniometric and videographic evaluation. *Clinical biomechanics* 1999;14:361-3.
29. O'Sullivan PB, Burnett A, Floyd AN, et al. Lumbar repositioning deficit in a specific low back pain population. *Spine* 2003;28:1074-9.
30. Dolan KJ, Green A. Lumbar spine reposition sense: the effect of a 'slouched' posture. *Manual therapy* 2006;11:202-7.
31. Hides JA, Richardson CA, Jull GA. Multifidus muscle recovery is not automatic after resolution of acute, first-episode low back pain. *Spine* 1996;21:2763-9.
32. O'Sullivan P. Diagnosis and classification of chronic low back pain disorders: maladaptive movement and motor control impairments as underlying mechanism. *Manual therapy* 2005;10:242-55.
33. Ribeiro DC, Sole G, Abbott JH, et al. Extrinsic feedback and management of low back pain: A critical review of the literature. *Manual therapy* 2011;16:231-9.
34. Richard A, Wrisberg SaCA. Motor learning and performance: a situation-based learning approach., 2008.
35. Magnusson ML, Chow DH, Diamandopoulos Z, et al. Motor control learning in chronic low back pain. *Spine* 2008;33:E532-8.
36. Henry S, Teyhen D. Ultrasound Imaging as a Feedback Tool in the Rehabilitation of Trunk Muscle Dysfunction for People With Low Back Pain. *journal of orthopaedic & sports physical therapy* 2007;37:627e34.
37. Newton-John TR, Spence SH, Schotte D. Cognitive-behavioural therapy versus EMG biofeedback in the treatment of chronic low back pain. *Behaviour research and therapy* 1995;33:691-7.
38. Donaldson S, Romney D, Donaldson M, et al. Randomized study of the application of single motor unit biofeedback training to chronic low back pain. *Journal of occupational rehabilitation* 1994;4:23-37.
39. Bush C, Ditto B, Feuerstein M. A controlled evaluation of paraspinal EMG biofeedback in the treatment of chronic low back pain. *Health psychology : official journal of the Division of Health Psychology, American Psychological Association* 1985;4:307-21.
40. Asfour SS, Khalil TM, Waly SM, et al. Biofeedback in back muscle strengthening. *Spine* 1990;15:510-3.
41. Shepherd RB. Exercise and training to optimize functional motor performance in stroke: driving neural reorganization? *Neural plasticity* 2001;8:121-9.
42. van Vliet PM, Heneghan NR. Motor control and the management of musculoskeletal dysfunction. *Manual therapy* 2006;11:208-13.
43. Shumway-Cook A, Woollacott MH. Motor control: translating research into clinical practice ed. px. Philadelphia, PA; London: Lippincott Williams & Wilkins, 2007.
44. Smeets RJ, Beelen S, Goossens ME, et al. Treatment expectancy and credibility are associated with the outcome of both physical and cognitive-behavioral treatment in chronic low back pain. *The Clinical journal of pain* 2008;24:305-15.
45. Luomajoki H, Kool J, de Bruin ED, et al. Movement control tests of the low back; evaluation of the difference between patients with low back pain and healthy controls. *BMC musculoskeletal disorders* 2008;9:170.
46. Sahrman S. Diagnosis and treatment of movement impairment syndromes ed. St. Louis Mosby, 2001.
47. Comerford M, Mottram S. Kinetic Control: The Management of Uncontrolled Movement ed. Australia: Elsevier Health, 2012
48. Hodges PW. Core stability exercise in chronic low back pain. *The Orthopedic clinics of North America* 2003;34:245-54.
49. Bauer C, Baumgartner L, Schellendorfer S et al. Technical validation of a new movement therapy system for treatment of low back pain. *Gait Posture* 2012 36:40-1.
50. Von Korff M, Jensen MP, Karoly P. Assessing global pain severity by self-report in clinical and health services research. *Spine* 2000;25:3140-51.
51. Chapman JR, Norvell DC, Hermsmeyer JT, et al. Evaluating common outcomes for measuring treatment success for chronic low back pain. *Spine* 2011;36:S54-68.
52. Nicholas MK. The pain self-efficacy questionnaire: Taking pain into account. *European journal of pain* 2007;11:153-63.

53. Roland M, Morris R. A study of the natural history of back pain. Part I: development of a reliable and sensitive measure of disability in low-back pain. *Spine* 1983;8:141-4.
54. Stratford PW, Gill C, Westaway M, et al. Assessing disability and change on individual patients: a report of patient-specific measure. *Physiotherapy Canada* 1995 47:258-63.
55. Vlaeyen JW, Kole-Snijders AM, Boeren RG, et al. Fear of movement/(re)injury in chronic low back pain and its relation to behavioral performance. *Pain* 1995;62:363-72.
56. Lame IE, Peters ML, Kessels AG, et al. Test--retest stability of the Pain Catastrophizing Scale and the Tampa Scale for Kinesiophobia in chronic pain over a longer period of time. *Journal of health psychology* 2008;13:820-6.
57. Devilly GJ, Borkovec TD. Psychometric properties of the credibility/expectancy questionnaire. *Journal of behavior therapy and experimental psychiatry* 2000;31:73-86.
58. Deci EL, Ryan R. The "What" and "Why" of goal pursuits: Human needs and the self-determination of behavior. *Psychol Inq.* 2000 11:227-68.
59. Walsh TL, Hanscom B, Lurie JD, et al. Is a condition-specific instrument for patients with low back pain/leg symptoms really necessary? The responsiveness of the Oswestry Disability Index, MODEMS, and the SF-36. *Spine* 2003;28:607-15.
60. Ware JE, Kosinski M, Keller SD. SF-36 Physical and Mental Health Summary Scales: A User's Manual.ed. Boston, MA: The Health Institute: QualityMetric 1994.
61. MacCaffery M, Beebe A. Pain: Clinical manual for nursing practiceed: Mosby St. Louis, 1989.
62. Frost H, Klaber MJ, Moser J, et al. Evaluation of a fitness programme for patients with chronic low back pain. *Brit Med J* 1993;310:151-4.
63. Miller RP, Kori SH, Todd DD. Tampa Scale. *Tampa, FL* 1991.
64. Maughan EF, Lewis JS. Outcome measures in chronic low back pain. *European spine journal : official publication of the European Spine Society, the European Spinal Deformity Society, and the European Section of the Cervical Spine Research Society* 2010;19:1484-94.
65. Keefe FJ, Rumble ME, Scipio CD, et al. Psychological aspects of persistent pain: current state of the science. *The journal of pain : official journal of the American Pain Society* 2004;5:195-211.

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Richting: **master in de revalidatiewetenschappen en de kinesitherapie-revalidatiewetenschappen en kinesitherapie bij musculoskeletale aandoeningen**

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